

INFLUENCE OF LEXICAL VERSUS PROCEDURAL KNOWLEDGE IN SENTENCE  
PRODUCTION IN RESPONSE TO THEMATIC ROLE ASSIGNMENT TREATMENT

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A Master's Thesis

Presented to

The Faculty of the Department  
of Communication Sciences and Disorders

University of Houston

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In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

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By

Katsiaryna Kazhuro

May, 2017

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Thematic Role Assignment Treatment

**Abstract**

We tested whether one source of variability in treatment response and generalization for sentence production (Mitchum, Greenwald, & Berndt, 2000; Rochon, Laird, & Scofield, 2000) in individuals with non-fluent agrammatic aphasia is a deficit in the ability to assign thematic roles (procedural mapping). We propose that agrammatic individuals with better lexical verb retrieval abilities have a procedural mapping deficit (Schwartz, Saffran, Fink, Myers, & Martin, 1994; Marshall, 1995), and, therefore, demonstrate better response and generalization to treatment which focuses on the procedural assignment of thematic roles. In contrast, we hypothesized agrammatic individuals with poorer lexical verb retrieval abilities have a lexical mapping deficit and exhibit worse treatment outcomes and generalization of treatment. Fifteen right-handed, monolingual English-speaking adult males and females who had unilateral left hemisphere CVAs with subsequent chronic non-fluent aphasia and no co-morbid neurologic impairments participated in this study. All participants had agrammatism as confirmed by their poor performance during production of passive reversible verb sentences at baseline ( $\leq 30\%$  accuracy). Verb retrieval, as measured by the Action Naming Test (Opler & Albert, 1986), and active sentence comprehension, as measured by the active sentences on the Circles and Squares Syntactic Comprehension Test, (adopted from Schwartz, Saffran, & Martin, 1980) served as indicators of lexical and procedural mapping abilities, respectively. The dependent variables were treatment response, as determined by sentence production to picture stimuli using correct thematic role assignment, and treatment generalization, as measured by the non-treated sentence

production using correct thematic role assignment. In order to examine the relationship between verb retrieval and active sentence comprehension correlation analysis was used. Linear regression was used to determine the strength of the relationship between the independent variables (severity of the type of mapping deficit) and dependent variables (treatment outcomes), while considering the potential impacts of overall aphasia severity and age. The analyses revealed no significant correlation between verb retrieval and active reversible sentence comprehension ( $r=0.417$ ,  $p=.122$ ) suggesting these two measures test separate stages of sentence processing. We found overall aphasia severity as indicated by the Western Aphasia Battery A.Q. (Kertesz, 1982) correlated with verb retrieval ( $r=0.781$ ,  $p=.001$ ) and active sentence comprehension ( $r=0.653$ ,  $p=.008$ ), suggesting that overall aphasia severity considers linguistic impairments captured by both verb retrieval and active sentence comprehension measures. Overall aphasia severity was the main predictor of treatment response ( $R^2=.382$ ), whereas age was not correlated with either treatment response ( $r=-0.18$ ,  $p=.53$ ) or generalization ( $r=-0.15$ ,  $p=.60$ ), which is consistent with the literature (Pederson, Vinter, & Olsen, 2004; Plowman, Hentz, & Ellis, 2011). Verb retrieval, however, was the only statistically significant predictor of treatment generalization ( $R^2=.351$ ). Our results demonstrate that better mapping treatment outcomes are predicted by relatively preserved verb retrieval, where individuals with poor verb retrieval demonstrate treatment specific gains but no treatment generalization. However, individuals who can access the lexical representation of the verb for further processing demonstrate not only a positive treatment response, but also a generalized response suggesting procedural re-learning of the process of thematic role assignment.

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## Literature Review

The present study was designed to examine the hypothesis that the variability in the treatment outcomes following mapping therapy treatment may be attributable to the specific type of a mapping deficit an individual with non-fluent agrammatic aphasia exhibits.

Aphasia is an acquired communication disorder that results from damage to the areas of the brain involved in language processing. Aphasia is most often caused by a cerebrovascular accident (CVA), that is, stroke, however it can also occur following a traumatic brain injury (TBI), or result from other neurologic events, such as progressive neurological disorders. Aphasia manifests in impairments in oral/verbal (speaking, listening) and written (writing, reading) language comprehension and production (Chapey, 2008). Individuals diagnosed with aphasia can present with a broad spectrum of symptoms ranging in severity. One of the symptoms often observed in patients with aphasia is agrammatism. Agrammatism in itself involves a cluster of language symptoms (Caplan, 1987). These symptoms result from damage to the peri-sylvian regions of the left hemisphere of the brain. Agrammatism is characterized by a higher ratio of content (nouns and verbs) than function words (prepositions, articles, auxiliary words) in speech production, which is why the resultant speech is described as telegraphic (“textographic”). Typical utterances produced consist of verbs and nouns put together in the absence of articles and prepositions with few, if any, morphological markers. Syntactic complexity of sentences produced by a speaker with agrammatism is therefore reduced, e.g., production of “girl book” as a response to a picture stimulus depicting a girl reading a book. Language production is effortful and fragmented. Auditory comprehension in most cases is also impaired when it is syntax-dependent and is described as asyntactic (Rochon, Laird, Bose, & Scofield, 2005). The deficits in production and comprehension are expressed similarly, that is, an

individual with agrammatism exhibits difficulty interpreting and/or producing syntactically complex sentences (e.g., passive sentences), particularly if they are semantically reversible, i.e. when either noun can serve as the agent or the patient. For example, in the sentence, “The boy was taught by the girl,” the thematic roles in this sentence are assigned, however they can be reversed and this passive voice sentence will still be logical and cohesive (“The girl was taught by the boy”).

The underlying cause of agrammatism is unclear, however there are several recognized hypotheses on which currently available treatments of agrammatism are based. These hypotheses can be grouped based on the educational, or theoretical, background of the researchers, as well as the formal school of thought to which they belong. That is, they are typically linguistics-based or neuropsychology-based.

Some of the most prominent linguistics interpretations of agrammatism are “trace-based” theories (Grodzinsky, 1995; Mauner, Fromkin, & Cornell, 1993; O’Grady & Lee, 2004). A trace is defined as an empty category that occupies a position in a sentence (Lightfoot, 1976). Trace theory as a concept was first introduced by Chomsky (1973) and since then has become an accepted linguistic theory to explain *wh*-word movement within a sentence. Let us consider a sentence, “Mary liked the first dress.” If we were to ask a question “Which dress did Mary like \_\_\_?” the empty position after the word “like” in the question would be considered a trace as it was previously occupied by the word “dress” and is important for an accurate interpretation of the question.

The best-known example of a “trace-based” theory is Grodzinsky’s (1995, 2000) Trace Deletion Hypothesis (TDH). Grodzinsky suggests that traces of objects are lost from the syntactic representations of the individuals with agrammatism as the result of their language

deficits. This loss in turn interferes with the assignment of thematic roles to move the components of the utterance within the utterance (O'Grady & Lee, 2004). The inability to actively perform thematic role assignment leads to the usage of default strategies of thematic role assignment that are based exclusively on linear position in sentences that have undergone movement. That is, the first noun of the utterance is assumed to be the agent, or the doer of the action, therefore "agent-first" strategy is applied in the absence of the trace of the object that has been moved. Applying this strategy will yield a chance performance on sentences where argument roles can be reversed since the individual with agrammatism has to guess thematic role assignment. For example, in the phrase "The girl who the boy chased," the assigned thematic roles can be reversed and the sentence would still be semantically and syntactically correct. That is, either "the girl" or "the boy" can be the agent, the doer of the action. Inability to analyze the sentence structure and overreliance on the "agent-first" strategy would in this case yield a 50-50% chance of correctly identifying the agent.

In addition to Grodzinsky's TDH, there is a Double Dependency Hypothesis (DHH) proposed by Mauner and colleagues (1993) that suggests that object traces are not deleted, but there is rather a disruption in the relationship between them and their antecedent. If there is one antecedent-trace dependency within an utterance such as there is within active sentences, then the syntactic representation will be incomplete, however possible to interpret accurately. If there are two antecedent-trace dependencies, such as there are in passive sentences, the representation becomes harder to interpret due to semantic ambiguity as it is unclear who did what to whom in this case. Essentially, DHH offers a hypothesis as to why individuals with agrammatism typically perform above chance on active sentences but demonstrate at chance or poorer performance on passive sentences.

Another group of linguistics-based hypotheses regarding the nature of the deficits in agrammatism consists of “canonical order models” (Caplan, Baker, & Dehaut, 1985; Dick et al., 2001; Schwartz, Saffran, & Marin, 1980). Similar to the other existing linguistics-based models, these are based on the assumption that there is a problem with word order and syntax. Specifically, “canonical order models” propose that individuals with agrammatism experience difficulty with comprehension and production of utterances in which the word order deviates from the accepted, most frequently used, syntactic pattern of agent-verb-theme. That is, if the sentence is not formulated according to this typical subject-verb-object pattern, such as non-canonical sentences are not (e.g., passive sentences, questions, etc.), then the individual with agrammatism would have difficulty processing such a sentence.

Neuropsychology-based theories of agrammatism are based on a processing deficit (Caplan, Waters, DeDe, Michaud, & Reddy, 2007) or working memory limitations (Miyake, Carpenter, & Just, 1994). According to these theories, limited working memory capacity, that is, limited ability to process information, prevents individuals with agrammatism from successfully performing multiple syntactic operations at once. These theories account for co-morbidity of aphasia and higher-level cognitive deficits (i.e., working memory, short-term memory, attention, executive function) and propose that it is the underlying working memory impairment that makes individuals with non-fluent aphasia agrammatic (Caplan, Michaud, & Hufford, 2013; Mayer, Murray, Turkstra, & Lorenzan, 2006).

Processing deficit hypotheses have been further examined through the theory on impaired discourse-linking in agrammatism (Avrutin, 2006; Bos, Dragoy, Avrutin, Iskra, Bastiaanse, 2014). According to this theory, discourse-linked utterances and *wh*-questions imply existence of a certain context outside of the sentence. The utterances and *wh*-questions that are not discourse-

linked, on the other hand, contain enough information within themselves to be processed independently. *Which*-questions, for instance, are linked to discourse outside of the sentence because they imply there is a group of familiar people or objects. Consider the sentence “Which man is Mary asking to read the book?” There is an implication that there is a group of familiar men. The theory of discourse-linking proposes that in order to process *which*-questions, past tense, and personal pronouns an individual needs access to discourse outside of the sentence (Bos et al., 2014). This need to access additional discourse therefore puts additional processing demands on the individual resulting in observed deficits of sentence comprehension and production in people with agrammatism (Bos et al., 2014).

Regardless of the differences in the hypotheses explaining agrammatism there appears to be a general agreement on the fact that there is an issue with sentence structure and word order within the utterance. Additionally, most theories, including those based on working memory limitations (Avrutin, 2006; Bos et al., 2014; Caplan et al., 2007; Caplan et al., 2103; Mayer et al., 2006; Miyake et al., 1994; ), trace deletion hypothesis (Grodzinsky, 1995; Grodzinsky, 2000; O’Grady & Lee, 2004; ), and canonical order (Caplan et al., 1985; Dick et al., 2001; Schwartz et al., 1980) agree that there is a deeper level processing issue involved in the impairment of agrammatism. That is, linguistics-based and neuropsychology-based theories of agrammatism offer different explanations of what the issue might be, but they all appear to agree that there is more to the deficit than surface level syntax issue, as supported by the performance of the individuals with agrammatism. Surface structure and deep structure as linguistic concepts were first proposed by Chomsky in his study of transformational grammar (Chomsky, 1965). He suggests that sentence processing involves a system of grammatical transformations that need to occur in order for sentences to be processed (Chomsky, 1965). Surface structure, or surface level

syntax, is the lexical representations of words that constitute the base of syntax. In order for sentence processing to occur, these lexical representations (i.e., surface syntax) need to be mapped onto semantic representations by the semantic rules of thematic role assignment (Chomsky, 1965). Deep structure therefore is the abstract level of structural organization as it dictates how the sentences and be processed and interpreted.

The mapping deficit hypothesis (Rochon et al., 2005; Schwartz, Linebarger, Saffran, & Pate, 1987) proposes that the issues observed in agrammatism are due to the difficulty in assigning thematic roles to the sentence components. Consequently, there is a deficit in “mapping” between the deep structure, the functional sentence structure (predicate-argument level encoding), the sentence meaning and the surface syntax, or sentence form. That is, agrammatism reflects a general weakness in producing linguistic structures that encode relations, in mapping those functional relations to surface syntax. Individuals with agrammatism are typically rather accurate in identifying grammatical violations that are related to phrase structure rules, addition or deletion of grammatical morphemes as indicated by retained ability to judge whether or not sentences presented auditorily are grammatically correct (Linebarger, Schwartz, & Saffran, 1983). For example, a grammatically incorrect sentence “Is the boy is having a good time?” was judged as incorrect by individuals with non-fluent aphasia in a study by Schwartz and colleagues (1987). However, more difficulty with agreement of two lexical forms with respect to semantic features such as gender, tense, or animacy has been observed (Linebarger et al., 1983). Additionally, comprehension appears to be unaffected when a simple active voice sentence is made longer and more elaborate (Schwartz, Saffran, Fink, Myers, & Martin, 1994). For example, an individual with non-fluent agrammatic aphasia would demonstrate the same degree of accuracy when interpreting a simple active sentence such as “Mary is eating apples”

and when interpreting the same sentence with the addition of adjectives and adverbs, e.g., “Mary is quickly eating big red apples.” Based on that evidence, Schwartz and colleagues (1994) concluded that asyntactic comprehension is not a failure to perform syntactic analysis, but rather an issue with assigning thematic roles. That is, deficits in language comprehension and production in individuals with agrammatism are indicative of impaired syntax-semantics mapping, which is a deep level issue, occurring during the input stage. Mapping deficit theory also provides an explanation for the verb retrieval deficit associated with agrammatism. It suggests that thematic role assignment is crucial for verb retrieval and accurate differentiation between reversed role verb pairs (e.g., give-take, buy-sell) due to the fact that lexical representations for verbs must specify what arguments are associated with the verb, what thematic roles these arguments have, and how this argument structure is realized syntactically (Marshall, Chiat, & Pring, 1997).

There are a number of rehabilitative treatments developed to target the deficits associated with agrammatism. Traditionally, the majority of the treatments for agrammatism have focused on the morpho-syntactic surface level, and have not addressed the deep level issue of impaired syntax-semantics mapping. Typically, the treatment protocols focus on retraining specific sentence types, for instance by stimulating syntactic production with multiple exemplars (e.g., Helm-Estabrooks, Fitzpatrick, & Barresi, 1981; Helm-Estabrooks, & Ramsberger, 1986) or by means of direct production techniques (e.g., Naeser, 1975; Wambaugh & Thompson, 1989). Mapping therapy, however, addresses the deeper level issue of impaired syntax-semantics mapping as opposed to the surface level impairment manifestation. Mapping therapy is a sentence level treatment program that focuses on strengthening the connection between sentence meaning and sentence structure (Fink, 2001). During the course of the treatment the individual is

provided with explicit training that is aimed at making the individual aware of "who is doing what to whom" in a sentence. This is achieved through first focusing the person's attention on the components, or constituents, of the sentence by asking probe questions (i.e., "What is the verb?", "Who is doing the verb-ing?", and "Who or what is she or he verb-ing?"). The "doer" of the action, or the agent and the "done to", or the theme, are the thematic roles assigned with the verb. There is some variability among the existing mapping protocols, however most mapping treatments utilize pictured or written sentence stimuli that can be color-coded. The complexity of the targeted sentences can be increased or decreased by changing the number of arguments within a sentence and by using reversible or non-reversible verbs (Fink, 2001).

It is important to point out that two types of the mapping impairment are hypothesized to exist; the lexical deficit variant and the procedural deficit variant (Mitchum, Greenwald, & Berndt, 2000; Schwartz et al., 1994). A lexical deficit is expressed as a loss of lexically-specified information that the verb contains. Consequently, when there is a lexical deficit the information about the thematic structure of the sentence and how it should be expressed syntactically can no longer be obtained through processing of the verb. That is, the individual cannot infer from the sentence "who is doing what to whom." Individuals with a lexical deficit therefore, exhibit poor comprehension and production of even the simplest reversible sentences (Marshall, 1995). Additionally, poor verb comprehension, verb production, and verb argument structure during language production are observed. Alternatively, a procedural deficit is expressed as a sentence processing failure evident only when the arguments are moved from their canonical position (e.g., passive voice sentences). Individuals with a procedural deficit would exhibit some preservation of verb processing, such as relatively uncompromised comprehension and/or production of verbs in isolation.



The results of mapping treatment studies reported to date have been predominantly favorable, however there is a degree of variability with some individuals demonstrating response to treatment and generalization, some individuals only exhibiting response to treatment without generalization to untreated sentences and some who did not appear to demonstrate statistically significant change in performance following the treatment. This variability in treatment outcomes, although observed, have not been yet been accounted for to our knowledge. One of the theories discussed in several studies (Marshall, 1995; Mitchum et al., 2000; Rochon et al., 2000; Schwartz et al., 1994) was that the response to treatment and generalization to untrained sentences following mapping therapy may be dependent upon the type of mapping deficit (lexical versus procedural). This hypothesis, although formulated, has not been empirically tested to our knowledge. The present study has been designed to test this hypothesis.

The first published mapping therapy study was by Jones (1986). Jones carried out a case study with B.B., who was classified as a patient with severe agrammatism. B.B. was 6 years post onset and his verbal output consisted of isolated nouns and automatic phrases such as “I don’t know.” No spontaneous verbs or phrases were observed in his speech pre-treatment. B.B. demonstrated the ability to mark phrase boundaries within written sentences, however his comprehension of even simple subject-verb-object sentences was significantly impaired. For instance, a comprehension task was administered pre-treatment where B.B. had to match spoken subject-verb-object sentences to one of the three pictures (the target, the reversal, and a lexical distractor). He scored 24/60 (40% accuracy), which suggested his interpretation of word order was at chance. He performed similarly on production tasks and was unable to manipulate verbs to achieve sentence structure, even when provided with a verb. B.B., however, had relatively well preserved verb retrieval skills, as indicated by his performance on a verb naming test at

baseline pre-treatment (83% accuracy). During treatment B.B. was instructed to divide written sentences into phrases and mark the verb and its arguments (an agent and a theme). These thematic roles were identified through what and who questions. As the therapy progressed, new roles, goal and location, were added. In its final stages the treatment focused on complex, non-canonical sentences. The therapy was administered three times a week for the duration of 8 months. The study was focused on comprehension only and no verbal sentence production was permitted. The treatment outcomes were impressive. B.B. demonstrated marked improvement in comprehension of both simple and complex non-canonical sentences (77% accuracy).

Additionally, these gains in comprehension reflected in his language production. That is, post-treatment his speech included a variety of verbs and verb phrases. His Cookie Theft picture description pre-treatment consisted of nouns and automatisms only: “girl, boy...eh...don’t know...um...water...don’t know” and so forth. Following treatment marked improvement was observed: “The woman is washing up...and water is flowing over the bowl...on concrete floor and the boy is reaching for cookies and the stool falling down.” The remarkable gains in both production and comprehension were hypothesized to be attributed to improved verb retrieval. Noun production was observed to have improved greatly as well. Nouns are arguments of the verb, the expression of the verb’s thematic roles, therefore the recovery of nouns was likely to have been stimulated by improved verb retrieval (Marshall, 1995).

Several replication studies followed Jones’ study (1986). Le Dorze and colleagues (1991) published the results of their subject, M.G., who was given a shorter, 17-session long version of the Jones’ treatment. M.G. presented with a similar patient profile as did B.B. He had chronic aphasia (14 months post onset), his spontaneous speech output was grammatically and structurally poor and his auditory comprehension was also similarly impaired. It must be noted,

that M.G.'s verb retrieval skills were significantly impaired, unlike B.B.'s. M.G. performed at 42.5% accuracy versus 83% accuracy for B.B. on a verb naming test. Additionally, because M.G. could not read, pictorial representations of agent, verb, and patient were used instead of the written words during the treatment implementation. Therapy outcomes were evaluated using a picture description task with 41 pictures used as therapy stimuli and an additional 10 used as control items. There were also two complex narrative pictures used to further assess M.G.'s performance post treatment. The outcome measures revealed increased production of verbs and verb-noun phrases across treated tasks, whereas noun production remained unchanged. The results were indicative of gains specific to the treatment content. Comprehension was not assessed post treatment. The deviations in the treatment protocol compared to that of Jones' made the interpretation of the obtained results difficult. It is possible to attribute gains in therapy to the use of pictorial representations of the targets as they could have stimulated M.G.'s abilities to conceptualize events. The actual relationships between the agent, verb, and patient, which comprise the core of the mapping therapy, were not targeted in treatment as administered by Le Dorze and colleagues (1991).

Schwartz and colleagues (1994) reported on the outcomes of the implementation of another modified protocol of Jones' (1986) original treatment. They separated the treatment into three phases that lasted for a total duration of up to four months. Each of the six participants was seen three times a week. The first phase introduced action verbs (e.g., "build", "drink", "cook", "hug") presented in canonical sentences. The second phase focused on verbs that referred not to actions, but to states of mind (e.g., "believe", "know", "love", "hate") presented in canonical sentences. The third and final stage went back to the action verbs, however presented them in non-canonical sentences. All of the participants had chronic aphasia (at least 18 months post

onset). They all exhibited symptoms of agrammatism, although one of them demonstrated unimpaired auditory comprehension. G.G. and G.R. both had poor lexical verb retrieval skills at baseline pre-treatment, whereas E.W. was the only participant who had relatively unimpaired lexical verb retrieval skills at baseline. It must be noted that most of the participants were reported to have comorbid language deficits, such as severe anomia and parsing difficulties, which could have contributed to the observed variability in the outcomes. Four out of six patients demonstrated significant improvement, however, considerable variability was observed. For instance, E.W. and G.G. both improved in comprehension and production, however E.W. demonstrated the most progress with comprehension of non-canonical sentences whereas G.G.'s improvement was most notable with simple, action verb utterances. That is, E.W. not only improved on the targeted structures, but also demonstrated generalization of treatment to untreated sentences, whereas G.G.'s gains were treatment specific. Another participant, G.R., who had a similar patient profile to G.G.'s in that he had relatively poor lexical retrieval for verbs, demonstrated similar treatment outcomes to G.G., that is, statistically significant improvement on treated sentences, but no treatment generalization to untreated sentences. I.C. was the participant with apparently the poorest lexical verb retrieval abilities at baseline pre-treatment and he did not demonstrate either response to treatment or generalization of treatment. Furthermore, there was one patient, F.O., who exhibited intact auditory comprehension at baseline and therefore did not necessarily fit the mapping deficit profile, and yet, he demonstrated significant progress following the implementation of the treatment. Schwartz and colleagues (1994) hypothesized that therapy enabled this participant to more efficiently and successfully access and utilize his mapping knowledge to promote the observed gains. This

hypothesis supported the idea that therapy has the capacity to promote more efficient use of residual skills in patients.

Initially, support for the hypothesis that mapping therapy could potentiate residual skills in individuals with agrammatism was provided by the outcomes of a treatment study by Byng (1988). Byng's study (1988) was a comprehension study where three types of verb pairs were targeted. They were reverse direction pairs (e.g., "push" and "pull"), reverse action pairs (e.g., "hit" and "miss"), and reverse role pairs (e.g., "buy" and "sell"). These verb types were selected based on the mapping hypothesis as to distinguish such pairs one would need to access and retrieve the verb's thematic information. Two individuals with non-fluent agrammatic aphasia participated in Byng's study (1988). Both participants presented with non-fluent agrammatic aphasia, however B.R.B.'s lexical retrieval for verbs was relatively unimpaired, whereas J.G.'s verb retrieval abilities were poor. The first participant, B.R.B., demonstrated significant progress following only several weeks of mapping therapy. He performed at 100% accuracy on the target items in both trained and untrained sentences. Additionally, his comprehension of passive verb structures improved significantly. There was also generalization of skills to sentence production. These results led Byng to conclude that B.R.B.'s mapping mechanism was not damaged, but rather non-accessible and the administration of the mapping treatment allowed for B.R.B. to regain access to his mapping mechanism and therefore provide for such rapid and significant progress. Byng's second participant, J.G., presented with more severe deficits, making more reversal errors in both comprehension and production. Additionally, as mentioned earlier, J.G. had more difficulty with verb retrieval even in isolation. Originally, Byng (1988) attempted a slightly modified version of the same protocol with J.G., however six weeks later no progress was observed. Consequently, the mapping treatment was changed to only include action verbs

targeted through a picture description task. The treatment required of J.G. to identify the agent and the theme in an action picture, then select the appropriate labels, and organize them accordingly in their positions within an SVO sentence structure. The thematic role assignment was explicitly explained by the therapist. The treatment was provided for two hours weekly for a duration of three months. J.G. was observed to make progress, however it was not as significant as B.R.B.'s. In J.G.'s case, comprehension improved on treated action verb sentences as well as on treated reverse role verbs. J.G.'s comprehension of passive voice and reversible locatives, however, remained unchanged. Byng argued that J.G.'s general mapping mechanism improved as evident by his progress. That is, J.G. could correctly identify the agent of a verb or an event, which would help him interpret both reversible and non-reversible sentences. The agent-first strategy, however, would not work with locative predicates as they do not fit within a pattern of action verb utterances. J.G.'s poor performance of the passive voice structures (13% correct) supports this hypothesis. Rather, Byng (1988) proposed that these difficulties could be indicative of a parsing mechanism impairment, which would in turn constitute a comorbid deficit that could have impeded the progress and diminished the effectiveness of the mapping therapy. This would be consistent with the results reported by Schwartz and colleagues (1994).

Byng (1991) later replicated the therapy given to J.G. with three participants who presented with chronic aphasia and agrammatism. The results of this study were reported by Byng and colleagues (1994) as well as by Nickels and colleagues (1991). This time the researchers addressed both comprehension and production. They explicitly targeted first comprehension then production of simple reversible S-V-O sentences using a sentence ordering task. Minimally contrastive picture pairs were used as the materials. The cues were withdrawn gradually just as the targets gradually increased in complexity. The thematic roles were explicitly

taught to the participants, similar to the original study by Byng (1988). All three participants had non-fluent agrammatic aphasia and demonstrated poor lexical verb retrieval skills as well as poor comprehension of active sentences with reversible verbs at baseline. Their level of accuracy was below chance across tasks at baseline. Upon mapping treatment completion, all subjects demonstrated improvement in verb naming, however these gains were restricted to trained verbs sentences only. Despite demonstrating response to treatment, none of the participants exhibited generalization of treatment to untreated sentences and tasks.

Marshall and colleagues (1993) reported on a case study of a female patient with chronic aphasia and agrammatism (14 years post onset). This patient, M.M., presented with relatively preserved comprehension of sentences containing non-reversible verbs (i.e., verbs for which subject and object cannot be reversed without losing meaning, e.g., “eat”, “drink”) and poor comprehension of utterances containing reversible verbs (e.g., “push”, “give”). M.M.’s verbal output was significantly impaired. She presented with reduced verb production and practically no functional sentence output. Even though she exhibited relatively preserved comprehension for canonical sentences, M.M.’s production of both non-reversible and reversible sentences and verbs in isolation was severely impaired. She participated in twelve 1-hour therapy sessions where she was explicitly taught to identify the action, the agent, and the theme. The stimuli were two-argument events presented on video, that is, events that comprised of one agent and one theme (e.g., “woman shoots man”). The study was designed as a comprehension only study, however it must be noted M.M. did attempt to describe some of the events during treatment. The therapy resulted in M.M.’s improved ability to describe targeted two-argument pictures, however her narrative production ability did not improve (Marshall, Pring, & Chiat, 1993). No significant gains in sentence comprehension were reported and no generalization to untrained sentence types

was observed. That is, she demonstrated improvement with item-specific sentence structures targeted in the thematic role assignment treatment, but no treatment generalization.

The following year Marshall reported on another case study (Marshall, 1994). Prior to treatment, the participant, P.B., demonstrated good comprehension for active sentences (80% accuracy), but he had difficulty with comprehension and production of even the simplest reversible sentences. Additionally, his verb retrieval abilities were poor (48% accuracy). P.B. was, however, rather fluent in his speech and indeed was able to produce a sentence, although his sentence structure was significantly impaired with incorrect thematic role assignment. For example, the following sentence was produced when describing a picture of a man buying a cat from a woman: “in the shop or pet shop one woman and a cat is buying the man and paying the money the till.” A similar design was employed with the focus, however, being on three-argument verbs (.e.g., “John gives a jumper to Bob”). This study consisted of a comprehension and a production phase and involved color-coded written sentences instead of the video picture presentations. At the end of twelve weeks of therapy sessions there was a significant improvement in both comprehension and production of the targeted sentence types, that is, three-argument sentences. No generalization to other types of sentences, such as two-argument sentences or sentences containing location verbs (e.g., “pour”) was observed for either comprehension or production. Additionally, P.B. demonstrated significant improvement on a narrative production task with both targeted and non-targeted verbs within the treated sentence type. In sum, P.B. demonstrated response to treatment as well as generalization of treatment to untreated sentences within the three-argument sentence type. The results obtained from these two studies led Marshall to suggest that it is possible that particular predicate classes operate as



“linked networks” of verbs with shared properties and that re-gaining access to one network through mapping therapy may not necessarily lead to re-gaining access to the other networks.

In 1998 Fink and colleagues carried out two experiments in an attempt to develop a sentence query mapping therapy protocol that could be used with a range of patients with chronic aphasia and agrammatism in the clinical setting. In Experiment 1 the participants were to identify the action verb, the agent and the theme for each of the sentences read to them aloud in response to queries. In Experiment 2 thematic roles were probed during separate phases, for instance, Phase 1 consisted of queries for the verb and the agent only and each subsequent phase used a different argument query (e.g., theme query alone, agent followed by theme, etc.). The sentence types targeted in both experiments were reversible active sentences, passive voice sentences and object clefts (i.e., “It was the boy who drank the juice”). A total of 7 participants (Experiment 1) and a total of 6 participants (Experiment 2) completed the treatment. All that is known from the published article is that the patients were classified as having chronic aphasia and agrammatism based on Quantitative Production Analysis (Saffran, Berndt, & Schwartz, 1989). No information about participants’ lexical verb retrieval abilities at baseline was provided for either study. Fink and colleagues (1998), however, did provide baseline and post-treatment scores on treated sentences for the participants in the first experiment. Interestingly, all participants in Experiment 1 performed at 65-90% accuracy range on active reversible sentences at baseline, which suggests that they were likely to be in the mild to moderate impairment severity range. The researchers reported that the positive response to treatment was observed across participants with most participants also demonstrating a pattern of generalization to untreated sentences (Marshall, 1995).

Rochon and colleagues (2000) reported on a mapping therapy study they conducted to address sentence production deficits in three individuals with chronic agrammatic aphasia. All three participants demonstrated better comprehension of non-reversible sentences than reversible ones. Additionally, none of them was able to produce non-canonical sentences, while their simple active non-reversible sentence production appeared to be relatively unimpaired. During the treatment phase, they were required to produce sentences when given the cues that probed for the verb, agent, or theme. The therapy addressed the agent cue first and gradually included different sentence types. Two canonical and two non-canonical sentence types were addressed in this treatment. The researchers reported good acquisition of target skills, across-task generalization to some untrained sentence types, narrative structure improvements, as well as generally good maintenance.

A second study was published by Rochon and colleagues (2005) that reported on the results of a similar mapping therapy protocol where production of both canonical and non-canonical reversible sentences was targeted. At baseline all three participants demonstrated rather good grammatical judgment and lexical comprehension abilities and they all performed at zero percent accuracy during non-canonical sentences production task. No measures of the participants' verb retrieval abilities were reported. Two participants, S.M. and Q.O., demonstrated good active sentence comprehension at baseline pre-treatment, while N.S.'s active sentence comprehension was at chance. All three patients exhibited significant improvement on all target sentences, therefore demonstrating a positive response to treatment. Statistically significant generalization to untreated sentences was observed for S.M. and N.S., whereas Q.O.'s results, although approaching statistical significance, did not reach it (16% gain).

In summary, individuals with nonfluent aphasia who participate in mapping therapy treatment tend to demonstrate predominantly positive outcomes, as evident from the current literature review. The results, however, are variable. There are two variants of mapping deficit that are hypothesized to exist. They are the lexical mapping deficit and the procedural mapping deficit (Mitchum et al., 2000). It has been proposed that different therapy outcomes might be expected based on which variant of the mapping deficit an individual with nonfluent aphasia presents with (Marshall, 1995). This hypothesis, although formulated, has not been empirically tested.

The purpose of the present study is to examine existing de-identified archival data to compare individuals with non-fluent aphasia exhibiting signs consistent with a procedural mapping deficit with individuals with non-fluent aphasia exhibiting signs consistent with a lexical mapping deficit following treatment for thematic role assignment in sentence production. The existing data was collected for a previously conducted research project titled “Treatment of Aphasia and Related Disorders: Subproject 3: Contrasting Treatment for Sentence Production Deficits.” The faculty sponsor of the current study’s primary investigator, Dr. Lynn Maher, was the primary investigator for the project. The individuals in the original study participated in both errorful and errorless learning paradigms of a thematic role assignment treatment. The studies reviewed followed a traditional errorful learning paradigm, in which the individual is to produce a response to a stimulus independently and then to be provided with corrective feedback. Application of such a procedure potentially allows for an agrammatic response to be produced prior to an instruction of the correct answer. According to the parallel distributed processing (PDP) models of cognitive function, the connection between the stimuli and responses gets stronger the higher the frequency of stimuli and response association is (Rumelhart &

McClelland, 1986). Consequently, a stronger connection translates into a lower response threshold. Therefore, allowing erroneous or variable associations to occur interferes with the connection and potentially leads to inhibition of correct response from production (Rumelhart & McClelland, 1986). In recent years, however, it has been shown that errorless learning is more effective than errorful learning in the remediation of memory impairments (Fillingham, Hodgson, Sage, & Lambon Ralph, 2006; Wilson, Baddeley, Evans, & Sheil, 1994). Currently, to our knowledge, an errorless learning procedure has not yet been applied to the rehabilitation of sentence production deficits, such as those observed in the individuals with nonfluent aphasia. In the errorless learning procedure the agrammatic response is avoided almost completely by providing the correct response as part of the presented stimulus. Errorless learning has been demonstrated to be equally or more effective than errorful learning in rehabilitation of not only memory impairments but also in naming deficits in aphasia. To avoid a confound of errorful versus errorless learning, only the errorless administration of the treatment was examined for the purposes of the current study (Fillingham et al., 2006; Wilson et al., 1994).

In summary, mapping deficit is hypothesized to be exhibited as an inability to relate sentence form to its meaning, that is, to accurately assign thematic roles to a sentence components (Rochon et al., 2005; Schwartz et al., 1987). The two types of mapping deficit explain two facets, or two stages of one's performance during sentence processing (Mitchum et al., 2000). In a lexical mapping deficit the verb is believed to no longer provide information about its thematic roles due to a loss of lexically-specified information that the verb contains (Byng, 1988; Marshall, 1995; Mitchum et al., 2000; Rochon et al., 2005). In a procedural mapping deficit there is a loss of the rules which assign thematic roles to a moved argument. An individual with nonfluent aphasia who has a lexical mapping deficit is expected to present with

poor comprehension of canonical sentences; poor comprehension and retrieval of verbs in isolation, particularly in sentences where verbs' thematic assignment needs to be considered; and reduced verb production and impaired verb argument structures in sentences (Byng, 1988; Marshall, 1995; Mitchum et al., 2000; Rochon et al., 2005). Consequently, such an individual is expected to exhibit poorer performance on the test of verb retrieval such as verb naming or verb comprehension. An individual with nonfluent aphasia who has a procedural mapping deficit would experience difficulties in both sentence comprehension and production, however typically only in sentences with moved argument structures (Schwartz et al., 1994; Rochon et al., 2005), and verb retrieval on the word and sentence level would not be as significantly impaired compared to when there is a lexical mapping deficit.

The following hypothesis was tested: Response to mapping treatment can be predicted by the presence of a procedural mapping deficit versus a lexical mapping deficit. Specifically:

- 1) Individuals with nonfluent agrammatic aphasia who had a procedural mapping deficit as evidenced by better lexical verb retrieval abilities, i.e., higher lexical verb retrieval scores, would demonstrate a better treatment response, as measured by improvement on sentence production and thematic role assignment on treated sentences, as well as by generalization to untreated sentences following an errorless mapping treatment.
- 2) Individuals with non-fluent agrammatic aphasia who had a lexical mapping deficit as evidenced by poorer lexical verb retrieval abilities, i.e., lower lexical verb retrieval scores, would demonstrate a worse treatment response or no treatment response, as measured by improvement on sentence production and thematic role assignment, as well as no generalization to untreated sentences following an errorless mapping treatment.

### Methods

The current study was an analysis of errorless mapping treatment for sentence production using de-identified archival data collected when the faculty sponsor, Dr. Lynn Maher, was employed at Baylor College of Medicine prior to coming to the University of Houston. The current study was approved by the University of Houston Institutional Review Board (STUDY0000135), and because the current analyses were consistent with the aims of the original study no additional informed consent was needed.

The hypothesis tested was that the individuals with better lexical retrieval abilities had a procedural mapping deficit and therefore were expected to demonstrate better treatment outcomes and generalization of treatment. The individuals with poorer lexical retrieval abilities were hypothesized to have a lexical mapping deficit and therefore were expected to exhibit worse treatment outcomes and poor or no generalization of treatment, since mapping treatment focuses on the procedural assignment of thematic roles.

The subjects were all right-handed adult males and females who had unilateral left hemisphere CVA as confirmed by CT and/or MRI studies. All the participants presented with a predominantly nonfluent, expressive aphasia. All the participants had agrammatism as indicated by their poor performance during the production of passive reversible verb sentences at baseline. The accuracy on this task ranged between 0% and 30% across participants. Non-native English speakers were excluded to avoid interference from the native language during English language tasks. Individuals with a medical history significant for developmental learning disability and/or other neurologic impairments (e.g., Alzheimer disease, Parkinson disease, etc.) were excluded to avoid interference with treatment outcomes attributable to these disorders. Potential subjects who presented with severe sensory deficits (i.e., hearing, vision) were also excluded from the study. A

full speech-language assessment was completed with each participant to determine eligibility for participation in the original study. Additionally, potential participants' medical records and available copies and reprints of brain scans were examined by the researchers. A total of 25 individuals that fit eligibility criteria were selected. Although 25 participants were recruited for the original study, not all of them received the same combination of treatments. 16 subjects received errorless mapping treatment, which was targeted in the current study. One out of 16 subjects was excluded from the current study due to evidence of him being a bilingual English-Spanish speaker, despite the initial screening, to avoid interference from Spanish language during English language tasks.

The original study employed a within subject experimental design in which each subject served as her/his own control. There were three sets of reversible verb sentences used: One set contained sentences treated with errorless mapping, the second set was treated with a different treatment and is not considered in this study, and the third set consisted of untreated sentences as a measure of generalization. A total of 60 sentences were probed daily. The daily probes consisted of both treated and untreated sentences with active and passive syntax.

In each session the participants were presented with pictures of line drawings of actions using reversible verbs. A "map" of the corresponding written versions of the target sentences as well as thematic roles ("who", "is doing", "to whom") were used for the procedure. All the written stimuli were color-coded (agent=blue, action=red, patient=green) and placed above the picture stimuli. Constant time delay (Wolery et al., 1992), a "near errorless procedure," was used in the treatment protocol. During the first stage of the treatment, the task was to repeat the sentence without delay after the SLP indicated the action, agent and patient of the sentence always beginning with the verb and placed corresponding written stimuli in the correct location.

A 5-second delay was introduced once the subject reached 80% accuracy for two consecutive sessions at the immediate repetition stage. The participant was instructed to only produce a response if he or she was certain of it to eliminate error. If the participant could not respond, the above described protocol was repeated. Once the subject reached 80% accuracy for two consecutive sessions at a 5 second delay, delay time was further increased to 15 seconds. Each correct response was repeated consecutively for practice 3 times. Each one of the 15 participants included in the present study participated in a total of 20 treatment sessions. The first eight sessions focused on production of active sentences, the following eight sessions focused on production of passive sentences and the remaining four sessions addressed both sentence types together.

For the present study we further analyzed the outcome data in this group of 15 individuals to determine if there was a relationship between lexical verb retrieval and response to treatment as well as between lexical verb retrieval and generalization of treatment. Two measures were used as the measures of lexical retrieval: the baseline score on the Action Naming Test (ANT) (Oblor & Albert, 1986) and the pre-treatment baseline scores on the comprehension of active sentences on the Circles and Squares Syntactic Comprehension Test (adopted from Schwartz, Saffran, & Martin, 1980). The ANT is a confrontation naming test for verbs that is comprised of picture stimuli that represent simple non-reversible verbs to be labelled in isolation. Consequently, individuals with non-fluent agrammatic aphasia who have a lexical mapping deficit are expected to perform poorly on the ANT due to their significantly impaired comprehension and production of verbs. Individuals with a procedural mapping deficit should perform significantly better on this test as their verb retrieval skills for verbs in isolation are relatively unimpaired. The Circles and Squares Syntactic Comprehension Test (adopted from



Schwartz, Saffran, & Martin, 1980) is a measure of thematic role assignment within a sentence using line drawings of reversible simple sentences (e.g., “The circle kicks the square”). This test requires an individual to assign thematic roles within active and passive reversible sentences, therefore providing information about an individual’s verb processing. It is expected that both the individuals with procedural and lexical mapping deficits will demonstrate relatively poor performance on this test. However, the individuals with a procedural mapping deficit are expected to do worse on test items for which the thematic roles are moved into non-canonical sentences, whereas the individuals with a lexical deficit will do poorly on both canonical and non-canonical verb sentences. Consequently, the participants with better lexical retrieval abilities, that is, those with a procedural mapping deficit, are expected to demonstrate higher scores on the active sentences on Circles and Squares Syntactic Comprehension Test. The participants whose lexical retrieval abilities are significantly impaired, those with a lexical mapping deficit, are expected to receive low scores on the same measure.

These two measures, the ANT (Obler & Albert, 1986) and the Circles and Squares Syntactic Comprehension Test (adopted from Schwartz, Saffran, & Martin, 1980), served as the independent variables for the present study as measures of lexical and procedural mapping. The dependent variable was the response to treatment as determined by sentence production using correct thematic role assignment, consisting of the mean percent correct of active and passive sentences produced in four post-treatment probes. Another dependent variable in the study was the generalization of treatment outcomes as measured by the non-treated sentence production using correct thematic role assignment, consisting of percent correct of active and passive sentences produced in four post-treatment probes. The hypothesis tested was that better lexical verb retrieval would yield a better treatment response, i.e., the higher lexical verb retrieval score

was, the better treatment outcomes were expected. Subsequently, the opposite was expected to be true and the lower the lexical verb retrieval score was, the worse treatment outcomes were expected. The participants with higher lexical verb retrieval abilities were hypothesized to have a procedural mapping deficit and therefore were expected to demonstrate better treatment outcomes and generalization of treatment. The participants with lower lexical verb retrieval abilities were hypothesized to have a lexical mapping deficit and therefore were expected to exhibit poorer treatment outcomes and poor or no generalization of treatment, since mapping treatment focuses on the procedural assignment of thematic roles.

The following questions were posed in order to test the hypothesis:

1. *Was there a statistically significant change in performance from pre-treatment to post-treatment levels for the errorless mapping treatment?*
2. *Was there a statistically significant treatment generalization to untreated sentences from pre-treatment to post-treatment levels for the errorless mapping treatment?*
3. *Are scores on the Action Naming Test and active sentences on Circles and Squares Syntactic Comprehension Test correlated?*
4. *Is there a relationship between response to treatment and verb retrieval, active sentence comprehension, and aphasia severity?*
5. *Is there a relationship between treatment generalization to untreated sentences and verb retrieval, active sentence comprehension, and aphasia severity?*

Several repeated measures statistical analyses were employed to address these questions.

Response to treatment, that is change in mean percent accuracy in sentence production performance from pre-treatment to post-treatment levels, was analyzed using a paired sample *t* test, which is sensitive to change within the same measure. This analysis was necessary to

demonstrate statistically significant improvements in performance on the experimental task, that is, to show that the treatment was effective. Similarly, a paired sample *t* test was also used to analyze generalization of treatment gains to untreated sentences to demonstrate the existence of statistically significant generalization following errorless mapping treatment.

Linear regression was used to determine the strength of the relationship between the independent and dependent variables. Specifically, we used linear regression to explore whether or not the independent variables (pre-treatment baseline scores on the ANT and active sentences of the Circles and Squares Syntactic Comprehension Test) predicted the response to treatment. Additionally, we used linear regression to establish if the same independent variables predicted generalization of treatment to untreated items.

Linear correlation was employed to determine whether or not the independent variables were correlated. That is, whether or not there was a relationship between the ANT score and comprehension of active sentences on the Circles and Squares Test. Additionally the influence of other factors on treatment outcomes was examined. Specifically, overall aphasia severity as determined by the Aphasia Quotient on the Western Aphasia Battery (Kertesz, 1982) (the WAB AQ) was examined. Finally individual participants' profiles were further analyzed to allow for a more in-depth discussion of individual performance.

## Results

The 15 participants included in the current study were right-handed adult males and females who had unilateral left hemisphere CVAs and presented with predominantly non-fluent, chronic, expressive aphasia. All of the participants were monolingual native English speakers with a minimum of 8<sup>th</sup> grade education.

All of the participants presented with predominantly non-fluent agrammatic aphasia. They all demonstrated poor performance during production of passive sentences that contained reversible verbs. The accuracy achieved on this task at baseline ranged between 0% and 30%. The detailed participant characteristics can be found below (Table 1).

*Table 1: Participant Characteristics at Baseline.*

<b>Participants</b>	<b>Age</b>	<b>Gender</b>	<b>Baseline Passive Sentence Production (% correct)</b>	<b>Baseline Action Naming Test Score (% correct)</b>	<b>Baseline Active Sentences on Circles/Squares (% correct)</b>	<b>Baseline AQ on the WAB</b>
1	71	M	0	40.4	70.8	53.7
2	40	M	0	40.4	54.2	47
3	53	M	0.63	40.4	62.5	65.8
4	72	F	30	80.7	95.8	81.9
5	59	F	12.5	80.7	70.8	69.4
6	48	F	0	36.8	41.7	44
7	50	F	0	66.7	83.3	69.6
8	58	M	19.53	93	79.2	85.6
9	40	M	0	84.2	66.7	77.2
10	58	M	0	40.4	62.5	64.8
11	51	F	0.17	43.9	83.3	73.6
12	56	F	0	43.9	58.3	67.9
13	68	M	0	43.9	33.3	57.7
14	61	M	0.13	78.9	50	71.5
15	74	M	0	38.6	70.8	58.8

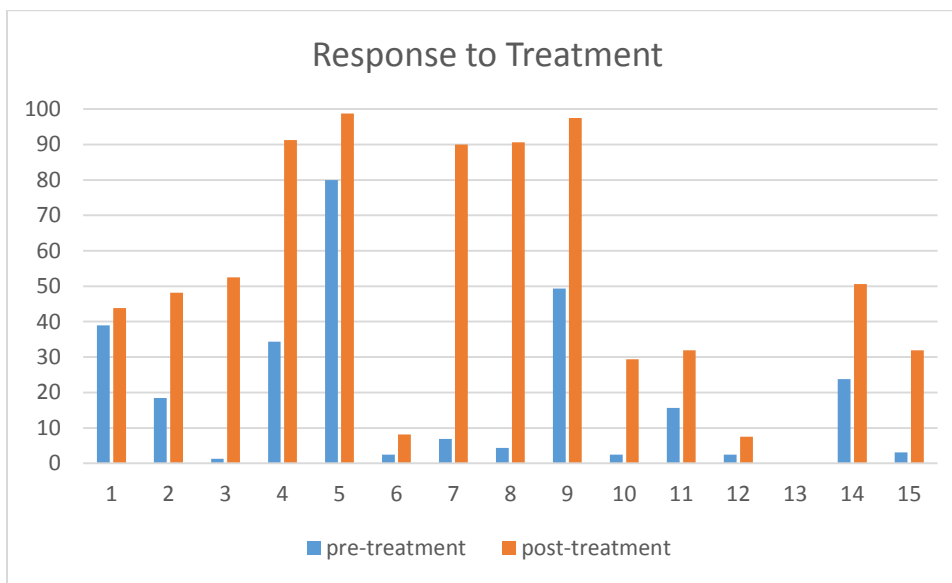
The following questions were answered during data analysis:

1. *Was there a statistically significant change in performance accuracy from pre-treatment to post-treatment for the errorless mapping treatment?*

A paired sample *t* test was used to analyze response to treatment, that is, change in performance from pre- to post-treatment levels. The analysis revealed that there was a significant positive change from pre- to post-treatment for the group,  $t(14)=-4.610$ ,  $p=0.0004$ . The group mean for sentence production using correct thematic role assignment pre-treatment was 18.91

(SD=23.02). The group mean for sentence production using correct thematic role assignment post-treatment was 51.47 (SD=34.58). Given the observed significant change in performance from pre-treatment to post-treatment levels, it is safe to conclude that a positive response to treatment occurred (see Table 2).

*Table 2: Response to Treatment – comparison of mean percent accuracy for pre-treatment baseline (n=8) and post-treatment probe (n=4) for each subject.*

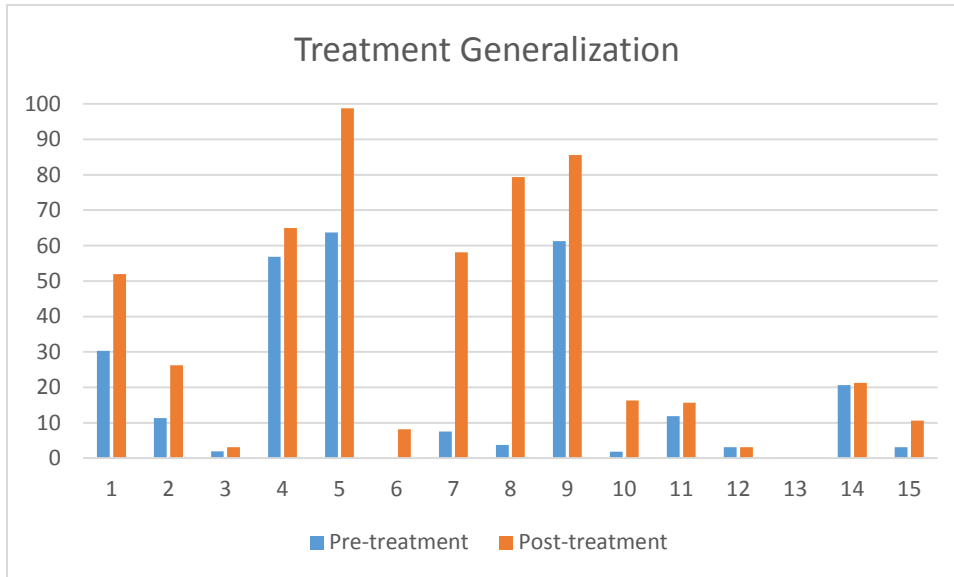


2. *Was there a statistically significant treatment generalization to untreated sentences from pre-treatment to post-treatment levels for the errorless mapping treatment?*

A paired sample *t* test was used to analyze treatment generalization to untreated sentences, that is, change in performance from pre- to post-treatment levels. The analysis revealed that there was a significant positive change from pre- to post-treatment for the group  $t(14)=-3.19$ ,  $p=0.0065$ . The group mean for sentence production using correct thematic role assignment pre-treatment was 18.48 (SD=23.35). The group mean for sentence production using correct thematic role assignment post-treatment was 36.22 (33.66). Given the observed significant change in

performance from pre-treatment to post-treatment levels, it is safe to conclude that a positive response to treatment occurred (see Table 3).

*Table 3: Treatment Generalization to Untreated Sentences – comparison of mean percent accuracy for pre-treatment baseline (n=8) and post-treatment probe (n=4) for each subject.*



3. *Are the Action Naming Test and the active sentences on Circles and Squares Syntactic Comprehension and Production Test correlated? Are these measures correlated with aphasia severity, as indicated by the Aphasia Quotient on the Western Aphasia Battery?*

The analysis revealed the correlation between lexical verb retrieval, as measured by the ANT, and active sentence comprehension was not statistically significant ( $r=0.417$  – see Table 4). A statistically significant correlation was observed between the WAB AQ, which was used as a measure of overall aphasia severity, and the ANT ( $r=0.781$ ) as well as between the WAB AQ and active sentences on the Circles and Squares Syntactic Comprehension and Production Test ( $r=0.653$ ) (See table 4).

*Table 4: Pearson correlation coefficient values – Response to Treatment.*

	<b>Response to Treatment</b>	<b>Baseline ANT Score</b>	<b>Baseline Active Sentences on Circles/Squares Test</b>	<b>Baseline AQ on the WAB</b>
<b>Response to Treatment</b>		.610*	.597*	.618*
<b>Baseline ANT Score</b>			.417	.781*
<b>Baseline Active Sentences on Circles/Squares Test</b>				.653*

\*Correlation is significant at the 0.05 level (2-tailed)

4. *Is there a relationship between response to treatment and verb retrieval, active sentence comprehension and overall aphasia severity?*

The analysis revealed a statistically significant correlation between response to treatment and each of the test measures (see table 4). Subsequently, a linear regression analysis was performed to determine how much variance in response to treatment is explained by these three different measures. The analysis revealed aphasia severity, as determined by the WAB AQ, to have the most predictive value as it accounts for 38.2% of the total variance ( $R^2=.382$ ). A separate linear regression analysis was run for verb retrieval, as measured by the ANT, and active sentence comprehension, as measured by the active sentences on the Circles and Squares Syntactic Comprehension Test, excluding aphasia severity. The two measures together accounted for 51.4% of the variance ( $R^2=.514$ ), however separately their contribution to predicting response to treatment did not reach the level of statistical significance.



5. *Is there a relationship between treatment generalization to untreated sentences and verb retrieval, active sentence comprehension and overall aphasia severity?*

The analysis revealed a statistically significant correlation between the scores on the Action Naming Test and generalization of treatment ( $r=.593$ ,  $p>.05$ ). The obtained value for active sentence comprehension, as determined by the active sentences on the Circles and Squares Syntactic Comprehension and Production Test, did not reach the level of statistical significance ( $r=.476$ ,  $p>.05$ ). Similarly, results were not statistically significant for the aphasia severity as determined by Aphasia Quotient on the Western Aphasia Battery ( $r=.401$ ,  $p>.05$ ). See table 5.

A linear regression analysis was then performed to determine how well these measures predict treatment generalization to untreated sentences. The analysis revealed the Action Naming Test to be the only statistically significant predictor of treatment generalization accounting for 35.1% of variance ( $R^2=.351$ ). Although the results did not reveal active sentences on Circles and Squares Syntactic Comprehension Test to have a strong predictive value for treatment generalization, together with the Action Naming Test they account for 41.4% of the total variance ( $R^2=.414$ ). Aphasia severity, as determined by Aphasia Quotient on the Western Aphasia Battery, was not found to account for a statistically significant amount of variance in treatment generalization.

Table 5: Pearson correlation coefficient values – Treatment Generalization

	<b>Treatment Generalization</b>	<b>Baseline ANT Score</b>	<b>Baseline Active Sentences on Circles/Squares Test</b>	<b>Baseline AQ on the WAB</b>
<b>Treatment Generalization</b>		.593*	.476	.401
<b>Baseline ANT Score</b>			.417	.781*
<b>Baseline Active Sentences on Circles/Squares Test</b>				.653*

\*Correlation is significant at the 0.05 level (2-tailed)

The summary of the individual results for each participant can be found in Table 6.

Table 6: Individual Participant Results.

Participants	Age	Gender	Baseline Passive Sentence Production (% correct)	Baseline Action Naming Test Score (% correct)	Baseline Active Sentences on Circles/Squares (% correct)	Baseline AQ on the WAB	Response to Treatment (% gain)	Treatment Generalization (% gain)
1	71	M	0	40.4	70.8	53.7	4.89	21.75*
2	40	M	0	40.4	54.2	47	29.75*	14.94
3	53	M	0.63	40.4	62.5	65.8	51.25*	1.24
4	72	F	30	80.7	95.8	81.9	56.88*	8.13
5	59	F	12.5	80.7	70.8	69.4	18.75	35*
6	48	F	0	36.8	41.7	44	5.63	8.13
7	50	F	0	66.7	83.3	69.6	83.13*	50.62*
8	58	M	19.53	93	79.2	85.6	86.23*	75.62*
9	40	M	0	84.2	66.7	77.2	48.13*	24.37*
10	58	M	0	40.4	62.5	64.8	26.87*	14.38
11	51	F	0.17	43.9	83.3	73.6	16.25	3.75
12	56	F	0	43.9	58.3	67.9	5	0
13	68	M	0	43.9	33.3	57.7	0	0
14	61	M	0.13	78.9	50	71.5	26.87*	0.63
15	74	M	0	38.6	70.8	58.8	28.75*	7.5

\*Clinically significant change determined as a gain of 20% or higher.

### Discussion

This study was designed to test the hypothesis that some of the variability in the treatment outcomes following a mapping therapy treatment may be attributable to the specific type of a mapping deficit an individual with non-fluent agrammatic aphasia exhibits. The two types of the mapping deficit hypothesized to exist are a lexical mapping deficit and a procedural mapping deficit (Byng, 1988; Mitchum, et al., 2000; Schwartz et al., 1994). An individual with a lexical mapping deficit is believed to demonstrate impaired verb knowledge as the result of the loss of lexically-specified information that the verb contains (Byng, 1988; Marshall, 1995; Mitchum, et al., 2000; Rochon et al., 2005). Such an individual, therefore, demonstrates poor verb comprehension and verb production even in isolation as well as poor comprehension and production of the simplest reversible sentences (Marshall, 1995; Rochon et al., 2005). An individual with a procedural mapping deficit, however, demonstrates some preservation of verb processing, such as relatively good comprehension and/or production of verbs in isolation as well as simple reversible sentences with deficits evident during processing of sentences with moved arguments (Mitchum et al., 2000; Rochon et al., 2005; Schwartz et al., 1994). It has been proposed that different treatment outcomes might be expected based on the type of the mapping deficit an individual with nonfluent aphasia presents with (Byng, 1988; Marshall, 1995; Mitchum et al., 2000; Schwartz et al., 1994). To our knowledge, this hypothesis, although formulated, has not been empirically tested.

This study examined a group of 15 individuals with predominantly non-fluent chronic aphasia who previously participated in errorless mapping treatment. All of the participants had agrammatism as evidenced by their severely impaired production of passive reversible sentences at baseline (0%-30% accuracy range). Based on the existing descriptions of how a lexical and a

procedural mapping deficit are expressed, we proposed that we might be able to differentiate a lexical versus a procedural mapping deficit based on the individual's verb retrieval ability as well as active sentence comprehension. Baseline pre-treatment scores on the Action Naming Test and the performance on the active sentences of the Circles and Squares Syntactic Comprehension Test were used as the measures of verb retrieval and active sentence comprehension respectively. The hypothesis tested was that the individuals with a procedural mapping deficit, as suggested by higher lexical verb retrieval abilities and better active sentence comprehension at baseline, would demonstrate better response to an errorless mapping treatment as well as greater generalization of treatment to untreated sentences. Similarly, the individuals with a lexical mapping deficit, as suggested by lower lexical verb retrieval abilities and poor active sentence comprehension, would demonstrate poorer response to errorless mapping treatment as well as limited if any generalization of treatment to untreated sentences. Mapping therapy is a sentence level treatment program that aims at strengthening the connection between sentence meaning and sentence structure (Fink, 2001). Mapping therapy is a procedural treatment that addresses sentence processing deficits of agrammatism by explicitly re-teaching thematic role assignment procedure within a sentence. Mapping therapy was designed to address the procedural deficits of thematic role assignment and therefore we expected the individuals with a procedural mapping deficit to demonstrate better treatment response and generalization to untreated sentences.

The results of the present study revealed that there was no statistically significant correlation between the ANT and active sentences on the Circles and Squares Syntactic Comprehension Test ( $r=.417$ ,  $p<.05$ ). These findings indicate that the ANT and active sentences on the Circles and Squares Syntactic Comprehension Test are independent of each other, or at least are measuring different aspects of sentence processing. That is, they are not testing the

same skills. Considering these measures and their purpose provides us with further support of this finding. The ANT is a confrontation naming test for simple non-reversible verbs in isolation whereas the Circles and Squares Syntactic Comprehension Test is a measure of thematic role assignment within a sentence. Essentially, these measures test two separate stages of verb processing, that is, to process a verb within a sentence one has to first retrieve the verb and then to be able to assign thematic roles based on the retrieved verb. Consequently, the ANT allows us to identify the degree of lexical verb retrieval impairment in an individual, whereas the active sentences on the Circles and Squares Syntactic Comprehension Test provide us with the information about an individual's ability to comprehend simple canonical reversible sentences. An individual who has poor lexical retrieval skills for verbs would exhibit difficulties with their comprehension of simple reversible sentences, whereas someone who has less impaired lexical verb retrieval abilities should be able to process simple reversible verbs within canonical sentences and therefore exhibit better performance on the active sentences of the Circles and Squares Syntactic Comprehension Test.

Our findings also indicated that both the ANT and the active sentences on the Circles and Squares Syntactic Comprehension Test were significantly correlated with the overall aphasia severity as determined by the Aphasia Quotient on the WAB. These results suggest that there is a strong relationship between each of these measures separately and the WAB AQ. The WAB is a standardized assessment designed to test linguistic and some non-linguistic skills of adults with aphasia (Kertesz, 1982). The AQ is the combined score on the WAB that indicates overall severity of aphasia across language domains. Given that both the ANT and the active sentences on the Circles and Squares Syntactic Comprehension Test examine an aspect of linguistic impairment in aphasia, the observed correlation between the WAB AQ and the ANT as well as

between the WAB AQ and the active sentences on the Circles and Squares Syntactic Comprehension Test is a rather logical and expected finding.

With respect to the relationship between response to treatment and the ANT, the active sentences on the Circles and Squares Syntactic Comprehension Test and the WAB AQ, our results suggest that there is a statistically significant correlation between response to treatment and each one of these three measures. However, when a linear regression analysis was performed including three tests, only the WAB AQ was revealed to be a statistically significant predictor of response to treatment accounting for 38.2% of the total variance in participants' response to treatment. What these findings suggest is that overall aphasia severity is the main predictor of treatment outcomes for the subjects in the current study. These findings are consistent with the current literature as aphasia severity has long been considered one of the strongest predictors of language outcomes for individuals with aphasia (Plowman, Hentz, & Ellis, 2011). For instance, Pedersen and colleagues (2004) found that language outcomes for individuals following a CVA could be predicted by initial stroke and aphasia severity, but not other factors such as age, gender or aphasia type. They used the WAB AQ as the measure of aphasia severity and their study included 270 aphasia patients. Similarly, Laska and colleagues (2001) found that patients with milder aphasia tended to have higher degree of aphasia recovery compared to those with more severe aphasia. In several treatment studies designed to address deficits in different language areas in individuals with non-fluent aphasia, a relationship was found between overall aphasia severity and treatment outcomes for chronic aphasia (Cherney, 2010; Lee, Kaye, & Cherney, 2009). For instance, Lee and colleagues (2009) found chronic aphasia severity to be negatively correlated with amount of treatment, that is, the more severe the aphasia was in chronic phase, the more practice during treatment the individuals needed to demonstrate response to treatment.

Their results also revealed that the more treatment the individuals with severe chronic aphasia received, the more improvement they demonstrated. Specifically, the number of words the individuals were able to retrieve increased as the duration of treatment increased. This was not true for less severe participants in the reported study as the improvement in content was not found to increase as the duration of treatment was increased. Cherney (2010) found treatment outcomes to be modality-specific based on aphasia severity for individuals with chronic non-fluent aphasia following Oral Reading for Language in Aphasia (ORLA) treatment. Specifically, she found participants with severe aphasia to be the only group of participants based on severity who demonstrated improvement in reading following treatment, as measured by the WAB reading scores (Cherney, 2010). Participants with mild aphasia in this study were the only group to demonstrate a positive change in writing, whereas a positive change in discourse following treatment was observed for both mild and mild to moderate aphasia severity groups (Cherney, 2010). These findings suggest that overall aphasia severity remains a significant factor affecting response to treatment even in the chronic phase. Our results are consistent with this finding. However, severity alone does not explain the differences across treatment studies, and may mask other factors that can assist in selecting the best candidates for a specific intervention such as mapping treatment.

Subsequently, when the WAB AQ was removed from the regression we found that together the ANT and the active sentences on the Circles and Squares Syntactic Comprehension Test accounted for 51.4% of the variance, which was significant whereas separately their contribution to predicting response to treatment did not reach the level of statistical significance. These findings suggest that the WAB AQ, being the strongest predictor of aphasia recovery, masks the contribution of both the ANT and the active sentences on the Circles and Squares

Syntactic Comprehension Test as predictors of response to treatment. However, once the WAB AQ was removed, we saw that these two measures accounted for a significant amount of variance in participants' response to treatment (51.4%). These results support our hypothesis that the individuals with a procedural mapping deficit, as suggested by a higher lexical verb retrieval abilities and better active sentence comprehension at baseline, indeed exhibit better response to errorless mapping treatment. Similarly, the individuals with a lexical mapping deficit, as suggested by lower lexical verb retrieval abilities and poorer active sentence comprehension, tended to exhibit poorer response to treatment. These findings suggest that while neither measure of sentence processing alone should be used alone, together verb retrieval and active sentence comprehension are important skills an individual with chronic non-fluent aphasia need to have to demonstrate a positive response to thematic role assignment treatment.

With respect to generalization of treatment gains, a statistically significant correlation between the ANT and generalization of treatment to untreated sentences was found. No such correlation was found between the active sentences on the Circles and Squares Syntactic Comprehension Test and treatment generalization ( $r=.476$ ,  $p<.05$ ) as well as between the WAB AQ and treatment generalization ( $r=.401$ ,  $p<.05$ ). Furthermore, linear regression analysis performed for all three measures revealed the ANT to be the only statistically significant predictor of treatment generalization accounting for 35.1% of the total variance. These results support our hypothesis that the individuals with higher lexical verb retrieval abilities would demonstrate generalization of treatment to untreated sentences, whereas those with lower lexical verb retrieval abilities would not.

Mapping treatment is a procedural treatment because it explicitly addresses the deficit of impaired thematic role assignment within a sentence. An individual who has poor lexical verb



retrieval skills, that is someone with a lexical mapping deficit, has a difficulty with accessing the lexical representation of the verb. If one cannot retrieve the verb, then he or she would not be able to further process it within a sentence on either comprehension or production level. Inability to process a verb within a sentence is expressed as the inability to assign thematic roles to sentence components (Marshall, 1995). Therefore, if an individual with a lexical mapping deficit participated in mapping treatment, although possibly demonstrating response to treatment on the trained items, he or she would not be likely to exhibit generalization of treatment to untreated sentences due to having difficulty with the first step of the verb processing within a sentence, that is, verb retrieval. The gains an individual with a lexical mapping deficit may demonstrate would be treatment specific, that is, an individual would get better at retrieving the specific verbs, likely due to repeated practice. However, someone with a procedural mapping deficit is someone who has relatively high lexical verb retrieval skills, which means he or she is able to access lexical representation of the verb in order to retrieve the verb for further processing. The individuals with a procedural mapping deficit can therefore not only demonstrate response to treatment on the treated items but also re-learn to process thematic roles associated with untreated verbs due to the fact that they are able to retrieve the verb in the first place. He or she is therefore also able to demonstrate a mildly impaired performance pattern on a task that probes comprehension of simple reversible sentences. An individual who has substantially impaired lexical retrieval skills, as supported by our results, performs at chance or worse on the same task, which means he or she cannot accurately process the verb within even a simple reversible sentence due to the underlying deficit being impaired lexical verb retrieval. Our findings suggest that although active sentences on the Circles and Squares Syntactic Comprehension Test do not have a strong predictive value for treatment generalization, together with the ANT they account

for 41.4% of the total variance in the participants' generalization to treatment, that is, active sentence comprehension is a contributor to predicting treatment generalization to untreated sentences following errorless mapping treatment.

Our results indicate, as mentioned earlier, that aphasia severity, although being a predictor of response to treatment, is not a statistically significant predictor of treatment generalization. The WAB AQ is an overall measure of aphasia severity and as discussed earlier it has been previously found to be a significant predictor of aphasia recovery, which is supported by our findings. Being an overall severity measure, however, the WAB AQ measures a variety of language abilities such as fluency, auditory comprehension, repetition, reading, word finding, writing, information content and naming among others (Kertesz, 1982). Although response to treatment is correlated with the WAB AQ, that is, with aphasia severity, the WAB AQ may be too broad of a measure to explain treatment generalization for mapping treatment that is designed as a sentence level procedural mapping treatment aimed at rehabilitation of thematic role assignment. Consequently, the WAB AQ as a measure of overall aphasia severity cannot fully capture the changes in the procedural processing that result in improved sentence production. Further examination of treatment generalization is required in order to find out what other factors contribute to treatment generalization to untreated sentences. Our findings suggest the aphasia severity is not one of these factors whereas verb retrieval is.

The results of the previous studies suggest that there is a relationship between lexical verb retrieval and the use of verbs for sentence production (Mitchum et al., 2000). Particularly, the results of some studies suggest that verb retrieval ability is correlated with response to treatment, which is supported by our findings (Mitchum & Berndt, 1992; Mitchum, Haendiges, & Berndt, 1993). However, the findings regarding the relationship between verb retrieval and

treatment generalization to untreated sentences have been inconsistent (Marshall, 1995). Carragher and colleagues (2013) reported on results of a verb retrieval therapy for 9 participants with non-fluent aphasia. They found that the participants with the highest scores on baseline verb retrieval exhibited significant generalization of treatment to untreated verbs immediately following therapy as well as during follow-up assessment 4 weeks later. Our findings are consistent with the findings of Carragher and colleagues (2013). It must be noted, however, that the studies that have examined the relationship between verb retrieval and treatment generalization used a variety of treatments. For instance, Mitchum and colleagues (2000) suggested that treatment generalization might be dependent on whether or not verb retrieval treatment employed explicit structural training, that is, whether or not verb retrieval was addressed within the context of a sentence. Mapping treatment specifically addresses sentence level deficits within the framework of explicit structural training as it focuses on retraining thematic role assignment of sentence components. Our results provide preliminary data suggesting that lexical verb retrieval skills are in fact a significant predictor of treatment generalization to untrained sentences following errorless mapping treatment.

While group data is important, it is also necessary to look at the individual participants for people whose outcomes are consistent and those whose outcomes are inconsistent with the group data. Examination of the individual data revealed that one of the participants, participant 2, demonstrated an unusual pattern of performance. He was a 40-year-old male who had the WAB AQ of 47 and also a relatively low ANT score of 23/57. Additionally, he performed nearly at chance on the active sentences of Circles and Squares Syntactic Comprehension Test obtaining a score of 13/24. He also demonstrated a strong left-to-right bias (9/12) and poor accuracy on right-to-left sentences (4/12). Despite this participant exhibiting poor lexical retrieval skills

according to both measures as well as having overall severe aphasia as determined by his AQ, he did demonstrate both a positive response to treatment (29.75% gain) as well as treatment generalization to untreated sentences (14.94% gain). Saffran and Schwartz (1988) argued that such gains would not be possible for someone with such poor lexical retrieval abilities. Marshall (1995), however, proposed that it is possible for lexical representations of verbs to be damaged but not completely deleted, which would account for someone presenting with a lexical mapping deficit but having lexical representations of verbs re-activated as a result of participation in a treatment aimed at restoring retrieval of verbs' thematic properties. Essentially, if that was the case one could conclude that this person has a procedural mapping deficit and not a lexical one due to the fact that he was able to regain access to verbs and perform verb retrieval for correct thematic role assignment following the treatment.

Participant 4 was another individual whose outcomes were inconsistent with the group data. She was a 72-year old female who had relatively good verb retrieval skills (the ANT score of 46/57) and good active sentence comprehension at baseline pre-treatment (23/24 correct on the active sentences of Circles and Squares Syntactic Comprehension Test). Her WAB AQ at baseline was 81.9, which indicates her aphasia was in the mild to moderate severity range. Participant 4, therefore, presented as someone with a procedural mapping deficit. She demonstrated a positive response to treatment (56.88% gain), however no meaningful positive treatment generalization to untreated sentences was observed (8.13% gain). This pattern of treatment outcomes is inconsistent with what is expected of an individual with a procedural mapping deficit due to the fact that no statistically significant generalization to untreated sentences occurred. Fink and colleagues (1998) suggested that increasing treatment duration for an individual with chronic non-fluent aphasia who presents with a procedural mapping deficit

but demonstrates no treatment generalization may result in significant improvement in performance. They found that one of their participants did not demonstrate any gains initially, however once given additional 4 treatment sessions his performance improved substantially (Fink et al., 1998). Additionally, Lee and colleagues (2009) found that individuals with severe chronic non-fluent aphasia demonstrated additional gains with increased treatment duration (Lee et al., 2009). Although participant 4 did not have severe aphasia and was in the mild to moderate severity range (WAB AQ of 81.9), she could have demonstrated more significant treatment generalization to untreated sentences than she did (8.13% gain), if provided with a longer treatment, similarly to the one participant in the study by Fink and colleagues (1998).

Participant 14 was a 61-year old male who at baseline pre-treatment demonstrated relatively good verb retrieval skills as indicated by his ANT score of 45/57. His WAB AQ was 71.5, which indicates his overall aphasia severity was in the mild to moderate range. His active sentence comprehension was significantly impaired, however, with him performing at chance on the active sentences of the Circles and Squares Syntactic Comprehension Test. He demonstrated a positive response to treatment (26.87% gain), but no positive treatment generalization to untreated sentences occurred (0.63% gain). As discussed earlier, although verb retrieval alone was the only statistically significant predictor of treatment generalization, when verb retrieval and active sentence comprehension are combined, together they account for more variability in observed generalization of treatment to untreated sentences. These two measures, verb retrieval and active sentence comprehension, were found to not be correlated and to be independent of each other. In the case of participant 14, it is possible that it is active sentence comprehension that is most predictive of treatment generalization. That is, although his ability to retrieve verbs was relatively good, he demonstrated poor active sentence comprehension and therefore no

generalization to untreated sentences was observed post-treatment. Consequently, it is possible that participant 14 had a lexical mapping deficit and therefore he demonstrated only a positive response to treatment in the absence of treatment generalization, as would be expected of someone with a lexical mapping deficit.

To further examine our hypothesis, we retrospectively analyzed the profiles of the participants from the mapping treatment studies reviewed in chapter 1. We looked at the participants' verb retrieval abilities as well as their active sentence comprehension, whenever such information was available from the studies' data, and classified them as having a lexical or a procedural mapping deficit, based on these data. Additionally, a summary of treatment outcomes is also provided in our analysis. The individual data from the reviewed studies is offered below in table 7. It must be noted, our definition of verb retrieval and active sentence comprehension as "good", "relatively good", "poor" and "relatively poor" was based on how it was described in the original studies. Not all of the studies reviewed reported actual baseline scores for their participants and often provided descriptive summaries of the participants' pre-treatment performance instead. None of the authors of the studies reviewed, with the exception of Marshall (1993, 1994), actually classified their participants as having a lexical or a procedural mapping deficit. Instead, all of the participants were diagnosed with a general mapping deficit.

*Table 7: Summary of the Retrospective Analysis.*

<b>Subject</b>	<b>Study</b>	<b>Verb Retrieval</b>	<b>Active Sentence Comprehension</b>	<b>Retrospective diagnosis: Lexical or Procedural Mapping Deficit</b>	<b>Response to Treatment</b>	<b>Generalization to Untreated Sentences</b>
B.B.	Jones (1986)	good (83% accuracy)	poor	procedural	yes	yes
M.G.	Le Dorze (1991)	relatively poor (43% accuracy)	poor	lexical	yes	no
G.R.	Schwartz et al. (1994)	poor	good	lexical	yes	no
G.G.	Schwartz et al. (1994)	poor	poor (at chance)	lexical	yes	no
E.W.	Schwartz et al. (1994)	good	relatively good	procedural	yes	yes
I.C.	Schwartz et al. (1994)	poor (severe impairment)	relatively poor	lexical	no	no
F.O.	Schwartz et al. (1994)	good	intact	N/A (does not fit a mapping deficit profile)	yes	yes
B.R.B.	Byng (1988)	good	good	procedural	yes	yes
J.C.	Byng (1988)	poor	poor	lexical	yes	no
A.E.R.	Byng et al. (1994)	poor	poor	lexical	yes	no
E.M.	Byng et al. (1994)	poor	poor	lexical	yes	no
L.C.	Byng et al. (1994)	poor	poor	lexical	yes	no
M.M.	Marshall et al. (1993)	poor (severe impairment)	relatively good	lexical	yes	no
P.B.	Marshall (1994)	poor (48% accuracy)	poor	lexical	yes	yes, but limited to a trained class of three-argument sentences
group 1 7 subjects	Fink et al. (1998)	N/A	good	N/A (not enough information provided)	yes – across participants	variable results – mostly yes
group 2 6 subjects	Fink et al. (1998)	N/A	N/A	N/A (not enough information provided)	yes	no

<b>Subject</b>	<b>Study</b>	<b>Verb Retrieval</b>	<b>Active Sentence Comprehension</b>	<b>Retrospective diagnosis: Lexical or Procedural Mapping Deficit</b>	<b>Response to Treatment</b>	<b>Generalization to Untreated Sentences</b>
3 subjects	Rochon et al. (2000)	N/A	N/A	N/A (not enough information provided)	yes	yes
S.M.	Rochon et al. (2005)	N/A	good	N/A (not enough information provided)	yes	yes
Q.O.	Rochon et al. (2005)	N/A	good	N/A (not enough information provided)	yes	no (approaching significance at 16% gain)
N.S.	Rochon et al. (2005)	N/A	poor	N/A (not enough information provided)	yes	yes

B.B. was the first known individual with non-fluent agrammatic aphasia to be diagnosed with a mapping deficit and to participate in a mapping treatment study (Jones, 1986). As discussed in the first chapter, B.B. demonstrated remarkable response to treatment that generalized across language domains. B.R.B. (Byng, 1988) was also one of the first mapping treatment study participants and he also demonstrated impressive gains with treatment generalization evident not only from the analysis of his production of untreated sentences, but also from his discourse analysis. Byng (1988) stated B.R.B. had poor lexical abilities, despite him having good verb retrieval and good active sentence comprehension. She did not, however, label B.R.B. as having a lexical mapping deficit. Schwartz and colleagues (1994) discussed both B.R.B. and B.B. and suggested they believed both of these participants demonstrated deficits consistent with a procedural mapping deficit, which we also believe to be true. Marshall (1995) supported Schwartz and colleagues (1994) in their conclusion regarding B.B. suggesting that if his lexical representations were damaged but not completely deleted, then the treatment aimed at restoring retrieval of verbs' thematic properties could have produced such activation



and treatment generalization (Marshall, 1995). That is, Marshall (1995) suggested that the lexically-specified information that the verbs contain was not lost, as is hypothesized to be in the case of a lexical mapping deficit, but rather inaccessible in B.B.'s case. If the lexical representations of verbs were inaccessible but not lost, a mapping treatment, being a semantic level treatment, could have promoted re-activation of lexical verb retrieval and therefore allowed for such favorable treatment outcomes to occur (Marshall, 1995). If that indeed was the case, it would be more accurate to classify B.B. as having a procedural mapping deficit, rather than a lexical mapping deficit.

B.R.B., unlike B.B., had both good verb retrieval abilities and good active sentence comprehension, which would suggest he had a procedural mapping deficit. The other participant in Byng's study (1988) was J.C., who presented with poor verb retrieval abilities and poor active sentence comprehension, which led us to conclude J.C. had a lexical mapping deficit. The results of the study were consistent with what would be expected of an individual with a lexical mapping deficit, that is, J.C. had a positive response to treatment, however no generalization to untreated sentences. The three participants in the study conducted by Byng and colleagues (1994) all presented with similar profiles to J.C.'s, consisted with a lexical mapping deficit. Furthermore, their treatment outcomes were the same as J.C.'s.

Interestingly, although Byng (1988, 1994) never used the terms lexical or procedural mapping deficit, she did comment on her participants as having good or poor verb retrieval skills. She also concluded (Byng et al., 1994) that it was those individuals with good verb retrieval, like B.R.B., who would benefit the most from a mapping treatment. Similarly to Byng and colleagues (1994), Schwartz and colleagues (1994) concluded that the more pure agrammatism is, the better treatment outcomes following a mapping treatment should be

expected. Schwartz and colleagues (1994) also stated that verb retrieval is central to the purity of agrammatic deficits.

Although Schwartz and colleagues (1994) provided a discussion on the two variants of the mapping deficit in the introduction to their study, they did not classify their participants as having a lexical or procedural mapping deficit. G.G. and G.R. had very similar profiles consistent with a lexical mapping deficit, based on their poor verb retrieval abilities. They both demonstrated a pattern of response to treatment and no generalization to untreated sentences, as would be expected of the individuals with a mapping deficit. I.C. also presented with a profile consistent with a lexical mapping deficit, however he did not demonstrate response to treatment or generalization. It must be noted that I.C. was described as the participant with severely impaired verb retrieval and his active sentence comprehension was also relatively poor. Consequently, it is possible that those individuals who present with severe verb retrieval deficits and poor active sentence comprehension are unable to benefit from the mapping treatment due to severity of deficits. It is also possible that I.C. needed a treatment of longer duration to benefit from it, as suggested by Fink and colleagues (1998). E.W. presented with a procedural mapping deficit profile and she indeed demonstrated remarkable gains following treatment. Not only she exhibited generalization to untreated sentences, E.W. also showed improvement in the areas of reading, naming and function word production. Marshall (1995) argued that these outcomes were outside of the mapping therapy hypothesis, however, assuming E.W. had a procedural mapping deficit, re-learning the rules of thematic role assignment could have, in theory, allowed for such a significant improvement across skills. Finally, F.O. was the only participant in the study who did not necessarily fit mapping deficit hypothesis profile, despite of being an individual with non-fluent aphasia. He demonstrated good verb retrieval and intact active sentence comprehension at

baseline pre-treatment. He, however, demonstrated a positive response to treatment and treatment generalization to untreated sentences. This led Schwartz and colleagues (1994) to hypothesize that mapping therapy enabled F.O. to more efficiently and successfully access and use his mapping knowledge, which resulted in significant gains following the treatment. This hypothesis provided support for the idea that therapy has the capacity to promote more efficient use of residual skills in patients.

M.G., the participant in Le Dorze's case study (1991), presented with relatively poor verb retrieval skills and also poor active sentence comprehension, which led us to conclude M.G. had a lexical mapping deficit. M.G.'s treatment outcomes were what one would expect from an individual with a lexical mapping deficit, that is, a positive response to treatment, however no treatment generalization to untreated sentences.

As reported by Marshall and colleagues (1993), and evident from the patient's profile, M.M.'s symptoms appeared to be consistent with a lexical mapping deficit. Even though she exhibited rather preserved comprehension for canonical sentences, M.M.'s production of both non-reversible and reversible sentences and verbs in isolation was severely impaired, which is atypical of someone with a procedural mapping deficit. The therapy outcomes observed for M.M. appear to be consistent with the expected outcomes of a patient with a lexical mapping deficit. That is, she demonstrated improvement with item-specific sentence structures targeted in the thematic role assignment treatment. On the other hand P.B., the participant in the other case study reported by Marshall (1994), presented with poor verb retrieval skills and poor active sentence comprehension, consistent with a lexical mapping deficit. P.B.'s treatment outcomes are also consistent with his lexical mapping deficit profile as his treatment outcomes were specific to the treatment content.

Although treatment outcomes were reported for the participants in the studies conducted by Fink and colleagues (1998), Rochon and colleagues (2000) and Rochon and colleagues (2005), no information was provided regarding these participants' verb retrieval abilities so it is not possible to classify these individuals as having either a lexical or a procedural mapping deficit. All of these participants were observed to demonstrate a positive response to treatment, however the available information on some of the participants' active sentence comprehension did not appear to predict generalization of treatment to untreated sentences. This is consistent with the results of our study as we found that active sentence comprehension alone does not predict generalization of treatment. The data on the participants' verb retrieval is needed to be able to make treatment generalization predications.

Further examination of the contribution of active sentence comprehension to predicting treatment generalization following a mapping treatment is needed. Particularly, the contribution of left to right bias during sentence processing to prediction of response to treatment and treatment generalization needs to be examined. It is typical for an individual with a mapping deficit to use a temporal-spatial strategy during sentence processing. That is, when an individual cannot infer information about thematic role assignment from semantic cues, he or she then will tend to exhibit a strong left to right bias in assigning thematic roles (Maher, Chatterjee, Rothi, & Heilman, 1995). It is expected that individuals with a lexical mapping deficit and individuals with a procedural mapping deficit would exhibit a strong left to right bias, however it is unknown what is the contribution of the left to right bias as exhibited during an active sentence comprehension task to predicting response to treatment and treatment generalization to untreated sentences following a mapping treatment.

As discussed earlier, duration of treatment was found to be correlated with aphasia severity (Lee et al., 2009) as well as with response to treatment and generalization (Fink et al., 1998). It is possible that given more treatment sessions, individuals who present with a lexical mapping deficit might exhibit even better response to treatment, as was the case of the study of ORLA treatment for subjects with chronic non-fluent aphasia by Lee and colleagues (2009). It is also possible that given more treatment sessions individuals who present with a procedural mapping deficit might demonstrate better generalization to untreated sentences, as in the case of the participant Fink and colleagues reported on (1998). More research is needed to test this hypothesis and determine if indeed duration can affect response to mapping treatment and generalization to untreated sentences for individuals with chronic non-fluent aphasia and lexical or procedural mapping deficit.

The results of our study suggest that it is the individual with chronic non-fluent aphasia who has a procedural mapping deficit that would demonstrate both response to treatment and generalization to untreated sentences. That is, someone who has relatively good verb retrieval abilities will exhibit better treatment outcomes following participation in a mapping treatment. Schwartz and colleagues (1994) suggested that an ideal candidate for mapping therapy is an individual with relatively pure agrammatism, that is, someone who has good verb retrieval abilities. Our findings support this hypothesis as our group results showed verb retrieval to be a significant predictor of treatment generalization to untreated sentences. It must be noted, however, that a verb retrieval deficit has been shown to be best addressed within a treatment that uses tasks that involve at least some degree of sentence-level information (Mitchum et al., 2000). Therefore even though individuals with a lexical mapping deficit do not tend to exhibit generalization of treatment to untreated sentences after participating in a mapping treatment, they

still benefit from it as they demonstrate statistically significant improvement on treated structures, as supported by our findings.

The current study employed errorless mapping treatment, therefore a contribution of error to treatment outcomes needs to be examined. To our knowledge, the majority of mapping therapy studies to date employed a traditional errorful learning paradigm, which means a participant was to produce a response independently and if the response was incorrect, corrective feedback was then provided. Such a paradigm allows for agrammatic response to be produced prior to instruction of the correct response. However, according to the parallel distributed processing models of cognitive function, the higher the frequency of association between a stimulus and a response, the stronger the connection between them gets (Rumelhart & McClelland, 1986). Consequently, the stronger the connection between a stimulus and a response, the faster the response is generated. If an erroneous response is reinforced, it begins to interfere with a correct response leading to decreased accuracy of response (Rumelhart & McClelland, 1986). In the errorless learning procedure the incorrect response is avoided completely by providing the correct response as a part of the presented stimulus. Implementation of errorless learning has been demonstrated to be equally or more effective than implementation of errorful learning in rehabilitation of memory impairments as well as some aphasia associated deficits, such as anomia (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003; Fillingham et al., 2006; Wilson et al., 1994). Given that the current study applied errorless learning paradigm to mapping treatment, it is possible that the removal of error in itself contributed to observed positive response to treatment and treatment generalization to untreated sentences. The role of error in mapping treatment as well as its influence on treatment outcomes needs to be further examined in the future.

As evident from the results of our study we have found that aphasia severity is a contributing factor when determining whether or not an individual with non-fluent agrammatic aphasia is going to respond to errorless mapping treatment. We have not found aphasia severity to be a factor predicting generalization of treatment to untreated sentences, as previously discussed. When considering other possible contributing factors to observed response to treatment as well as generalization we determined that spontaneous recovery cannot be a contributing factor due to the fact that all of the individuals who participated in the current study has chronic aphasia, at least 1 year post onset and with stable pre-treatment baselines. When considering age of the individuals with aphasia, the results of previous studies that examined aphasia prognosis suggest that age is a poor prognostic indicator of aphasia recovery (Pederson et al., 2004; Plowman et al., 2011). Treatment duration is a possible factor that might affect response to treatment in individuals with a lexical mapping deficit and treatment generalization to untreated sentences in individuals with a procedural mapping deficit (Fink et al., 1998; (Lee et al., 2009), however this hypothesis was not addressed in the current study and needs to be examined in the subsequent mapping treatment studies. Our findings suggest that individuals with a procedural mapping deficit show generalization of treatment to untreated sentences whereas individuals with a lexical mapping deficit do not. These findings are supported by the findings of Schwartz and colleagues (1994) who proposed that individuals with relatively pure agrammatism, that is relatively good verb retrieval abilities, are the best candidates for mapping treatment. We do believe, however, that individuals with a lexical mapping deficit also benefit from mapping treatment as they show improvement in verb retrieval and current literature suggests that verb retrieval is best addressed in a sentence-level treatment (Mitchum et al., 2000). Furthermore, current treatment was conducted within errorless learning paradigm, unlike the rest

of the mapping treatment studies reviewed. The removal of error could have had a significant effect on both response to treatment and treatment generalization to untreated sentences. We are unable to determine if that indeed occurred due to error not being a focus of the present study, however, the role of error in mapping treatment needs to be examined in the future.

The outcomes of this study have significant implications for identifying those individuals with non-fluent agrammatic aphasia who may potentially benefit the most from an errorless mapping treatment. Consequently, the outcomes of this research provide an important contribution to the field of speech-language pathology and have significant implications for clinicians that provide aphasia rehabilitation services as well as for people with non-fluent agrammatic aphasia.



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