THE EFFECT OF CONSTRAINT-INDUCED APHASIA THERAPY ON NAMING AND DISCOURSE IN INDIVIDUALS WITH APHASIA

by

JESSICA DAWN RICHARDSON

(Under the Direction of Anne Bothe and Rebecca Shisler Marshall)

ABSTRACT

Participation in aphasia therapy generally results in positive outcomes. Constraint-induced aphasia therapy (CIAT) researchers in particular make bold claims about the efficacy of the approach, but pervasive methodological problems throughout the literature detract from the impact of those claims. The study reported in this dissertation was designed to determine the effect of CIAT on standardized measures of language ability, functional communication, and quality of life. In addition, continuous assessment of dependent variables occurred to ensure that improvements in naming and discourse behaviors could be attributed to CIAT and not to other extraneous factors. Six adults with aphasia participated in this modified single-subject, multiple-baseline across individuals design consisting of a baseline, treatment, and maintenance phase. Results provide the new information that the CIAT protocol utilized in this study resulted in a reduction in activity and participation limitations. Furthermore, this study demonstrated the effect of CIAT on naming of trained items and on untrained discourse tasks though the stability criteria used in this study did not prevent the occurrence of accelerating trends in baseline data and therefore reduces the impact of these claims.

Results also supply needed information about treatment elements and preliminary information about dosage that will serve as a platform for future research. Suggestions for future research geared towards refining aphasia treatment are provided.

INDEX WORDS: Constraint-induced aphasia therapy, multiple-baseline, activity limitations, participation limitations, naming, discourse, procedural reliability, treatment elements, dosage

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by

JESSICA DAWN RICHARDSON

B.S., The University of Georgia, 2001

M.S., The University of Arizona, 2003

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JESSICA DAWN RICHARDSON

Major Professors: Anne Bothe
Rebecca Marshall

Committee: Albert DeChicchis
David Gast
Richard Andreatta

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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DEDICATION

This dissertation is dedicated to the wonderful individuals who participated in this study and their caregivers. You have touched my life in many ways, and I will never forget the lessons I learned during my time with you. Thank you for the laughs, for the tears, for the joy, for the pain, and for the memories that will last a lifetime.

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CHAPTER 1

INTRODUCTION

Aphasia is an acquired language disorder with many subtypes. The most common presentation is an impaired language processing system that can affect speech production as well as auditory comprehension, thus inhibiting verbal communication (Douglas, Brown, & Barry, 2002). It is most commonly the result of a stroke that has caused damage to speech and language areas of the brain. Stroke ranks third among all causes of death in the United States (Thom et al., 2006). It is estimated that 1-2 people per thousand suffer a new or recurrent stroke each year (Douglas et al., 2002; Hirtz et al., 2007), though the incidence of strokes for several minority populations are reported to be as high as 3.23 per thousand up to 6.6 per thousand (Thom et al., 2006). The actual number of individuals who acquire aphasia post stroke is unknown and incidence reports vary greatly, reporting that a range of 20 to 50% of stroke survivors acquire aphasia (Berthier, 2005; Douglas et al., 2002; Kauhanen et al., 1999; Laska, Hellblom, Murray, Kahan, & Von Arbin, 2001; Meinzer et al., 2004; Pedersen, Jorgensen, Nakayama, Raaschou, & Olsen, 1995; Pulvermüller & Berthier, 2008; Thom et al., 2006). As medical advances continue and as stroke mortality continues to decrease (Pessah-Rasmussen, Engström, Jerntorp, & Janzon, 2003), it is expected that the increasing number of stroke survivors will lead to an increasing number of stroke survivors with aphasia.

Impact of Aphasia

Defining aphasia and reporting its incidence does not adequately convey the pervasive impact of the disorder. Researchers within the stroke and aphasia rehabilitation communities are advocating for measurement of treatment outcomes on multiple levels. Specifically, developers and providers of aphasia treatment are encouraged to adopt a life and social participation approach when measuring outcomes (Boles & Lewis, 2003; Dalemans, DeWitte, Wade, & Van den Heuvel, 2008; Fratalli, 1998; Olswang, 1998; Simmons-Mackie & Damico, 2007). One classification system that allows such an approach is the World Health Organization – International Classification of Functioning, Disability, and Health (WHO-ICF), which describes disorders in terms of the resultant limitations placed upon the individual. The 3 primary categories are limitations in body function and structure, activity limitations, and participation limitations, as discussed for aphasia in the following sections.

Limitations in Body Function and Structure

The first category, limitations in body function and structure, relates most closely to the former term impairment, which is a deviation from the norm in terms of structure and function (Fratalli, 1998). The instruments used to determine these limitations are typically diagnostic assessment measures that identify deficits of structure and function, and lead to the determination of aphasia subtype and severity (Fratalli, 1998). Included also are imaging tools to identify site and size of lesion.

Though there is no universally agreed upon classification system for aphasia types (Patterson & Chapey, 2008), there is general agreement that most presentations of aphasia can be subdivided into either fluent (receptive) or nonfluent (expressive) aphasia types. Discussing only those types that occur as a result of stroke, Wernicke's aphasia, conduction aphasia, and transcortical sensory aphasia fall under the umbrella of fluent aphasia, whereas Broca's aphasia and transcortical motor aphasia are considered nonfluent aphasias (Damasio, 2008). Other types of aphasia that do not fit neatly into this classification scheme include the following: global aphasia, a more severe subtype with both expressive and receptive deficits; anomic aphasia, which involves category-specific word retrieval deficits in the face of otherwise preserved expressive language abilities; crossed aphasia, which occurs in a right-handed person because of a right hemisphere lesion; and atypical aphasia, which has a mixed constellation of language deficits attributed to premorbid idiosyncratic cortical organization (Berthier, 2005; Damasio, 2008). The aphasia subtypes and their unique language deficits are listed in Appendix A. It is common for individuals to change aphasia subtype as they recover over time (Cherney & Robey, 2008; McDermott, Horner, & DeLong, 1996; Pashek & Holland, 1988).

Activity Limitations

The category of activity limitations is analogous to the definition of disability, and relates to the functional consequences of the limitations of body function and structure. The aforementioned limitations may address specific deficits in receptive or expressive language, but activity limitations are described in terms such as "the individual is unable to add ideas and take turns in conversation" (Glista & Pollens, 2007, p.355). The instruments used are often functional communication and level of independence measures that determine the degree of limitations placed upon the different language modalities (speaking, listening, reading, and writing) and the impact upon functioning in everyday activities (Fratalli, 1998; Patterson & Chapey, 2008; Spreen & Risser, 2003). Several studies have demonstrated that activity limitations are predictive of the next domain to be discussed, participation limitations, specifically asserting that a reduced degree of functional communicative ability predicts a lower quality of life (QOL; Cruice, Worrall, Hickson, & Murison, 2003; Hilari, Wiggins, Roy, Byng, & Smith, 2003).

Participation Limitations

The final category of limitations is that of participation, which is related to the idea of handicap. This category is tied intrinsically to one's well-being and the social consequences that arise from having communicative exchanges negatively affected by aphasia (Le Dorze, Croteau, Brassard, & Michallet, 1999), and it is discussed relative to the individual's life roles (Glista & Pollens, 2007). Is the individual with aphasia still able to lead a meeting, conduct class lessons, sing, etc.? If not, then participation in pre-aphasia life activities is limited. Generally, QOL and life participation measures are used to determine the level of participation limitations (Frattalli, 1998; Simmons-Mackie, 2001).

It is difficult to determine QOL and life participation in this population and to make specific recommendations to guide treatment development for several reasons. Though the WHO has developed a QOL measurement with many domains and sub-domains (e.g., level of independence, social relationships, etc.), there are no opportunities to weight the importance of domains, leading to a resultant score that does not truly capture QOL (Ross & Wertz, 2003a, 2003b). Also, this measurement is not likely to be able to be completed or understood by many individuals with aphasia, and there is currently no psychometrically proven or comprehensive measure of QOL in individuals with aphasia (Hilari et al., 2003; Ross & Wertz, 2003b). Though modified versions of QOL measurements do exist for individuals with communication impairments, these are not proven to provide accurate representation. One proposed solution is to have caregivers fill out forms to determine QOL, but research has shown that "proxies systematically rated stroke survivors as having more QOL impairments than did stroke survivors themselves" (Ross & Wertz, 2003b, p. 356). Moreover, proxy reports of such a subjective and personal construct should be questioned (Hilari et al., 2003). It is difficult to get a clear picture of this category of limitations in this population, but it is safe to say that the QOL of individuals with aphasia is at least as reduced as those individuals with stroke. It is likely more negatively affected because of limitations associated specifically with a communication deficit, such as reduced opportunities for acquiring new information and reduced social involvement (Doyle et al., 2004; Kauhanen et al., 1999; Ross & Wertz, 2003a).

Recovery from Aphasia

Individuals who participate in physical and speech rehabilitation post stroke demonstrate marked improvements versus individuals who do not (Hallet, 2001). Rehabilitation is described as "the provision of planned experience to foster brain changes leading to improved daily life functioning" (Robertson, 1999, p. 385). If rehabilitation truly aims to provide experience to produce structural changes that lead to functional changes, then it must take into account the science of the brain, or neuroscience. Attempts to integrate neuroscientific methods with rehabilitation procedures have led to the emergence of a new field of study termed neurorehabilitation, an approach seeking the "reconstitution of neural function after injury” (Nadeau, 2002, p. 126). Research in neurorehabilitation seeks to discover ways to manipulate the system such that plastic mechanisms can be triggered, enhanced, disrupted, reversed, and/or prolonged. In order to effect change in the nervous system, the substrates that comprise it must be understood. Understanding can then lead to the development of more effective, efficient, and efficacious rehabilitation procedures to bring about desired change and/or prevent undesired change (Kaas, 2002).

Plasticity

Plasticity is the term used to describe the nervous system’s ability to alter the neuronal structure established by genetic coding and shaped by epigenetic influences and experience. Two types of plasticity are discussed when referring to plasticity outside of the developmental realm: lesion-induced plasticity and activity-dependent plasticity (Dinse & Böhmer, 2002). Both types will be discussed, as the former occurs as a result of injuries such as stroke, and because the best rehabilitation programs seek to capitalize upon the latter.

Two interrelated domains characterize plasticity following injury: stage of plasticity and mechanisms of plasticity (Florence, 2002; Kaas, 2002). Short-term plasticity refers to plastic changes and reorganization that can be viewed immediately post injury. The mechanism of plasticity during this time period is the synaptic strengthening or weakening of existing connections. If dominant inputs are damaged, the nervous system will operate according to the residual function of the dominant inputs. If dominant inputs are destroyed, latent inputs from neighboring areas are disinhibited and assume the role of the new “dominant” input. In the case of anatomically redundant and degenerate networks like the human nervous system, it is possible that activation of the newly used anatomical connections can lead to production of the same behavior, thus recovery of function. The altered or new pathway of information flow is either strengthened according to use via long-term potentiation (LTP), in which a synaptic connection is strengthened secondary to continued activity, allowing that synaptic connection a competitive advantage over other connections; or weakened according to nonuse via long-term depression (LTD; Florence, 2002; Kaas, 2002; Singer, 1994).

Intermediate plasticity refers to a period of refinement and consolidation of the reorganization that occurred during the short-term stage. Evidence is limited, but this stage is thought to include sprouting of new connections (e.g., axons, dendrites) and pruning of unused connections (Kaas, 2002). The mechanisms for sprouting are unclear, but if they mimic neuron growth in the developing nervous system, it should involve the role of growth factors and molecular signals that signal synaptic availability (Kaas, 2002). These mechanisms are thought to be active for several months following injury. The long-term stage of plasticity includes up- and down- regulation of receptors, resulting in changes in gene expression following long-term alterations in synaptic activity (Kaas, 2002). LTP and LTD again play a role here, as prolonged states of LTP can eventually lead to the transcription of new genes and synthesis of new proteins, effectively changing the phenotype (Squire et al., 2003). This stage of plasticity can extend for years following injury.

Activity-dependent plasticity, or the ability to alter structure and function within the nervous system as a result of experience, actually begins in utero (Hafström & Kjellmer, 2000), operates during development, and is maintained throughout the lifespan. This is crucial, because organisms continually experience novel events and must have a nervous system that can adapt to these events given their finite amount of neural resources (Edelman, 1987; Nudo, Wise, SiFuentes, & Milliken, 1996; Singer, 1994; Thelen & Corbetta, 1994; Turkstra, Holland, & Bays, 2003). Though such plasticity can occur as a result of use and everyday experience (e.g., nursing rats who demonstrate expanded stomach sensory areas, alterations to motor and sensory maps of skilled musicians, etc.), activity-dependent plasticity can also be manipulated via treatment programs designed to bring about desired change in order to improve outcomes.

Plasticity in aphasia: Regional hierarchy

Converging clinical and imaging evidence suggests that recovery is often accompanied by activation of perilesional areas, increased activation in undamaged speech and language association areas, and activation of homologous areas in the non-dominant hemisphere (e.g., Calvert et al., 2000; Cao, Vikingstad, George, Johnson, & Welch, 1999; Martin et al., 2005; Mazziotta et al., 2000; Meinzer & Breitenstein, 2008; Pulvermüller, Hauk, Zohsel, Neininger, & Mohr, 2005; Thompson, 2000; Weiller et al., 1995). A regional hierarchy for recovery from aphasia post-stroke has been developed and proposed after a synthesis of neuroimaging and recovery data (Heiss & Thiel, 2006). Best possible behavioral outcomes in language performance would result from a complete physiological recovery, which is only possible following extremely minor damage (e.g., small lesion in non-primary area of language functioning; Berthier, 2005; Heiss & Thiel, 2006). The second tier in this regional hierarchy seems to arise from the emergence or restoration of perilesional function in the language dominant hemisphere.

This likely involves the residual function of the dominant inputs, or the disinhibition of latent inputs (i.e., reduction of collateral inhibition) which assume the role of the new "dominant" input. Such is the proposed second best case scenario for language functioning (Cornelissen et al., 2003; Hillis, 2006; Rosen et al., 2000). The third tier of this hierarchy involves recruitment of homologous language areas (e.g., right inferior frontal gyrus [R IFG], right primary motor cortex [R M1], right supplementary motor area [R SMA], etc.), as there is evidence that such recruitment correlates with some improvements in language performance, though often not to the degree of perilesional activity (Hillis, 2006; Rosen et al., 2000).

Plasticity in aphasia: Chronology

A closer look at recovery from aphasia reveals more complexities. Following a review of the imaging and plasticity findings in aphasia, Saur and colleagues (2006) realized that the majority were studies that involved primarily "recovered" individuals in the chronic stage of aphasia, concluding that "the observed activation describes the reorganized language network rather than the process of reorganization" (p. 1371). They performed a longitudinal functional imaging study to elucidate the reorganization process and revealed language recovery "curves," in which right hemisphere (RH) areas showed an initial increase, followed by a decrease, resulting in a biphasic curve. Conversely, left hemisphere (LH) activation post-stroke was characterized by a monophasic curve, as activation gradually increased over time. Authors concluded that the restoration of LH activity to near normal levels serves to inhibit the RH activity to near pre-morbid levels, contributing to the biphasic curve of RH activation. This timeline of recovery is supported by other findings (Fernandez et al., 2004; Heiss, Kessler, Thiel, Ghaemi, & Karbe, 1999). Neuroimaging research shows some promise of being able to explicate details of recovery in individuals post stroke, but much work remains to be completed before a cohesive account of neural recovery in individuals with aphasia is determined (Fadiga, 2007; Poldrack, 2006).

Aphasia Treatment Efficacy

Most individuals with aphasia participate in aphasia therapy with a speech-language pathologist at some point in their recovery. Many clinicians attempt to rehabilitate these individuals via compensation rather than remediation, assuming that the central areas responsible for particular aspects of speech and language cannot be retrained (Davis, 2005; Hopper, Holland, & Rewega, 2002; Kagan, Black, Duchan, Simmons-Mackie, & Square, 2001; Sacchett, 2002; Simmons-Mackie, 2009; Simmons-Mackie & Damico, 1995; van de Sandt-Koenderman, 2004). Current behavioral and neuroimaging evidence support more remediative approaches to treatment (Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005; Teasell & Kalra, 2004; Thompson, 2000). Aphasia therapy has not been proven to be either clearly effective or ineffective in experiments involving randomized controlled trials (RCTs), but it is generally accepted that individuals who participate in aphasia therapy demonstrate better outcomes than those who do not.

An early meta-analysis sought to determine the efficacy of aphasia treatment, and revealed that individuals who receive treatment for aphasia perform better than the untreated population, with significant effect sizes noted for both acute and chronic stages of aphasia (Robey, 1994). This finding was confirmed by Holland, Fromm, De Ruyter, and Stein (1996). Basso and colleagues (2001, 2005) validated the belief that more therapy sessions results in greater improvements, as intensive therapy for a prolonged period of time resulted in greater improvements on standardized measures as well as daily use of language and communication. Similarly, a review of eight clinical trials revealed that treatment programs that provided an average of 8.8 hours per week for an average of 11.2 weeks led to positive results while those that provided an average of two 2 hours per week for an average of 22.9 weeks led to negative results (Bhogal, Teasell, & Speechley, 2003).

A review of the aphasia treatment literature was conducted and summaries are listed in Appendix B. No attempt was made to review all aphasia treatment studies, rather the purpose was to provide a representative sample of seminal or most current findings from a wide variety of treatment approaches. Thirty-five different types of treatments were reviewed across the selected 69 articles. A specific type of treatment, constraint-induced aphasia therapy (CIAT), was excluded from Appendix B as it is addressed in more depth in a separate appendix (Appendix E), but results from CIAT are included in this summary. The studies reviewed revealed the following themes: improvement on trained items, increased scores on standardized measures of impairment and/or disability, and generalization to untrained items and/or discourse. Of the 69 aphasia therapy outcomes papers reviewed for this section, 29 report improvement on trained items or tasks, 17 report generalization to untrained items or tasks, and 5 report generalization to discourse. There were 33 reports of improvement on standardized measures of impairment or disability. Only 5 of the reviewed studies report that improvements were maintained at follow-up, and very few addressed the impact of treatment on measures of participation limitations (e.g., depression, QOL).

Several studies also include reports of improvement in mean length of utterance, vocabulary, naming, auditory comprehension, complexity of utterances, satisfaction with communicative ability, confidence, and positive caregiver feedback.

Analysis of the available literature reviews as well as of the articles reviewed in this document provides a positive answer to the question of whether or not aphasia treatment works. The pervasive problem within the entire aphasia treatment outcomes literature is that investigators often do not continue their lines of research to answer the even more important questions posed by Darley (1972) that address issues such as optimal matching of treatment approaches to the appropriate population, treatment elements (i.e., which treatment components differentially contribute to behavioral improvements; Frattali, 1998), and temporal considerations (i.e., timing, duration, and intensity of intervention). A discussion of research phases (Robey & Schultz, 1998) is relevant here, as it assists in further characterizing this problem. Briefly, Phase 1 research corresponds to the administration of a new treatment to a small number of individuals to test potential benefits, Phase 2 research seeks to determine for whom the treatment is most appropriate and to optimize treatment procedures, and Phase 3 is supposed to include larger group studies to determine treatment efficacy. Finally, Phase 4 is treatment effectiveness research (i.e., benefit of treatment in real-world settings; Frattali, 1998), and Phase 5 research is concerned with practical issues (e.g., cost, time commitment) of service delivery.

Examination of the 454 studies with both class and phase information included on the Academy of Neurologic Communication Disorders and Sciences (ANCDS) website, which represents research conducted between 1904 and 2007, revealed the following: Phase 1 studies represented 71% of the total, 26% were Phase 2, and 3% were Phase 3. There are currently no Phase 4 and 5 studies listed. Thus the majority of research to date remains in the discovery stage, with very little percentage devoted to answering Darley's questions of "who", "how", or "how much and how long." No studies that were designed to determine treatment effectiveness or other practical issues involved in treatment delivery were listed.

Along these lines, a discussion of the weight of the evidence, or class, is also relevant. Briefly, Class I refers to evidence provided by true experimental research in the form of RCTs with large populations (Armon & Evans, 2005; Frattali, 1998; Silberstein, 2000; Wijdicks, Hijdra, Young, Bassetti, & Wiebe, 2006). An additional four criteria are required to receive this classification and include the following: 1) clear definitions of primary outcome(s), 2) clearly defined inclusion and exclusion criteria, 3) low dropout rates and clear explanation of rates, and 4) presentation of baseline characteristics to demonstrate equivalence of groups, or appropriate adjustment in the case of differences (Armon & Evans, 2005). Class II evidence involves RCTs that may be missing one of the criteria listed above, or quasi-experimental research, in that similar studies are performed but without randomization and often in smaller target populations (Armon & Evans, 2005; Frattali, 1998; Silberstein, 2000; Wijdicks et al., 2006). Evidence included in Class III arises from all other forms of controlled trials that involve objective assessment of outcomes (Armon & Evans, 2005; Wijdicks et al., 2006). Finally, Class IV evidence includes that from case reports, uncontrolled studies, and/or expert opinion (Armon & Evans, 2005; Frattali, 1998; Holland et al., 1996; Wijdicks et al., 2006).

According to the 454 studies examined on the ANCDS website, 5% were Class I studies, 11% were Class II studies, and 84% were Class III studies. These classes are in accordance with those presented by Holland et al. (1996) and Frattali (1998), and not the recently updated classification system, so a portion of the Class III studies would be recategorized as Class IV studies (e.g., case reports, uncontrolled studies). Still, it can be derived from this information that the majority of studies are small N, non-randomized studies that carry less weight and are also less able to achieve higher "grades" of research. Because of the nature of this disorder and the availability of subjects, often small N and single-subject designs (SSDs) are the only viable option, and are certainly necessary for discovery phases of treatment outcomes research. Because this is the case, investigators should be careful to employ the best methodological practices to ensure internal and external validity. Yet, the literature base is marked by a lack of replication (Adrian, Gonzalez, & Buiza, 2003; Flowers & Danforth, 1979; Francis, Clark, & Humphreys, 2002), overuse/inappropriate use of both parametric and nonparametric statistics with small N studies (Francis et al., 2002; Loverso, Prescott, & Selinger, 1988; Maher et al., 2006; Peck et al., 2004; Robson, Marshall, Pring, & Chiat, 1998), and an abundance of SSDs that employ only one subject (Adrian et al., 2003; Boyle & Coelho, 1995; Coelho, McHugh, & Doyle, 2000; Davis, Harrington, & Baynes, 2006; Francis et al., 2002; Goral & Kempler, 2008; Helm-Estabrooks & Albert, 2004b; Kearns, 1985; Li et al., 1988; Robson et al., 1998). Observed also are studies that claim to be SSD but that do not employ repeated measurement of dependent variables throughout the different phases of experimentation (Breier, Maher, Schmadeke, Hasan, & Papanicolaou, 2007; Goral &

Kempler, 2008; Robson et al., 1998), or if they do, do not present repeated measures evidence for visual inspection by the consumer of research (Peck et al., 2004; Rochon, Laird, Bose, & Scofield, 2005).

The most effective procedures or their matching neural substrates remain unknown (Douglas et al., 2002; Hallet, 2001; Mazziotta, Toga, & Frackowiak, 2000; Robey, 1998). Given this information, there is the concern that critics and third party payers will begin to question the necessity of continued provision of aphasia therapy services. Though funding caps can be reconsidered for individuals with aphasia when there is a documented need for services, criteria for establishing a need for services differ among institutions and state agencies (Field & Jette, 2007), and do not generally encompass ultimate treatment goals important to the individual with aphasia (e.g., increased life participation, ability to return to work, etc). The fear of being denied services based upon “lack of medical necessity” after less than 6 months of therapy, despite pronounced speech and language deficits, was valid for most participants in this present study. The research community must continue efforts to prove that aphasia therapy is indeed worthy of implementing and funding (Douglas et al., 2002; Simmons-Mackie & Damico, 2001).

Constraint-Induced Aphasia Therapy

Constraint-induced aphasia therapy (CIAT) is a new approach to remediation of aphasia that is proving effective at both behavioral and neural levels. It is an intensive therapeutic approach in which individuals with aphasia engage in games and other speech production tasks with therapists and other individuals with aphasia. It differs from approaches such as Schuell’s stimulation approach, which relies heavily upon the auditory modality and receptive language tasks, though expressive language and written language tasks are utilized also (see Coelho, Sinotte, & Duffy, 2008 for a review). Instead, CIAT stems from the view that improving spoken language abilities requires practicing the behavior of speaking. The goal of this therapeutic approach is to facilitate the development of a bias to use spoken language versus other communication modalities (Nadeau, Gonzalez Rothi, & Rosenbeck, 2008). This approach combines elements of language games that have been employed in aphasia therapy for decades with elements of a popular physical therapy approach.

Origins

Pragmatic Approach to Aphasia Therapy

Witttgenstein (1953) introduced a "builder's game" that required communicative interaction between a builder and an assistant (i.e., clinician and client) in order to successfully complete a construction or craft project. In this game, communicative acts were salient and relevant, as they had a clear purpose and effected action. He believed that language was systematically linked to actions, and such beliefs have since been confirmed with neurophysiological evidence that definitively demonstrate functional linkages in the cortex between linguistic areas and primary motor areas during language processing tasks (Hauk, Johnsrude, & Pulvermüller, 2004; Pulvermüller, Hauk, Nikulin, & Ilmoniemi, 2005; Pulvermüller, Shtyrov, & Ilmoniemi, 2005).

Following the introduction of these ground-breaking concepts, other pragmatic approaches that involved role-playing and scripted social communicative situations (e.g., shopping, dining, etc.) gained in popularity (Aten, Caligiuri, & Holland, 1982; Bolinger et al., 1993; Schlanger & Schlanger, 1970). Davis and colleagues (Davis, 2005; Davis & Wilcox, 1981, 1985; Li, Kitselman, Dusatko, & Spinelli, 1988) introduced an approach to aphasia therapy in the early 1980s entitled Promoting Aphasics Communicative Effectiveness (PACE). PACE treatment requires individuals to take turns sending and receiving messages in any communication modality (e.g., written, gestural, spoken, etc.). As long as the message is successfully conveyed, the communicative exchange is considered successful. In other words, communication by any means possible.

The earliest study in the aphasia literature related specifically to the development of CIAT is the Pulvermüller and Roth (1991) study that introduced a modification to PACE, and they coined the new approach Communicative Aphasia Treatment. The study utilized a requesting game for the PACE treatment, and introduced a barrier between subjects and clinicians. All participants in the game received identical picture stimuli, and were required to communicate the content of the picture to the other individual via any modality. If the receiver was able to identify which picture the sender was describing, then the turn was judged successful. The requesting game and the barriers utilized currently in CIAT likely arose from this PACE modification. This foundational therapeutic task was coupled with insights from motor learning and rehabilitation literature, which will be discussed in the next several sections.

Constraint-Induced Movement Therapy

Much work was performed in the 1960s through 1980s in terms of forcing use of affected limbs (Taub, Ellman, & Berman, 1966; Taub, Perrella, & Barro, 1973; Wylie & Tyner, 1981, 1989) and also restraining the unaffected limbs (Ostendorf & Wolf, 1981; Taub & Berman, 1968; Wolf, Lecraw, Barton, & Jann, 1989). These approaches (forced use and restraint) were frequently used as separate treatment regimens for improving motor functioning. Eventually researchers realized the value of combining these approaches for a potentially more efficacious treatment (Taub, 1980) and developed a treatment protocol for physical rehabilitation designed to induce individuals to use their affected limbs post stroke (Kunkel et al., 1999; Miltner, Bauder, Sommer, Dettmers, & Taub, 1999; Taub et al., 1993; Taub, Crago, & Uswatte, 1998; Taub, Uswatte, & Pidikiti, 1999).

Constraint-induced movement therapy (CIMT) was developed following work with primates and humans on a phenomenon called learned nonuse (Taub et al., 1994; Taub, 2004). Research shows that primates and humans with lesions that have caused neurological damage to one or more limbs may experience pain, uncoordination, and/or lack of success when using the affected limb, leading to avoidance of the use of the limb. It is presumed that this occurs because the behavior is punished (via pain, lack of success, etc.) and limb movement is suppressed. In addition, when success is achieved without the use of the affected limb, avoidance behavior is further reinforced. Thus primates and humans learn, via classic behavioral conditioning, not to use the affected limb in spite of residual function.

Once constraint of the unaffected limb is introduced, the reinforcement contingencies are altered, as the primate or human has two choices: attempt to use the affected limb to try to meet basic appetitive needs as well as participate in everyday activities, or forego eating, grooming, mobility, etc. As the latter is not preferable, this alteration in contingencies overpowers the strength of the previous behavior of learned nonuse, and the animal is “induced” to use the affected limb (Taub et al., 1994).

Interestingly, if the constraint was only required for a matter of hours to a couple of days, the monkeys would switch back to use of the unaffected limb immediately following removal of the constraint device. If the device was worn for “several days or longer,” the behavior of using the affected limb received more reinforcement, and hypothesized strengthening of neuronal group connections to support that behavior. Therefore, once the device was removed, the new behavior “is then able to compete successfully with the learned nonuse of that limb in the free situation” (Taub et al., 1994, p. 283).

Current treatment delivery. CIMT involves the constraint of unaffected limbs via hand splint, mitt, sling, and/or verbal instruction not to use the unaffected limbs, accompanied by forced use of the affected limb(s) during functional tasks (e.g., meal preparation, eating) for most of the individual’s waking hours (Nadeau et al., 2004; Taub, 2004; Wittenberg et al., 2003). See Appendix C for a list of different constraints, activities, and time commitments of various studies. The overarching objective is twofold: to increase the amount of time the individual uses their affected limb, and to shape the movement of that limb so that it is as “normal” as possible (Taub, 2004). Modifications to the current treatment delivery paradigm include: administration of donepezil as an adjuvant to rehabilitation (Nadeau et al., 2004); assignation of home practice exercises during intervention (Wolf et al., 2006) and/or for 30 minutes daily after completion of intervention (Shaw et al., 2005; Wolf et al., 2006); and development of an automated computer workstation (Lum et al., 2004).

Outcomes. CIMT outcomes research consistently reports increased use of the affected limb, transfer of skills to real-world settings, and retention of treatment effects for at least 2 years post-treatment. Taub (2004) reports that, of over 90 published studies on the topic of CIMT, all studies report positive outcomes. Behavioral improvements have been shown to be accompanied by cortical reorganization, in which increased neuronal activity and expansion of cortical areas devoted to the affected limb are observed following therapy (Liepert, Bauder, Miltner, Taub, & Weiller, 2000; Miltner et al., 1999; Plummer, 2003; Taub, 2004; Wittenberg et al., 2003).

Logic of Translation

Following the introduction of CIMT, CIAT developers incorporated neuroscientific principles from that approach to the speech and language realm (Pulvermüller et al., 2001), as individuals with aphasia live through similar experiences that could lead to learned nonuse. For example, many individuals with aphasia report emotions such as frustration, anger, and helplessness during and following failed communicative acts that involve spoken language (Brookshire, 1997). This onslaught of negative emotions accompanied by lack of success can serve to punish or suppress the speech production behavior, and the individual with aphasia is then more likely to rely on other methods of communication, such as writing, gesturing, and/or telegraphic speech (Brookshire, 1997; Pulvermüller et al., 2001). Consequently, if communication attempts with alternative methods are successful, then avoidance of spoken language is further reinforced. It is reasonable to presume that forcing individuals with aphasia to use their impaired speech production system and constraining their use of alternative methods of communication may have the same impact as CIMT (Pulvermüller et al., 2001).

Current Treatment Delivery

The principles of CIAT are as follows: constraint of alternative methods of communication and forced use of spoken language; shaping; participation in behaviorally relevant group activities (Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005); and massed-practice over a short period of time (usually 3-4 hours/day for 10 consecutive weekdays, though different schedules have been utilized; Breier, Maher, Novak, & Papanicolaou, 2006; Breier et al., 2007; Goral & Kempler, 2008; Maher et al., 2006; Szaflarski et al., 2008). These principles are implemented in order to obtain the objective of increasing spoken language. This is a departure from many current methods of therapy which consist largely of working in a 1:1 sterile clinical setting for 1-2 sessions per week, learning compensatory strategies or participating in traditional stimulus-response activities. See Appendix D for a list of the different constraints, activities, and time commitments of various CIAT studies.

During a typical CIAT session, a frequent activity is a modified form of "Go Fish" played with picture cards (Breier et al., 2006, 2007; Goral & Kempler, 2008; Maher et al., 2006; Meinzer, Djundja, Barthel, Elbert, & Rockstroh, 2005; Meinzer, Streiftau & Rockstroh, 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005; Szaflarski et al., 2008). Participants request, answer, or deny requests during this game in which the goal is to match picture cards. Barriers are placed between individuals so they are unable to view others cards. As therapy progresses, they are required to increase the level of difficulty and complexity of utterances. For example, if the individual is only able to produce the name of the picture (e.g., "book") in their attempt to request, this is acknowledged and the card is given. However, they are required to produce more complex utterances (e.g., “red book”, “I want the book”) as therapy progresses. All communication must be in the form of spoken words or sentences. No pointing, writing, or gesturing is allowed. Other activities include 20 questions (Maher & Schmadeke, 2007), Memory game (Goral & Kempler, 2008; Maher & Schmadeke, 2007) and other narrative production tasks (see Goral & Kempler, 2008). As is evident via a comparison of the activity lists for CIMT and for CIAT (see Appendices D and E), the number and variety of activities for CIAT is reduced relative to CIMT.

Modifications to the original implementation of CIAT include CIATplus, which involved the following: inclusion of pictures, written words, and real-world photographs as stimulus materials; assignment of home exercises to be completed with family members; involvement of caregivers, who were asked to encourage participant to engage in spoken communication as often as possible; and journaling of communicative activity by participants and their caregivers (Meinzer et al., 2005). Other modifications include encouragement to use spoken communication as much as possible outside of therapy (Breier et al., 2006). Lastly, Meinzer, Streiftau, and Rockstroh (2007) trained laypersons to provide CIAT and also allowed gestures if they were used to facilitate spoken language.

Behavioral Results

Results generally reveal significant differences between CIAT and traditional therapy approaches on standardized language measures and measures of functional communicative behavior, transfer to narrative discourse, and retention of treatment effects at 1-6 months follow-up (Maher et al., 2006; Meinzer et al., 2005; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005; Szaflarski et al., 2008). Two of 3 studies (CIAT versus other treatment) reporting group statistics reveal statistically significant differences between groups that received CIAT and those that received some other form of treatment (Maher et al., 2006; Pulvermüller et al., 2001). The exception is the CIAT group that was compared to a group that received an equally intensive model-based treatment; group differences were not discerned in this study (Meinzer et al., 2004). Other studies reporting group differences between post- and pre-treatment scores following administration of various forms of CIAT report significant improvements on standardized measures of language performance (Meinzer et al., 2005; Meinzer, Streiftau et al., 2007; Pulvermüller, Hauk, Zohsel et al., 2005; Richter, Miltner, & Straube, 2008).

Of the 13 original studies (i.e., not follow-up) in which some form of CIAT was administered to individuals with aphasia (see Appendix E), there appear to be 117 total participants. This number is likely inflated, however, because it seems as if participants of several studies overlap (Breier et al., 2006, 2007; Meinzer et al., 2004, 2005, 2006; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005). Assuming no overlap among participants, there are 117 participants, with no individual post-treatment data available for 28 participants (Pulvermüller et al., 2001; Meinzer et al., 2004). Of the remaining 89 participants whose individual data on standardized measures are reported, 48 were involved in studies that reported statistically significant change at the individual level. Forty-two of this subset of participants were reported to demonstrate statistically significant improvement on at least one standardized subtest, though information about whether or not they deteriorated on other subtests is not available (Meinzer et al., 2005, 2006; Meinzer, Obleser, Flaisch, Eulitz, & Rockstroh, 2007; Meinzer, Streiftau et al., 2007). Of the remaining 41 participants (of the 89 with individual data reported), 19 demonstrated the following pattern of improvement: all positive changes on tests/subtests, or a mixture of positive change and no change (Breier et al., 2006, 2007; Goral & Kempler, 2008; Maher et al., 2006; Pulvermüller, Hauk, Zohsel et al., 2005; Richter et al., 2008). The remaining 22 (of 41) demonstrated a mixture of improved and deteriorated performance, though biased to improvement. In summary, 42 of 89 (47%) participants for which individual data was available showed statistically significant improvement on at least one standardized subtest or subscale post treatment, and including these individuals, 61 of 89 (69%) showed a clear pattern of improvement on standardized measures of language improvement. Pulvermüller et al. (2001) and Meinzer et al. (2005) report improvements in functional communicative abilities, whereas no improvement in functional communicative abilities was observed in the Szaflarski et al. (2008) study. Several studies report improved performance on the tasks trained in therapy (Breier et al., 2006, 2007; Goral & Kempler, 2008; Maher et al., 2006). Lastly, three studies report improvements in narrative discourse (Goral & Kempler, 2008; Maher et al., 2006; Szaflarski et al., 2008), though measurement methods differed in each study.

Neural Results

Behavioral improvements are also accompanied by changes at the neural level, though interpretation and application of the varied findings proves difficult. Meinzer et al. (2004) collected functional neural information via magnetoencephalography (MEG) prior to and following participation in either CIAT or another equally intensive treatment protocol that emphasized speech production. Prior to treatment, the individuals displayed slow wave delta activity (1-4 Hz), which is indicative of dysfunction, near the lesion sites in the LH. Following intensive treatment, a majority of patients (16/28) demonstrated a reduction in this perilesional delta activity, indicating recovery of function, the magnitude of which correlated with improved speech and language abilities. An examination of the results leads to inconclusive interpretation in regards to CIAT effects at the cortical level. Of the 18 who received CIAT in this study, 9 demonstrated a reduction of perilesional delta activity, and 9 demonstrated increased perilesional delta activity. Other MEG studies also present inconclusive and difficult to interpret results, but the following can be determined: those that responded to treatment in the Breier et al. (2006) study demonstrated a RH emphasis post treatment, no or negligible LH activation, and a behavioral response to CIAT that correlated with the degree of pretreatment activation within the RH. In the case study presented by Breier et al. (2007), the individual showed increased RH activation immediately post treatment.

Results of functional Magnetic Resonance Imaging (fMRI) studies also do not provide a cohesive picture of changes in activation in response to CIAT. Meinzer et al. (2006) examined the activation patterns of a single subject when she produced words that were incorrect pre-treatment and correct post-treatment. They found that improvement correlated primarily with increased R IFG and R subcortical activation, visualized via 1.5 Tesla (T) fMRI. In another single participant, increased picture naming abilities were related to increased activation in perilesional as well as R homologous regions (Meinzer, Obleser et al., 2007). Lastly, in the Richter et al. (2008)

study, no statistically significant differences in activation (via 1.5T fMRI) from pre- to post- treatment (N=16) were observed, though higher language performance scores were correlated with reduced R IFG and R internal capsule activity post treatment.

Pulvermüller and colleagues' (2004, 2005) electroencephalography (EEG) research shows promise of providing valuable neurophysiological evidence of treatment outcomes. It is established that typical individuals reliably demonstrate more positive event-related potentials (ERPs) in response to real words versus nonsense pseudowords. Individuals with aphasia demonstrate a similar pattern, though an overall reduction in the response is observed. Data acquired from "recovered" individuals with aphasia as well as CIAT graduates demonstrate an altered response, in that there is no significant change in pseudoword processing, but more negative-going ERPs in response to real words are observed following treatment. Though unsure of the cause of this phenomenon, authors are coining it the aphasia recovery potential (ARP) and intend to use it as an indicator of treatment effectiveness. Individuals with aphasia also demonstrated faster response times to real word stimuli and increases in source strength for real words in both hemispheres following CIAT (Pulvermüller, Hauk, Zohsel et al., 2005).

Principles of Constraint-Induced Therapies

Constraint

Examples of constraints used in CIMT are listed in Appendix C, and all serve to restrict the use of the unaffected limb in some way. Constraints used in CIAT (Appendix D) are often implemented by restricting the response to spoken verbal production and prohibiting the use of alternative communication modes (e.g., writing, gesturing, pointing, self-cueing, etc.). The latter is accomplished by verbal instructions to the participants to use the spoken modality only, reinforcement of spoken language only, or instructions to the participants to "sit on their hands" if they feel the urge to use alternative methods (Breier et al., 2006; Breier et al., 2007; Maher et al., 2006; Meinzer et al., 2005; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005; Richter et al., 2008; Szaflarski et al., 2008). The use of a barrier on the table between the participants so they cannot see each other's cards or hands is also incorporated to further encourage reliance upon verbal output (Breier et al., 2006 ; Breier et al., 2007 ; Goral & Kempler, 2008; Maher et al., 2006 ; Meinzer et al., 2005 ; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001). Lastly, participants are required to produce utterances of increasing syntactic and linguistic complexity as treatment progresses. This will be discussed in more detail in the shaping section below.

The comparison of intensive PACE therapy and CIAT by Maher et al. (2006) supports the importance of constraint. All members of the CIAT group demonstrated increases in WAB AQ scores, with 3 of the 4 determined to be "clinically significant" (i.e., improvement of 5 points or more). Four of the 5 PACE participants also demonstrated increased scores, only 1 of which was considered clinically significant. Interestingly, the participant who made the clinically significant changes in the PACE group differed from his fellow group members in that he refused to use any other communication modality except for speech during PACE. Because the time commitment and the activities were held constant in this study, and because he only used spoken language, he was effectively receiving CIAT.

Variations. Meinzer, Streiftau, and Rockstroh (2007) operated on the assumption that constraint is not a necessary constituent in the rehabilitation approach, drawing from research in which constraint was believed to make only a small contribution to treatment outcomes in CIMT (Sterr & Freivogel, 2003), and also from the knowledge that gestures generally facilitate spoken language. Therefore, the 2007 study did not concentrate on preventing gestures; rather spoken communication was simply reinforced and gesturing was allowed as long as it was not primary mode of communication and if it facilitated language output. Even with this variation, the treatment was deemed successful, as 19 of the 20 individuals in the study demonstrated statistically significant improvement on AAT profile scores. These findings and the variation are consistent with the recent push by Pulvermüller & Berthier (2008) to replace the concept of "constraint" with the idea of "focusing" in order to avoid the negative connotation associated with the former. The focusing principle promoted by the authors for consideration when developing aphasia therapy approaches was subsequently described as follows: "It is advantageous to focus patients on their remaining language abilities, especially on those they avoid using" (p. 571).

Shaping

Within the constraint-induced therapies, there is a fine and not always clear line between the process of shaping and introducing constraints. Shaping most commonly involves reinforcement of behavior that in any way resembles the target behavior with the goal of increasing the probability that the organism under study will perform that behavior again (Skinner, 1951). The desired behavior is attained by "constantly redefining the contingent response while earlier approximations are extinguished by withholding reinforcement when they occur" (Savage, 1998, p. 322). If discussed in terms of neuroplasticity, then connections that support the behavior closest to the target are strengthened, and those that are furthest away from the target behavior are weakened. Shaping has proven successful for facilitating the emergence of new behaviors, as well as for the modification of existing behaviors (Peterson, 2004; Savage, 1998; Skinner, 1951, 1968; Taub et al., 1994), both essential to the rehabilitation process.

When considering shaping during development of CIMT, developers ensured that the "behavioral requirements did not exceed behavioral capacity excessively; thus the likelihood of failure is reduced," though errors are not purposefully prevented (Taub et al., 1994, p. 283). Shaping is actually manipulated in CIAT research through introduction of additional constraints. Individuals are required to gradually increase the syntactic complexity of utterances, moving from single words (or approximations thereof) to sentences of varying complexity. In addition, clinicians provide as much cueing as possible to enable participants to eventually produce target productions correctly, and gradually reduce the amount of support provided. Sometimes an error-reduction approach is also taken, in that participants are encouraged to produce a response only when they were confident it would be correct (Maher et al., 2006).

Thus, CIAT involves rule constraints that facilitate shaping, as participants are required to move from a low complexity syntactic structure to a high complexity syntactic structure throughout the course of treatment (Breier et al., 2006; Breier et al., 2007; Maher et al., 2006; Meinzer et al., 2005; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005; Richter et al., 2008).

In addition, the level of cueing, or reinforcement contingencies, are individually adjusted according to level of performance, in order to gradually reduce the level of scaffolding provided by the clinician so the participant becomes more independent (Breier et al., 2006; Breier et al., 2007; Maher et al., 2006; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005). Lastly, further material constraints are introduced, so that participants are initially dealing only with high frequency vocabulary targets, but once they achieve mastery with this, they move to targets that are low in frequency (Breier et al., 2006; Breier et al., 2007; Maher et al., 2006; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005).

Behavioral Relevance

The nervous system prefers neuronal activity that is synchronous with other neurons and neuronal groups, and this type of activity leads to functional and structural connectivity with these groups (Edelman, 1987, 1993; Sporns, 1994). For example, during the course of a simple lip movement, the abundant interconnections between primary motor cortex (M1) and primary somatosensory cortex (S1) allow for the continual spatiotemporal association of somatosensory signals with movements (Edelman, 1987; Sanes & Donoghue, 2000). It is suggested that the mappings from this experience are functionally connected and categorized. The nervous system is thus able to discriminate this gesture (e.g., lip closure), with its unique movement trajectory and subsequent sensory consequences, from others (Edelman, 1987). Given experience in which the gesture is successful, the synaptic efficacy of the connections between the neural structures involved will increase so that the individual is more likely to repeat the gesture in the future, generalizing the use of this gesture to novel situations in a probabilistic manner (Edelman, 1987). Over time, prototypical gestures that have proven effective and efficient are recognized, selected for categorization, assigned value via reentrant connections with appetitive and hedonic control centers (e.g., hypothalamus, brain stem, amygdala), and eventually learned (Edelman, 1987).

In the case of spoken language, the picture becomes more complex. Assume one wants to say a single word (e.g., “dog”), so that activation would be noted in the ideational centers of the cortex, as well as language areas in which higher linguistic functions occur (e.g., L IFG, pre-supplementary motor area; Alario, Chainay, Lehericy, & Cohen, 2006; Bohland & Guenther, 2006; Greenlee et al., 2004). Because the goal is to speak the word, speech sound maps in the left ventral premotor cortex will be activated, maps that can correspond to phonemes, syllables, words, or short phrases that are frequently encountered and have a stored motor plan (Guenther, Ghosh, & Tourville, 2006). From this area, the speaker’s linguistic intent and the plan for the word are sent to premotor and primary motor areas (directly, and indirectly via the cerebellum) so that commands can be issued from M1 to be carried out by the muscles of the vocal tract. Finally, the speech gestures that lead to the production of the desired phonetic sounds occurs. The intent and the plan for the speech sound are also sent to somatosensory and auditory cortices which contain the sensory expectations for that word, so that deviations from the expected sound or word can be corrected.

The cortical areas discussed in this example represent those minimally involved. Excluded from this discussion are even more representations, such as visual, auditory, olfactory, and somatosensory association areas, that contain knowledge about how a dog looks, sounds, smells, and feels, limbic areas that contain knowledge about how that individual feels about dogs (e.g., fear, joy), etc. (Nadeau et al., 2008). These numerous areas would demonstrate activation that is correlated in time and space, so that with experience, they will be functionally connected into global mappings (i.e., neuronal assemblies, neuronal ensembles, etc.) for that behavior.

Because movement is such an integral component of learning and categorization, specifically for the expression of language (via writing, speaking, singing, whistling, signing, etc.), the developers of CIAT deem it necessary for participants to actively participate in the communicative activity affected by the stroke, most commonly spoken language. This interpretation precludes the reliance upon alternative modes of communication, auditory stimulation approaches, or time spent developing compensatory strategies. Authors summarize this principle: “It is advantageous to practice language in relevant action contexts” (Pulvermüller & Berthier, 2008, p. 569).

Massed Practice

The previous neuroplasticity discussion emphasized the necessity of increasing synaptic efficacy via repetitive engagement of synaptic circuitry involved in the target behavior in order to facilitate learning and/or behavioral improvement. Because synaptic circuitry involved in “typical” language production is no longer in use in individuals with aphasia, the connections atrophy and the nervous system is no longer biased towards using those circuits. Thus, large amounts of therapy are provided within a short period of time in order to increase the “correlation of neuronal activity and thus frequency with which actions, objects, and words occur together” (Pulvermüller et al, 2005, p. 483). This is consistent with the fact that neurons and neuronal assemblies that fire in response to the same stimuli develop functional and structural connections with each other (i.e., “cells that fire together, wire together”, Hebbian plasticity, LTP). The massed practice principle of CIAT stems from this knowledge as is presented as follows: “It is advantageous to maximize quantity (number of therapy hours) and frequency (number of therapy hours per time) of language therapy” (Pulvermüller & Berthier, 2008, p. 566). The short but intense therapy schedule is also designed to reduce interference, or strengthening of other synaptic circuitry that supports alternate communicative behaviors.

Terminology. Use of the phrase “massed practice” can become problematic if interpreted strictly in the context of motor learning. In the motor learning literature, massed practice refers to the blocked repetition of a single task so that interference of exposure to irrelevant stimuli or activities is avoided (Nadeau et al., 2008; Schmidt & Lee, 2005). It is often discussed in contrast to distributed practice, which is the same amount of total practice, but with frequent and longer rest periods between repetitions (Nadeau et al., 2008; Schmidt & Lee, 2005). The latter has proven to be more effective at improving performance and facilitating generalization and retention of skills (Krakauer, 2006; Schmidt & Lee, 1999). Schmidt and Lee (2005) concede that even these labels are not entirely clear or absolute, as they are often used as relative terms to describe practice schedules within a specific experiment. It is certainly difficult to picture how one would adhere to the idea of “blocked repetition of a single task” in CIAT, when individuals are both sending and receiving messages, performing speech gestures with varying articulatory trajectories, and utilizing varied stimuli. Perhaps this is one of the reasons why “no speech-language therapy conforms to traditional definitions of massed practice” (Nadeau et al., 2008, p. 713).

The alternative terms frequently utilized are “intense” or “intensive”, and use of these terms is also problematic in the context of motor learning. In the aphasia literature, practice schedules described as “intense” have ranged from 3 to 20 hours a week; such time commitments are not equivalent to those employed in the physical therapy literature (i.e., CIMT) and thus use of the same term can be misleading. Also, in the motor learning literature, “intensity” refers to the number of repetitions per unit of time, so that translation of this definition to speech-language interventions would require investigators to focus on how many speech acts are produced per unit of time, instead of reporting how many overall hours were spent in treatment. Still, the terms “massed practice,” “intense,” and “intensive” are often used interchangeably to describe the practice schedules of both CIMT and CIAT. The Language Work Group (Raymer et al., 2008) recently proposed definitions in hopes of creating uniformity in research and discussion thereof. They use the term *intensity* to discuss the frequency of intervention (e.g., number of intervention hours per week). Their definition of *quantity* more closely relates to idea of intensity as presented in the motor learning literature (i.e., number of repetitions per unit of time).

Practice schedules. Practice schedules employed thus far in CIAT are: 3 hours of practice for 4 weekdays, for 2 weeks, for a total of 24 hours (Maher et al., 2006); 3 hours of practice on weekdays for 2 weeks, for a total of 30 hours (Meinzer et al., 2004; Meinzer et al., 2005; Meinzer, Obleser et al., 2007; Meinzer, Streiftau et al., 2007; Pulvermüller, Hauk, Zohsel et al., 2005; Richter et al., 2008); 3-4 hours of practice on weekdays for 2 weeks, for a range of 30-40 hours (Pulvermüller et al., 2001); and 3 hours of practice for 4 weekdays, for 3 weeks, for a total of 36 hours (Breier et al., 2006, 2007). The most recent variations in practice schedules include the following: four 75-minute sessions per week for 4 consecutive weeks, administered in an ABAB design, for a total of 40 hours (Goral & Kempler, 2008); and 3 hours of practice for 5 consecutive weekdays, for a total of 15 hours (Szaflarski et al., 2008).

Critique of Constraint-Induced Therapies

Generalization and Maintenance

Common critiques of CIAT and CIMT concern maintenance of acquired skills as well as generalization to real-world settings and situations. Taub (2004) claimed that participants demonstrate transfer of skills following participation in CIMT. Supporting results stem from studies that utilized methods of gauging treatment outcomes according to the clients' perspective of their activity levels. Wittenberg and colleagues (2003) found that CIMT "led to a degree of increased use of the affected side in the ADLs noticeable to the patient" based on Motor Activity Log (MAL) scores that were significantly different from the control group (p. 49). The greatest benefit from CIMT is consistently demonstrated by improvements on the MAL, but this self-assessment measure has not been proven psychometrically. Less benefit is observed when impairment is measured (Krakauer, 2006). There is also conflicting evidence from several studies in which individuals mastered simulated activities of daily living (ADLs) in the clinical setting but did not demonstrate transfer of this skill to more natural environments (Plummer, 2003) and observations that individuals quickly demonstrate marked deterioration of skills mastered in CIMT after therapy is terminated (Nadeau et al., 2008).

Similarly, Pulvermüller and colleagues (2001) reported significant differences between a CIAT group and a traditional therapy group on measures of communicative behavior in everyday life via the Communicative Activity Log (CAL), a measure modeled after the MAL that is also not tested psychometrically. Meinzer et al. (2005) administered the CAL to patients and caregivers and the Communicative Effectiveness Index (CETI) to caregivers to determine improvements in communicative effectiveness in everyday life. They observed significant improvements for recipients of CIAT and CIATplus that were maintained at 6-months follow-up. A shortened version of the CAL was utilized in the Szaflarski et al. (2008) study, and improvement on this measure was not observed post-treatment. Evidence for generalization and maintenance following CIAT is therefore weak, given the paucity of studies as well as the weakness of the measurement instruments. So, even though a tenet of CIMT and CIAT is that of behavioral relevance, there is some question as to how practice in the clinical or laboratory setting truly helps real-world functioning.

Discourse analysis for evidence of generalization? An improved approach for assessing generalization would entail measurement of spoken language abilities during conversational discourse in real-world settings. In lieu of that often impractical endeavor, measurement of communicative ability during structured discourse is often utilized, as specific analysis techniques (i.e., correct information unit [CIU] analysis; Brookshire & Nicholas, 1994; Nicholas & Brookshire, 1993) applied to structured discourse samples have emerged as reliable predictors of conversational abilities

(Doyle, Goda, & Spencer, 1995) and listener perceptions of informativeness (Doyle, Tsironas, Goda, & Kalinyak, 1996). CIU analysis has not been conducted in CIAT research to date, but findings from several formal and informal measures of discourse have been presented in the literature.

Maher et al. (2006) administered a story retell discourse measure pre-, post-, and 1 month following CIAT, and performed Quantitative Production Analysis on the language samples. Three of the four CIAT participants increased their number of words (range 9-60 word increase) but a decline was demonstrated by the remaining participant. Those same three participants increased their mean length of utterance (range .47 to 1.83 increase). Results were equivocal for the variables *number of utterances* and *number of sentences containing noun-verb structure*. Goral and Kempler (2008) administered a modified form of CIAT that emphasized verbs and utilized a more distributed treatment schedule to a single individual in an ABAB design. Despite the use of a SSD, dependent variables were not continually assessed throughout the experiment to chart response to CIAT and maintenance, rather data were recorded before the experiment and after each phase. The researchers examined narrative discourse, but did not report the use of a commonly used convention for analysis. Samples were transcribed and coded for words by grammatical category, and they looked specifically for increases in the following: words, treated elements (verbs), untreated elements (nouns), and verb-noun ratio. According to the authors, overall productivity of words was variable, and noun production did not show a pattern of change in response to CIAT. The number of verbs increased following both treatment blocks. The participant demonstrated an increase in verb-noun ratio from a pre-treatment .097 to .20 by the end of the study. Lastly, Szaflarski et al. (2008) administered 1 week of CIAT (3-4 hours/day) to three participants. They conducted a linguistic analysis of the BDAE fable retell only for the two participants with nonfluent aphasia, reporting average increases of 3.5 utterances, 25 words, and 20 word roots. Lexical diversity for the retell task, as measured via type-token ratios, increased for one participant and decreased for the other.

These findings illustrate that CIAT can result in increases in number of total words and utterances during discourse. However, the absence of precautions taken to guard against practice effects or the establishment of stable baselines greatly reduces the strength of the findings. The CIAT research base would benefit from a careful analysis of performance on discourse measures in response to treatment after a stable baseline has been established, as well as replication across subjects and studies utilizing a common and empirically supported method of analysis.

Treatment Elements

Another critique of both CIMT and CIAT is that even though they both have a set of principles around which to design therapy, it is not known if all of the principles are necessary to produce results. If not, then which principle or principles are contributing? Both clinical and functional imaging outcome data provide support for the massed practice principle (Bhogal et al., 2003; Meinzer et al., 2004; Meinzer et al., 2005; Plummer, 2003; Sterr et al., 2002; Teasell & Kalra, 2004). Generally, more practice leads to improved outcomes, but it remains to be determined if the constraint is a necessary component, or if individuals can intensively practice any communicative behavior. Research suggests that therapy which targets lost abilities (i.e., remediative in nature) is most effective (Pulvermüller et al., 2001; Teasell & Kalra, 2004; Thompson, 2000), which lends support to the inclusion of constraint. Maher and colleagues (2006) have demonstrated that if the massed schedule and therapy activities are kept constant, then forced use of spoken language does lead to greater gains in improvement. Conversely, Meinzer et al. (2004) compared CIAT to model-orientated aphasia treatment (MOAT), which did not incorporate constraint, with equivalent behavioral and neural results. When alternative modes of communication for the purpose of facilitating spoken language were allowed (Meinzer, Streiftau et al., 2007), participants still demonstrated statistically significant improvements on measures of language impairment. The latter two reports suggest that intensity of practice is the most important factor, which is supported by evidence from the CIMT literature (Sterr & Freivogel, 2003). There are no studies in the CIAT literature carefully looking at the differential contribution of intensity of practice versus constraint to treatment outcomes, nor are there studies in existence that look at the effects of a more intensive practice schedule (beyond the currently studied 24-36 hours within 2-3 weeks). When Goral and Kempler (2008) administered their modified CIAT on a distributed practice schedule to a single participant with chronic non-fluent aphasia, the only improvement observed on standardized measures was an increase of 17 percentile points on an auditory comprehension subtest. The authors also reported the following: improved naming of trained verbs; generalization of use of trained and untrained verbs during discourse; and no evidence of generalization to nouns.

Closer inspection of practice schedules reveals further weaknesses in the available research. Individuals participate in CIMT for an average of 6 hours daily

(Taub, 2004), during which time they engage in repetitive practice of functional movements (Fritz, Light, Patterson, Behrman, & Davis, 2005; Light, 2007; Taub, 2004). When this temporal component of the intervention was translated to CIAT, the amount of within-clinic time was cut in half with no explanation as to how it was determined. It seems that the idea of the "intensity" of treatment (i.e., number of repetitions per unit of time) has been ignored, with most accepting the 3-hour daily practice as evidence of the intensive nature of the intervention. However, there exist no data to date regarding the quantification of the practice time during that 3-hour daily practice period (i.e., the number of turns taken by individuals in CIAT). Similarly, the entire body of CIAT literature includes groups composed mostly of either 2 or 3 members (though some studies involve 1:1 administration of CIAT), but the idea that individuals in 2-member groups are likely to participate in more turns over a 3-hour period than those in 3-member groups, and are thus receiving a more intensive treatment, has not been addressed. One study provided raw data that allowed discernment of group membership in order to begin addressing this question of intensity of practice (Meinzer, Streiftau et al., 2007). Authors defined dyads as 2 individuals with aphasia participating in group therapy with 2 clinicians present, 1 of which participates in the game while the other clinician provides cues. A triad was 3 individuals with aphasia participating in group therapy with 2 clinicians with the same responsibilities. This study compared groups of participants who received CIAT when administered by a therapist versus a trained layperson. No significant differences were observed between groups, and the majority of individuals achieved statistically significant differences between pre- and post- test profile scores. Inspection of pre- and post- test *t*-transformed Aachen

Aphasia Test raw scores reveals the following: individuals who participated in CIAT when administered by a therapist or a trained layperson (N=8) in dyads improved profile scores an average of 3.075 points (range 1.1 – 5.9); those in triads (N=12) improved profile scores an average of 2.367 points (range 0.6 – 3.8). This finding, however slight the difference in scores, warrants further investigation of dosage.

In all other reports of CIAT, it is difficult to determine group membership, and with the exception of the aforementioned study, investigators have not taken the care to separate the data in this manner. Though not specified in many manuscripts, it seems a therapist is always a member of the game, so that a 2-member group can usually be interpreted to mean 2 individuals with aphasia plus at least 1 clinician playing the game. There are exceptions – the Breier et al. (2007) describes a "dyad" that involves only one individual with aphasia, the other member presumably the clinician, so that this is interpreted to be equivalent to 1:1 CIAT. The Richter et al. (2008) study administered CIAT in either a "two-person group setting," which could be interpreted in two ways (i.e., 2 individuals with aphasia playing a game with a clinician or 2 individuals with aphasia playing a game with each other and a clinician only involved in the shaping), or a 1 participant:2 therapist setting.

Treatment Fidelity

Discussions of generalization and schedule of practice highlight the glaring lack of attention to treatment fidelity within CIAT research. Establishing treatment fidelity is important for ensuring internal and external validity, and for avoiding the occurrence of a Type 3 error, defined as "concluding that the intervention is ineffective, when in fact it was never implemented" (Nigg, Allegrante, & Ory, 2002, p. 674). The National Institutes of Health has recently established a treatment fidelity workgroup within the Behavior Change Consortium (BCC) in recognition of this pervasive problem in behavioral research. This workgroup is tasked with defining treatment fidelity and offering guidelines for researchers (Bellg et al., 2004; Nigg et al., 2002). According to the BCC, establishing treatment fidelity should address the following five areas: study design, standardized provider training, treatment delivery, treatment receipt, and treatment enactment or adherence (Bellg et al., 2004). CIAT researchers have violated all areas of treatment fidelity research except for treatment receipt, in that they have not ensured equivalent doses of therapy, standardized provider training, ensured adherence to a treatment protocol, or ensured transfer of treatment skills to real-life settings. Therefore, CIAT findings should be rightfully questioned due to lack of attention to treatment fidelity, because significant findings could simply be a result of “unknown factors that may have been unintentionally added to or omitted from the treatment” (Bellg et al., 2004, p. 444) and not the actual treatment package. Conversely, insignificant findings that would lead readers to believe that the treatment is not effective could result simply from poor adherence to the treatment protocol, and not be due to a poor treatment approach (Bellg et al., 2004).

The Present Study

Summary and Statement of the Problem

Participation in aphasia therapy generally results in positive outcomes. However, answering such a simplistic question is inadequate, and the aphasia literature base as a whole does a poor job of answering the questions Darley (1972) posed nearly four decades ago. CIAT research in particular makes bold claims about the efficacy of the approach, but pervasive methodological problems throughout the literature detract from the impact of those claims. Missing from the evidence base are well-controlled studies employing repeated measures to track individual participant performance over time. Group data can be misleading, as reports of statistically significant change can correspond to a group whose members demonstrated less than 1 point change, no change, or even negative change post-treatment. Individual data are rarely presented, and if so, are not compelling. When it is available, a majority of CIAT participants demonstrate small improvements of statistical significance on one or more subtests of language impairment. Still, these statistically significant differences inform only that the results were unlikely to have occurred by chance (Keppel & Wickens, 2004; Ogles, Lunnen, & Bonesteel, 2001), and provide no information about whether or not the differences between groups, or the differences between pre- and post- treatment data, are large or meaningful (Sloan, Symonds, Vargas-Chanes, & Fridley, 2003). Maher et al. (2006) attempted to address this issue of "meaningfulness" by requiring a change of 5 points or more on the WAB AQ, which is equivalent to a change score of approximately a half of a standard deviation [SD], or a medium effect size (d = .5). The use of effect sizes to describe the magnitude of differences between two distributions is in fact the most common method for reporting change of *practical* significance (Kirk, 1996, 2007; Thompson, 1998). Within the same study, a change score of 2 SDs or more on the BNT and ANT was required, which is actually one method utilized for determining *clinical* significance (Evans, Margison, & Barkham, 1998), a more nebulous construct described broadly by Kazdin (1982) as change that is clearly evident in the individual's everyday life. Practical and clinical significance have not been systematically addressed in the aphasia treatment or CIAT literature, but these constructs could potentially be useful indicators for determining the true impact of a treatment approach.

As discussed, response to CIAT is most often measured via standardized measures of language ability, with a glaring lack of evidence demonstrating positive outcomes in terms of activity or participation limitations. Data regarding acquisition and maintenance of trained behaviors, as well as generalization to untrained behaviors, is also scarce. This is particularly intriguing because CIAT involves not only the acquisition of new vocabulary, but also the use of new vocabulary within the discourse acts of requesting, affirmatively responding to requests, denying requests, and clarifying responses and requests. Still, there is little emphasis on ensuring that individuals who receive CIAT actually improve the behaviors they spend so much time practicing or if they generalize acquired skills to other behaviors or settings. The failure to establish treatment fidelity calls into question CIAT findings as well, because evidence that CIAT was administered as intended has yet to be provided.

Research Hypotheses

The present study was designed to replicate previous CIAT research while systematically addressing these weaknesses and ensuring adherence to the CIAT protocol described in the method. The effect of CIAT on standardized measures of language ability, functional communication, and quality of life will be examined. In addition, continuous assessment of dependent variables will take place to ensure that improvements in naming and discourse behaviors can be attributed to CIAT and not other extraneous factors. Specifically, this study seeks to test the following hypotheses regarding anticipated behavior changes in response to CIAT:

1. Participants will demonstrate change of practical significance on standardized measures of language ability, functional communication, quality of communication life, and depression.
2. Participants will demonstrate improvement on behaviors trained in treatment, specifically practically significant improvement on naming of trained items as well as increases in levels of syntactic complexity.
3. Participants will demonstrate generalization to naming of untrained items within trained and untrained categories.
4. Participants will demonstrate generalization to discourse, as judged by change of practical significance in measures of informativeness of speech in untrained discourse samples.

In addition, this study will be the first to provide dosage information in the form of turn data for each participant. The relationship between number of turns and magnitude of improvement will be explored.

CHAPTER 2

METHOD

Participants

Six adults who met the following inclusion criteria participated in this study: diagnosis of mild to severe fluent or non-fluent aphasia as a result of a left hemisphere stroke, time post onset at least 4 months, between 18 and 85 years of age, at least a high school education, premorbidly right handed, one upper extremity sufficiently intact to manipulate treatment materials, corrected or uncorrected visual acuity of at least 20/40 as measured by the Snellen chart, and the ability to pass an audiometric screening, aided or unaided, at 500, 1000, 2000, and 4000 Hz at 40 dB HL in at least one ear. To ensure adequate cognitive abilities, participants were excluded if they had a history of other cognitive deficits according to neurological and caregiver report, and they were also required to demonstrate the following performance on at least 1 of the following measures: a score of 65 points or greater on the WAB-R auditory verbal comprehension score, a score of 17 or greater on the Benton Judgment of Line Orientation, or at least 65% accuracy on the iconographic symbol matching task. Individuals with comorbid apraxia of speech or cognitive deficits according to standardized measures were not excluded, though the severity of their deficits was documented. Individuals with severe depression, defined as a score of 10 or greater on the Geriatric Depression Scale Short Form (e.g., Akamatsu et al, 2005; Kuzuya et al.,2006; Ravina et al., 2007; Wada et al., 2004), were also to have been excluded from this study. All participants were asked to temporarily discontinue participation in other interventions until the study was complete. All sessions were conducted at no cost to the participants. Participant characteristics are presented in Table 1 (at the end of this chapter), and each participant is described in the following section.

P1 was a 63-year-old male, 13 months post stroke at the onset of the study. Prior to his stroke, he had completed a bachelor's degree, and he worked as a building contractor. At the onset of this experiment, he presented with severe Broca's aphasia, severe apraxia of speech, and mild oral apraxia. His spoken language was mostly unintelligible, characterized by distortions, additions, substitutions (primarily with bilabials), and the overuse of intelligible low content filler words (e.g., "and then," "that," "this," numbers). He also demonstrated moderate recurrent perseveration. Auditory comprehension was relatively spared compared to expressive abilities but was still compromised. Reading comprehension and writing were relative strengths for this participant. He exhibited residual hemiparesis of his right extremities and mild limb apraxia; though ambulatory with a cane for short distances, he utilized a wheelchair the majority of the time. He lived at home with his fiancé, a former nurse who was temporarily serving as his full-time caregiver and brought him to therapy. Upon enrollment in this study, he temporarily withdrew from speech-language therapy he had been receiving 1 to 2 days a week at a nearby hospital. That therapy had focused on the use of gestures and sign language as compensatory modes of communication.

P2 was a 52-year-old male who experienced a stroke 22 months prior to enrollment in the study. Prior to his stroke, he had earned a bachelor's degree and worked as a logistics director. At the onset of this experiment, he presented with moderate Broca's aphasia and mild apraxia of speech. His speech and language was characterized by agrammatism, word-finding difficulties, a distorted vowel system, substitution of voiceless for voiced sounds, epenthesis, and addition of /h/ or /s/ in front of vowel-initial words. Reading comprehension at the single word to short sentence level was a relative strength for this participant. Auditory comprehension and writing deficits were present. He lived at home with his spouse and drove himself to treatment. Before this study, he had not received speech-language services for at least 6 months but volunteered once weekly as a peer mentor for new stroke survivors. Previous therapy was reported to focus on speech sound errors, auditory comprehension, use of a communication book, and naming. He had also previously been enrolled in research studies at the University of Georgia that involved alternative approaches to recovery (Spring 2008) and intensive administration of traditional aphasia therapy (Fall 2007).

P3 was a 70-year-old male who was 15 months post onset of his most recent stroke. He had experienced five strokes, only 2 of which resulted in communication difficulties. The first of these occurred in 2001 and led to slight word-finding difficulties and what the participant described as an "accent." Before his first stroke in 1977, he had earned a college degree and worked as a computer programmer. More recently, he was receiving disability and worked as a bagger at a grocery store. At the onset of this study, he presented with moderate anomic aphasia, moderate-severe apraxia of speech, and mild oral apraxia. His speech and language was characterized by word-finding difficulties, a distorted vowel system, substitution of voiced for voiceless sounds, restarts, hesitations, and phoneme and syllable repetitions. Reading comprehension, writing, and auditory comprehension were areas of strengths for this participant. He exhibited some residual hemiparesis of his right extremities, but he was ambulatory and able to drive. He lived at home with his wife. Before this study, he had not received speech-language services for at least 6 months, but he attended a monthly peer-led conversation group, which he temporarily suspended during his involvement in this study. Previous therapy had focused on speech sound errors, word-finding, and the use of written language as a complement to residual spoken language abilities.

P4 was an 83-year-old female, 16 months post stroke at the onset of the study. Prior to her stroke, she had earned a bachelor’s degree, taught for many years, and retired from teaching. At the onset of this experiment, she presented with mild anomic aphasia and mild apraxia of speech. Her speech and language was characterized by distortions, word-finding difficulties, mazes, hesitations, and restarts. Reading comprehension, writing, and auditory comprehension were areas of strengths for this participant. She lived alone and was able to drive to therapy. She had not received speech-language services for at least 2 months before enrollment in this study. Previous treatment had focused on speech sound errors, word-finding, and money management.

P5 was a 57-year-old male who had a stroke 7 months prior to enrollment in the study. Prior to his stroke, he had completed high school, and he owned several office supply distribution warehouses. At the onset of this experiment, he presented with severe fluent aphasia, moderate apraxia of speech, and moderate oral apraxia. Further subtyping of aphasia was difficult. His speech was characterized as “empty” because of his overuse of stereotypical utterances (e.g., “It’ll be like this, like this and this and this, like this in the morning time”), but he demonstrated very few neologisms. Some paraphasias were present, but he mostly produced indefinite low content words with little self-correction and repair, and yet he demonstrated awareness that his output was not informative. He also presented with severe recurrent perseveration and moderate apraxia of speech with accompanying oral and limb apraxia. Deficits in auditory comprehension, reading, and writing were evident. He exhibited residual spastic hemiparesis of his right extremities but was ambulatory with a walker. He lived at home with his wife and was brought to treatment by a team of friends and family. His home-health speech-language services, which had focused on naming and auditory comprehension, expired two weeks before enrollment in this study.

P6 was a 55-year-old male who was nearly 6 months post stroke. Prior to his stroke, he had earned a bachelor's degree and worked as a telecommunications manager. At the onset of this experiment, he presented with moderate Broca's aphasia, moderate-severe apraxia of speech, and mild oral apraxia. Speech was characterized by reduced rate, markedly increased latencies for retrieval, effortful production, word-finding difficulties, and repetition of low content filler words or carrier sentences (e.g., "It is," "that is," "I want to say"). Auditory comprehension was a relative strength for this participant, whereas both reading and writing abilities were affected. He also presented with spastic hemiparesis of the right extremities and utilized a wheelchair. He lived at home with his spouse and daughter, but he stayed with family near the university for the majority of the experiment. A team of family members brought him to the daily sessions. Upon enrollment in this study, he temporarily withdrew from speech-language therapy he had been receiving 3-hour sessions 1 to 2 times a week at a metropolitan hospital. The focus of that therapy had been increasing verbal expression and use of gestures.

Materials

Standardized Assessment Measures

Limitations of Body Structure and Function

The Aphasia Quotient (AQ) subtests of the Western Aphasia Battery – Revised (WAB-R; Kertesz, 2007) were administered pre-treatment to determine the type and severity of aphasia, and post-treatment for comparison. The WAB-R has been used in most of the Northern American studies of CIAT and is also recommended by the Agency for Healthcare Research and Quality (Biddle, Watson, Hooper, Lohr, & Sutton, 2002). Though Kertesz did not re-standardize the revised assessment battery, he did conduct a pilot study in 2005 with 14 participants with aphasia and determined that replacement or modified items were comparable in terms of complexity and frequency of use (Kertesz, 2007). The original WAB standardization sample demonstrated good test-retest reliability and internal consistency (r=.99, p $\leq$ .001; and r=.91, p $\leq$ .001, respectively), and good criterion-related validity (r=.96) with the Neurosensory Center Comprehensive Examination for Aphasia (NCCEA; Spreen & Benton, 1977).

The Benton Judgment of Line Orientation (BJLO; Benton, Varney, & Hamsher, 1978), a measure of "spatial thinking" skills, was used to assess cognitive abilities. The BJLO reports a test-retest reliability coefficient of .90 in typical adults, and has been administered to individuals with cortical lesions. A score of 16 or below (out of 30) is considered "severely defective" in the typical population, and 49 of the 50 individuals with left hemisphere lesions in the sample scored a 17 or higher. During standardization, none of the individuals with aphasia secondary to a left hemisphere lesion performed in the “defective” range; however, this excluded individuals with aphasia who could not understand the instructions to complete the task.

Limitations of Activity

The Communication Activities of Daily Living – Second edition (CADL-2; Holland, Frattali, & Fromm, 1999) was administered pre-treatment to provide information about how individuals with aphasia perform functional communicative acts (speaking, reading, writing, daily planning) in simulated natural communicative activities of daily life, and post-treatment for comparison. This 50-item measure reports good test-retest reliability and internal consistency (r=.89 and r=.93, respectively). The CADL-2 and the CADL have been used in many of the Northern American studies of aphasia treatment, and they are recommended by Spreen and Risser (2003) in their review of aphasia assessment instruments.

Limitations of Participation

The ASHA Quality of Communication Life Scale (ASHA QCL; Paul et al., 2004) was administered pre- and post- treatment to determine the impact of aphasia on the following: relationships, communication interactions, participation in social, leisure, work, education activities, and overall quality of life. This 18-item visual analog scale is designed specifically to assess the “extent to which a person’s communication acts…allow meaningful participation in life situations” (Paul et al., 2004, p.1). This instrument does not report reliability or validity in accordance with standard conventions, though factor analysis of pilot testing results was performed to establish reliable internal structure. Though the psychometric properties of this instrument are not yet established, it is currently the only self-assessment QOL instrument designed specifically for individuals with language impairment, and thus was selected for use in this study.

The Geriatric Depression Scale Short Form (GDS-15; Sheikh & Yesavage, 1986) is a 15-item dichotomous scale of mood that was administered pre- and post- treatment to document the presence and severity of depression. This self-administered scale is described as a valid screening instrument for use in elderly patients, correlating well (r=.82 and r=.78) with scores on the Montgomery Asberg Depression Rating Scale (MADRS) in 2 separate studies (Almeida & Almeida, 1999; Herrmann et al., 1996). GDS-15 scores also correlate with scores from the original 30-item GDS (r=.84; Herrmann et al., 1996; Sheikh & Yesavage, 1986), which reports internal consistency of .94, test-retest reliability of .85, and high criterion-related validity with the Zung Self-Rating Depression Scale (r=.84) and the Hamilton Rating Scale for Depression (r=.83) (Yesavage et al., 1983). Modifications were made (e.g., large print, large yes/no icons available for pointing, etc.) to the GDS-15 to ensure participant comprehension of the questions and the task.

Other

The Apraxia Battery for Adults – Second edition (ABA-2; Dabul, 2000) and the Color Trails Test (CTT; D'Elia, Satz, Uchiyama, & White, 1996) were administered pre-treatment to further characterize the participants in the study. All ABA-2 subtests were administered to assess the presence and severity of apraxia. This instrument reports internal consistency for each subtest, and the r ranged from .83 - .99. Test-retest reliability was not reported. The ABA-2 is considered a valid measure of apraxia because it consistently differentiates between individuals with and without motor speech impairments and also demonstrates statistically significant correlation coefficients between subtests.

The Color Trails Test (CTT) was administered as a measure of cognitive ability, specifically sustained visual attention and frontal systems functioning. This test was modeled after the Trail Making Test (TMT), utilizing color instead of English alphabet letters in an attempt to rely less upon language abilities. CTT trial 1 requires participants to rapidly connect circles with numbers 1-25 in sequential order with no attention paid to the color of the circles. CTT trial 2 requires participants to perform the sequential ordering task again, but each consecutive number must be alternatively pink or yellow (e.g., odd numbers are pink, even numbers are yellow). The CTT is considered a valid measure of cognitive ability as it differentiates between individuals with and without cognitive impairment secondary to TBI and HIV-1, and also maintains the psychometrically sound properties of the well-established TMT.

Nonstandardized Assessment

An iconographic symbol recognition task (ISRT), modeled after that described by Thorburn, Newhoff, and Rubin (1995), was administered during the intake session. Each individual was shown a Picture Communication Symbol (PCS; Mayer-Johnson, 2007) on a 3 x 5 card and asked to select the matching pictured object from a field of four picture cards. The 20 symbols selected for the task were all concrete nouns of medium-to-high frequency. The ISRT task utilized by Thorburn et al. (1995) was shown to be reliable in normal controls, and similar performance was noted in individuals with aphasia, $F(1,16)=.727$, $p>.406$, with the variance explained by aphasia ($\omega^2 =.0975$). The data sheet with instructions for administration and the pictures are in Appendix F.

Stimuli for Repeated Measure: Picture Naming

Target stimuli for both assessment and intervention were selected according to their frequency of occurrence in written English language (Kucera & Francis, 1967) from the MRC Psycholinguistic Database. Most studies to date utilizing this database discuss their target selection in terms of high frequency (*f*: 26-242) and low frequency (*f*: 1-8). Excluded are medium frequency words (*f*: 9-25), likely because there are not enough exemplars in this category to create stimuli sets and also to compare performance on the extremes of frequency. A portion of medium frequency words were used in this study to ensure an adequate amount of training and generalization stimuli. An arbitrary cut-off was determined by this author so that high frequency words in this study have a frequency count of 22-242 and low frequency words have a frequency count of 1-13. Medium frequency words with a frequency count of 14-21 were excluded in order to maintain some division between the extremes of frequency. In addition, all words selected have high concreteness ratings (between 400 and 700) according to database references. Attention was paid to this variable in target selection because increased concreteness of words is suggested to increase reaction times, accuracy of response, and comprehension (Lee & Federmeier, 2008).

Four categories (clothing, household items and furniture, kitchen items, transportation and travel), with eight high frequency pictures and eight low frequency pictures per category, were selected for use for treatment (see Appendix G). The high frequency pictures have an average frequency count of 69.97 (+/- 49.62) and a range of

22-198 across all categories. The low frequency pictures have an average frequency count of 6.5 (+/- 3.98) and a range of 1-13 across all categories. Individual descriptive statistics for each category are listed in Appendix G. Picture stimuli utilized for treatment are comprised of 1-6 pictures per 3 x 5 card, utilizing pictures available via Microsoft Office picture databases (see Appendix H for sample treatment cards).

Twenty additional high frequency (*M* = 69.85, range= 22-193, *SD* = 49.29) and 27 low frequency (*M* = 6.37, range = 1-13, *SD* = 3.61) targets within the chosen treatment categories were withheld for generalization. In addition, 22 high frequency (*M* = 56.8, range = 23-122, *SD*: 32.10) and 27 low frequency (*M* = 5.89, range = 1-13, *SD*: 4.26) targets within two untrained categories (animals, body parts) were withheld for generalization (see Appendix I). Picture stimuli utilized for repeated measures assessment are comprised of a single picture represented on a 3 x 5 card, utilizing the same picture database (see Appendix J for sample probe cards). The data sheet for the picture naming probe is presented in Appendix K.

Stimuli for Repeated Measures: Discourse

Three tasks were utilized to measure generalization to discourse. The picture stimuli utilized were the kite picture from the Minnesota Test for Differential Diagnosis of Aphasia (MTDDA; Schuell, 1972) and the fireman picture from Nicholas and Brookshire (1993), both presented in Appendix L. Participants were also asked to describe an imaginary New York City vacation (see Appendix M; Harris et al., 2008).

Treatment Materials

Eight target words in 4 categories (clothing, household items and furniture, kitchen items, transportation and travel) were selected for use, and these words are represented twice in each deck with varying descriptors (see Appendix G) to enable more complex utterances. For example, the category “transportation” includes the target picture “truck,” which is depicted on cards as either “one red truck” or “two green trucks.” Thus, each category contains 8 target words represented twice within a deck with different descriptive terms (number and color), constituting 16 identical pairs of pictures within a category so that each deck contains 32 cards. Eight target low frequency words in the same 4 categories were also selected for use for participants (P3 and P4) who demonstrated a high degree of accuracy with the high frequency stimuli; each category deck similarly contains 8 target words represented twice within a deck with different descriptors, making 16 identical pairs of pictures within a category deck of cards. Barriers were placed between participants for selected activities so they could not view the other’s cards.

Dependent Variables

In addition to the standardized measures described in previous paragraphs (WAB-R, CADL-2, ASHA-QCL, GDS-15), which were administered at the beginning and at the end of the study, naming and discourse behaviors were continually assessed throughout all phases of the study. Dependent variables therefore included the following.

Naming

Naming score for trained items (N-T). Following presentation of stimuli for this dependent variable, the naming score for trained items was derived via the following system: If the participant produced an intelligible word that could be understood without context even with distortions, omissions, substitutions, and/or additions, it was marked as correct. Two points were awarded if a correct response was given within 5 seconds. A delayed correct response given within 20 seconds earned 1 point. Individualized sets of stimuli for each naming probe were determined for each participant (see Procedures for details). Sixteen 16 N-T stimuli were presented within each naming probe session, for a total of 32 possible points.

Naming score for generalization items within a trained category (N-GT). Ten pictures were presented within each naming probe session to determine the naming score for untrained (generalization) items from within trained categories, for a total of 20 possible points. The same scoring system described above was applied.

Naming score for generalization items within an untrained category (N-GUT). Ten pictures were presented within each naming probe session to determine the naming score for untrained (generalization) items from within untrained categories, for a total of 20 possible points. The same scoring system applied.

Discourse

Analysis of CIUs was selected because it is a proven method of reliably reporting the informativeness of connected speech of individuals with aphasia (Brookshire & Nicholas, 1994; Doyle et al., 1996; Nicholas & Brookshire, 1993). Nicholas and Brookshire (1993) reported good interjudge reliability (98% for words, 90% for CIUs) when judges were provided with the rules for counting and scoring that they made available in their appendix. Specifically, %CIUs was judged to be the most stable variable across repeated administration (Brookshire & Nicholas, 1994; Nicholas & Brookshire, 1993) and has proved to be an accurate predictor of how individuals with aphasia will perform in conversational speech conditions, accounting for 82% of the variance between structured sampling versus conversational sampling conditions (Doyle et al., 1995). Because longer speech samples produce increased test-retest reliability (Brookshire & Nicholas, 1994), the data from the 3 discourse samples were collapsed into one speech sample. Calculation of the following variables ensued in order to determine the effects of CIAT (which involves repeated production of discourse acts of requesting, responding, denying, and clarifying) on discourse and function in real-world settings, topics yet to be adequately addressed in the CIAT literature.

Percent correct information units (%CIUs). CIUs and words were identified in accordance with operational definitions and rules presented by Nicholas and Brookshire (1993). The total number of CIUs from the combined discourse samples were divided by the total number of words from the samples, and multiplied by 100 to obtain the percentage.

Total CIUs (TCIUs). Total CIUs is a measure of the total number of CIUs produced by the participant during a discourse probe session, regardless of the duration of their discourse samples or if they required encouragement or prompts to continue.

CIUs per minute (CIUs/min). Each discourse sample was timed and combined to determine the total time (in minutes) elapsed for all 3 discourse samples for each probe session. TCIUs was then divided by the total elapsed time to determine how many CIUs were produced per minute (CIU/min).

Procedure

Pre-Experimental Procedures

Telephone Screening

A telephone interview was conducted to determine certain inclusion variables (i.e., age, time post onset, education, premorbid handedness, and history of dementia and learning disability). As detailed in the telephone questionnaire (Appendix N), participants were first provided with a brief introduction to the research study and its demands. They were then asked if they wished to proceed with the telephone interview. If they refused, the telephone interview was concluded, and all information collected to date was destroyed. If they consented, they were asked to confirm their agreement. These two verbal affirmations, as well as the participant's continued presence on the phone, signaled the investigator to proceed with the telephone interview. At the completion of the telephone screening interview, participants who met the inclusion criteria it assessed were scheduled for the first face-to-face meeting.

Informed Consent Process

At the initial face-to-face meeting, the experimenter reviewed a one-page written outline of the study procedures (Appendix O) with the participant in the presence of another adult (family member, friend, or caregiver) who did not have impaired speech or language comprehension or production. Participants were required to answer several questions about the experiment to ensure their comprehension. A specialized consent form utilizing pictures and a reduced reading level was created for this study (Appendix P) and was approved by the Institutional Review Board of The University of Georgia. The experimenter read through this informed consent form with the participant and the other adult, highlighting each of its points. When all three persons agreed that the participant understood the consent form, the participant was asked to sign two copies. Participants were provided a copy of the summary of the study procedures and the consent form. At the beginning of the second session, the experimenter again offered to answer any questions the participant or the caregiver had about the study. Questions asked generally concerned the schedule of administration.

Initial Assessment and Formation of Groups

All participants who completed the informed consent process and agreed to participate in the study were then assessed with the standardized and non-standardized measures described in the Materials section to determine their inclusion in the study. Assessment occurred in one blocked session, during which short breaks and refreshments were frequently offered. Treatment dyads were formed on the basis of aphasia severity, as improvement has been shown to rely upon this variable rather than variables such as age, gender, or type of aphasia (Elman & Bernstein-Ellis, 1999; Meinzer, Streiftau et al., 2007). This meant that individuals with mild or moderate aphasia were grouped together, and individuals with moderate or severe aphasia were grouped together, but individuals with mild or severe aphasia were not assigned to the same group.

Identification of Individualized Stimuli

All high frequency targets (N=32; see Appendix G) were presented to each individual in the initial assessment session to identify individualized picture naming stimuli to be used for probes in this experiment. Individuals who performed with a high degree of accuracy on these targets were presented with low frequency targets as well.

Sixteen of the items on which they performed most poorly comprised their individualized set. To determine which picture stimuli to use for untrained items, all generalization stimuli (see Appendix I) were presented to each individual in the initial assessment session. Twenty of the items on which they performed most poorly, 10 within a trained category and 10 within an untrained category, comprised their individualized set. Naming probe stimuli for each participant are listed in Appendix Q.

Experimental Procedures

A modified single-subject, multiple-baseline across individuals design consisting of a baseline (A1), treatment (B1), and withdrawal phase (A2) was utilized. It was necessarily modified in order to replicate the schedule of administration of previous CIAT studies; thus, treatment did not continue until participants reached a certain criterion of performance but was continued until, and was discontinued after, each participant had received 10 consecutive weekdays of CIAT. Treatment was not initiated for Dyad 1 until both individuals demonstrated stability for a singular dependent variable of interest, %CIUs. Dyad 2 was required to maintain stability on the same probe for an additional two baseline sessions before exposure to treatment. Dyad 3 participated in the experiment approximately 1 month after Dyads 1 and 2. A multiple-probe design (Horner & Baer, 1978) was incorporated to avoid excessive probing, as habituation of responses when probe sessions were administered daily was observed in previous research (Richardson & Marshall, 2008). This approach has recently been implemented in CIAT research (see Breier et al., 2006).

Phase A1: Socialization Baseline

To control for the effect of increased socialization on treatment outcomes, all dyads began the experiment by participating in daily 2-hour nonspecific control sessions that involved participation in games, activities, and discussion with another individual with aphasia, the experimenter, and another trained researcher. Games were commercially available and were chosen for their reliance upon spatial and mathematical abilities. Other activities included puzzles, sorting tasks, and educational mini-sessions about issues of individuals with aphasia (rights, emotions, compensatory strategies, communication books, etc.).

Probe sessions were also administered during this phase before baseline sessions on a variable schedule. It was explained to participants that feedback regarding correctness of answers would not be supplied during probe administration, though encouragement and prompts to continue were provided (see Appendix R for script for introducing probe tasks). Following the initial probe administration, probe administrators used phrases such as “pretend you are telling me what the pictures are for the first time.” Probe sessions were divided into two parts – naming and discourse – and the order in which they participated in these parts was randomly ordered.

A trained research assistant administered the individualized naming probe that included 16 N-T, 10 N-GT, and 10 N-GUT items. For the first administration, the 36 cards were presented in random order. They were shuffled before all later probes. Three additional tasks that assessed generalization of skill to discourse via the dependent variables %CIUs, TCIUs, and CIUs/min were administered in random order by the experimenter (Appendices M and N).

All participant responses were transcribed online and also reviewed afterwards by the experimenter and trained judges via videotaped recordings. The initial baseline phase continued until both individuals in Dyad 1 demonstrated stability (defined as no more than 30% fluctuation across baselines and no more than 10% rise in the last baseline; Edmonds & Kiran, 2006; Kiran, 2008) for %CIUs for the 3 combined discourse samples.

Phase B1: Treatment for Dyad 1

Throughout treatment, naming and discourse probes continued to be administered 3-4 days a week before daily CIAT sessions. The independent variable, CIAT, was administered to Dyad 1 (P1 and P2) following participation in three baseline sessions. Dyad 2 remained in baseline conditions. The experimenter and trained research assistants facilitated each daily 3-hour therapy session. The experimenter introduced activities, provided feedback and cues, and facilitated navigation through the levels of syntactic complexity described below. The research assistants participated in games with the participants and modeled target behaviors.

Participants wore name tags for the first few days of therapy to enable development of rapport and to facilitate use of names during the game. The majority of therapy sessions were spent playing the card game described in the introduction (Go Fish). Each category card set was introduced at least 2 times before the games began. For example, the first two times the “kitchen items” cards were utilized, all target words were modeled by clinician (item, color, number) and the clinician modeled sentence structure for both requesting and responding. Visual/graphic aids were utilized as well for teaching of the concepts. A sample script for portions of the intervention is listed in Appendix S.

Following initial reviews, the cards within the selected category were distributed among participants, including the participating research assistant. The participants were initially encouraged to use as much speech and as many descriptors as possible when requesting or responding, so individual levels of syntactic complexity could be determined (see below). Other activities employed during breaks between the dual card task included naming drills, 20 questions, memory/matching, and picture description, all within the four categories selected for training. Participants were encouraged to work together to provide as much detail as possible about stimuli during picture description activities.

Reinforcement contingencies. Reinforcement contingencies were individually adjusted according to each participant's level of performance in order to gradually reduce the level of scaffolding provided by the clinician so each participant became more independent (Breier et al., 2006; Breier et al., 2007; Maher et al., 2006; Meinzer, Streiftau et al., 2007 ; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005). Throughout the assessment process, baseline sessions, and the initial CIAT session, the experimenter discarded ineffective cues and determined an individualized hierarchy of cues for each participant that provided the least to the most support. Commonly used cues, and their coding system for data collection purposes, are listed in Appendix T. The frequency of cueing was also manipulated and tracked via the following system: "independent" – immediately, or after self-correction; "minimal" – 1-2 cues; "moderate" – 3-5 cues; and "maximal" – 6 or more cues. It is important to note that cues of the type “unison production,” “repetition,” and “oral reading” (see Appendix T) were considered maximal cues regardless of their frequency of administration.

The general hierarchy of cues for P1 included the provision of graphic/visual organizer of the target response, graphemic cues (first 1 or 2 letters), tapping + graphemic cue, placement cues, voiced phonemic cues, oral reading, and repetition. Instructional cues and knowledge of performance feedback (KP) proved useful for P2. He would often verbalize his application of the KP and use it to self-correct (e.g., “Have cup. No, subject, subject. I. I have cup.”). If those cues did not successfully elicit the desired response, then the following cues were generally provided: graphic/visual organizer of target response, gesture, tactile cues, voiced phonemic cues, unison speech, and repetition.

Material constraints. Dyad 1 utilized high frequency vocabulary targets throughout the experiment. There were six levels of syntactic complexity for both requests and responses (Appendix U). Levels for requests were adapted from Maher and Schmadeke (2007); response levels were added by the experimenter. Individual levels of syntactic complexity were established during the initial treatment session. Once determined, they were guided to stay within the levels until they achieved a certain accuracy of production, at which time they were instructed on how to move up to the next level of complexity.

Before moving up the syntactic complexity hierarchy, each participant was required to complete 4/5 request turns independently as well as 4/5 response turns independently, allowing for self-corrections. This requirement assumed they would achieve both at the same time, and did not allow for deterioration of the previously mastered behavior if one is mastered before the other. So, at the point when the participant achieved mastery of the second communicative act (response or request, varied by individual), the experimenter had to examine the online data to determine the following: the first communicative behavior mastered must have been performed with no more than minimal cues for the previous 5 turns; or, if the participant was requiring more frequent cues (e.g., moderate), the first communicative act mastered must have been performed with at least 3/5 independent productions. Appendix V presents the table created for online data collection and also for performing reliability judgments via videotape. It allowed for documentation of level, type, and frequency of cues so that the experimenter and the reliability judge could readily determine when hierarchy movement was indicated.

Phase B1: Treatment for Dyad 2

Dyad 2 (P3 and P4) remained in baseline during Dyad 1's first two treatment sessions. Thus, they began to receive CIAT after 5 consecutive weekdays of baseline sessions. Low frequency stimuli were used, and levels of syntactic complexity, and movement within these levels, followed the same rules as Dyad 1. The experimenter determined a hierarchy of cues for each participant that provided the least to the most support, and manipulated and tracked the frequency of cues. The general order of cues for P3 was as follows: instructional cues, imposed time delay, knowledge of performance feedback + request for repair, graphemic cues, voiced phonemic cues, and repetition. Utilized most often for P4 were instructional cues, imposed time delay, knowledge of performance feedback + request for repair, silent phonemic cues, voiced phonemic cues, and repetition.

Phase B1: Treatment for Dyad 3

Dyad 3 (P5 and P6) participated in the experiment approximately 1 month after Dyads 1 and 2. They remained in baseline for a total of 4 sessions before beginning CIAT with high frequency targets. The same procedures for establishing levels of syntactic complexity and making movement decisions were followed.

Determination of cues for Dyad 3 proved to be a more difficult task when compared to previous dyads. Because of his severe perseveration, P5 continually produced numerous errors despite the experimenter's efforts to reduce perseveration (see Helm-Estabrooks and Albert, 2004b). The experimenter therefore switched to more of an errorless learning approach several days into the study, which has been implicated in naming therapies to reduce both long perseverative responses and reduce patient frustration (Nadeau et al., 2008). This course of action was decided upon to prevent the strengthening of synaptic connections between the intended target and errorful productions, and also to reduce the amount of errorful productions heard by the other member of the dyad. This approach was difficult to enforce at times because of the group setting and the impulsive nature of P5, but whenever possible, the experimenter would do the following: prime P5 with a model of the target stimulus before his turn (e.g., "This is a ____. We are going to talk about ___"). This was either paired with or immediately followed by a graphemic cue (first 1 or 2 letters) coupled with a voiced phonemic cue. This was often successful in eliciting the target word. If unsuccessful, the clinician would model the target word again, and then combine sentence completion + voiced phonemic cues with the graphemic cues already provided. When unsuccessful, this was followed by oral reading, unison speech, and repetition. When P5 was able to produce the target word, the experimenter would immediately ask “So, what is this?”, and he was expected to say the target again. This last exchange was often repeated again after a 3-5 second delay. If he reverted to an incorrect production, unison speech and repetition was employed again.

P6 frequently utilized gestures with circumlocution as a strategy to find words during his protracted periods of word retrieval. When instructed to avoid using gestures, the retrieval time before initiating utterance could be upwards of 1-2 minutes. Because delays exceeding 30 seconds are generally not advisable (Coelho et al., 2008) and because his use of gestures reduced retrieval time, P6 was allowed to use gestures to facilitate spoken language. He never attempted to use a gesture as a substitute for spoken language. The general hierarchy of cues for P6 was as follows: instruction to perform a gesture associated with the target, clinician-provided gesture + descriptors, graphemic cues, sentence completion + graphemic cues, silent phonemic cue, voiced phonemic cue, and repetition.

Phase A2: Return to Socialization Baseline

Following receipt of 10 consecutive weekdays of CIAT, all participants participated in daily 2-hour nonspecific control sessions for an additional 3-5 days. Probes continued to be administered during this phase. The experiment was considered complete when all groups had received 10 consecutive weekdays of CIAT and data had been gathered for at least 3 additional follow-up probes.

Post-Treatment Assessment

Participants were assessed again within a week of completion. The following measures were readministered: WAB-R, CADL-2, ASHA QCL and GDS-15.

Data Analysis

Visual inspection of performance on probes involved examination of stability during A1 and changes in level and/or trend upon introduction of CIAT. The percentage of nonoverlapping data (PND; Scruggs & Mastropieri, 1998) was also calculated to provide additional information about the difference, if present, between baseline and treatment phases. PND of 90% or higher has been said to indicate a highly effective treatment; 70-89% indicates a moderately effective treatment; 50-69% indicates minimal effectiveness; 49% and below is a hallmark of ineffectiveness. PND data alone are inadequate for judging treatment effectiveness and should not be used in the absence of visual inspection of the data.

Reporting Change of Practical Significance

Statistical significance will not be addressed in this study, as this study seeks to chart the magnitude of change in response to CIAT, or practical significance. Effect size is used to describe the magnitude of differences between two distributions, and various approaches have emerged as alternate methods of reporting change of practical significance. With pre- and post- treatment measures serving as the two distributions, effect size can be used to chart the magnitude of change in response to treatment. However, use of these criteria detailed below should not be viewed as a substitute for determination of clinically significant effects.

Repeated Measures

To determine if the application of CIAT resulted in change of practical significance, a modification of the standardized mean difference, *SMD3*, was used to calculate effect size at two points in time (Campbell & Herzinger, in press; Marquis et al., 2000; Olive & Smith, 2005) – by the end of treatment, and after treatment supports were removed. For the former, the difference between the means of the final three data points of Phase A1 (M_{A1}) and Phase B (M_B) was calculated and divided by the standard deviation of Phase A1 (SD_{A1}), as illustrated:

$$\frac{M_{B\text{ (final 3)}} - M_{A1\text{ (final 3)}}}{SD_{A1}} = \text{Effect size } (SMD3)$$

To accomplish the latter, the difference between the means of the final three data points of Phase A1 (M_{A1}) and of Phase A2 (M_{A2}) was calculated and divided by SD_{A1}, as illustrated:

$$\frac{M_{A2\text{ (final 3)}} - M_{A1\text{ (final 3)}}}{SD_{A1}} = \text{Effect size } (SMD3)$$

In the realm of aphasia treatment, effect sizes from single-subject research in aphasia have been determined (Robey, Schultz, Crawford, & Sinner, 1999), with treatment-specific benchmarks recently presented for syntactic production and lexical retrieval treatments (Beeson & Robey, 2006; Robey & Beeson, 2005). As authors categorize CIAT as either a “speech production and fluency” treatment or an “overall language performance” treatment (ANCDS website), the original estimates that arose from meta-analysis of general aphasia treatments were applied in this study, so that 2.6, 3.9, and 5.8 were used to identify small, moderate, and large effects, respectively (Beeson & Robey, 2006; Robey et al., 1999). For change to be deemed practically significant in this study, the medium effect size rule is honored, so that an effect size of 3.9 or greater had to be observed.

Standardized Measures

To determine if the application of CIAT resulted in change of practical significance on standardized assessment measures, the difference between the post-treatment and the pre-treatment scores was calculated and divided by the standard deviation provided by the instrument, as illustrated:

$$\frac{\text{Post-treatment score} - \text{Pre-treatment score}}{\text{Instrument } SD} = \text{Effect size } (d)$$

The general interpretation is that 0.2, 0.5, and 0.8 times the SD are small, moderate, and large effect sizes, respectively (Keppel & Wickens, 2004). However, a meta-analysis conducted by Robey (1998) established that average effects (*d*) of aphasia treatment during the post-acute and chronic stages were .57 and .66, respectively. Robey suggested that an effect size > .60 must be observed in order to claim that CIAT is more effective than the average aphasia treatment for individuals more than 3 months post-stroke, and this is the criterion utilized for determination of practically significant change in this study. The WAB-R offers divisions in aphasia subtype (e.g., global, Broca’s, etc.) when presenting means and standard deviations, and the ASHA QCL offers a division in type (fluent versus nonfluent). Practical significance on these measures was thus determined according to the divisions from the most recent standardization sample. Effect size was not calculated for the GDS-15, as it does not provide normative information.

Turns

Turns were operationally defined according to adapted conventions of conversation analysis as detailed in several speech and language studies (Comrie, Mackenzie, & McCall, 2001; Kennedy, Strand, Burton, & Peterson, 1994; Perkins, 1995). Cues for identifying turns included:

1. a period of silence, intonational change, or expectant look by the speaker signaling the relinquishment of the turn and/or expectation of a response or prompt;
2. the taking of a turn, or interruption, in the absence of a signal by the speaker;
3. the taking of a turn following a signal by the speaker, if number 1 fulfilled;
4. the completion of an ideational unit or strings of ideational units, though it does not have to be grammatically correct;
5. 1-2 word utterances used to answer questions, acknowledge hearing and/or understanding, comment or express emotions, and request information.

Turns could overlap and were not required to be intelligible. Once turns were identified, they were classified as major versus minimal turns. All turns were marked as major unless they were 1-2 word utterances used to acknowledge hearing and/or understanding, comment or express emotions, or quickly yield a turn. Lastly, major turns were categorized according to whether or not they involved treatment stimuli. More specific guidelines and examples for turn identification and classification are listed in Appendix W.

One 10-minute sample was randomly selected from each hour of all videotaped CIAT sessions. Turns were coded during each sample, resulting in 30 minutes of turn data per participant per CIAT session. Numbers were doubled to derive an estimate of turns per hour for each CIAT session. As in Comrie et al. (2001), coding of turns was accomplished by careful video observation; orthographic transcription was only conducted when overlapping turns made the process difficult or when judges disagreed about the turns.

Reliability

Observer Agreement

All assessment, probe, baseline, and treatment sessions were recorded on videotape. Two research assistants served as judges for the dependent variables in this experiment. They were trained until they met a criterion of 90% interjudge agreement with the experimenter for three training samples. Weekly inter- and intra-observer agreement measurements were performed on all dependent variables to guard against inconsistency, bias, or drift (Kazdin, 1982; McReynolds & Thompson, 1986). Eighty percent agreement was deemed acceptable for later weekly reliability checks. Interjudge reliability was assessed via point-by-point agreement (Kazdin, 1982) between the judges and the experimenter (Judge 1), and measurements are listed in Table 2. Intrajudge reliability was assessed by having each judge re-judge selected probes and perform the same computation, with results listed in Table 3.

Picture Naming

Judge 2 was a post-baccalaureate student transitioning into communication sciences and disorders with a year of experience with phonetic transcription. She was selected as a judge for this task because difficulty arose when determining whether or not a participant’s production was intelligible without context, because both the experimenter and the research assistant administering the probe knew the target words. She was provided videos of individuals with aphasia performing confrontation naming tasks and was instructed to orthographically transcribe the words if recognizable. If the production was not a real word, she was instructed to phonetically transcribe the production. She was never exposed to the stimulus lists or pictures, and the majority of videos included only the face of the participant. If the cards were visible on the video, she covered the screen and conducted her analysis with audio-only. To be considered correct, her orthographic transcription had to match the target word. All trials were selected for interjudge reliability, and point-to-point agreement indicated a reliability that ranged from 93.4-100% throughout the entire study. Twenty percent of trials were randomly selected for intrajudge reliability; measurements indicate that Judge 1 was 95.1-100% reliable, and Judge 2 was 92.4-100% reliable.

Picture Description

Judge 3 was an undergraduate student majoring in communication sciences and disorders. She was provided written instructions for CIU analysis (Nicholas & Brookshire, 1993) and then participated in guided CIU analysis of training videos of individuals with aphasia. Separate calculations were made for CIUs versus words. Approximately 50% of weekly discourse transcripts were selected for interjudge reliability. Reliability was generally higher for words than CIUs, with the former ranging from 93.2 to 98.7% and the latter ranging from 88.1 to 95.7%. Twenty percent of discourse transcripts across all phases of the experiment were randomly selected for retranscription. Measurements indicate that Judge 1 was 97.3-99.6% reliable for words, and 94.3-99.2% for CIUs. Judge 3 ranged from 91.4-98.6% agreement for words and 84.1-97.3% for CIUs.

Turns

Judge 4 was a graduate student majoring in communication sciences and disorders. She was provided written instructions for coding of turns (see Appendix W) according to adapted conventions of conversation analysis (Comrie et al., 2001; Kennedy et al., 1994; Perkins, 1995). She was then exposed to sample transcripts coded by the experimenter that accompanied a video and participated in guided turn-taking analysis with the experimenter. Two minutes of each 10-minute sample was selected for recoding. Point-by-point interjudge agreement indicated reliability measurements of 94.5% for Dyad 1, 92.9% for Dyad 2, and 95.4% for Dyad 3, for an average of 94.2% agreement across all dyads. Intrajudge estimates for Judge 4 indicated agreement of 94.5% for Dyad 1, 94.9% for Dyad 2, and 95.2% for Dyad 3, for an average of 94.9% agreement across all dyads.

Treatment Fidelity

Results for all measures of treatment fidelity are listed in Table 4. Treatment fidelity was assessed weekly by the experimenter. More than 20% (range 23-28%) of CIAT data sheets were randomly selected for recoding of level and cueing frequency. Intrajudge procedural reliability was computed via the following method (Reichle, Dropik, Alden-Anderson, & Haley, 2008; Schlosser, 2002):

$$\frac{\text{opportunities with correct implementation}}{\text{total opportunities}} \times 100 = \text{Procedural reliability}$$

Correct implementation meant that the treatment had to be provided in a manner consistent with that described in the method and that recoded data sheets had to match, in terms of type and frequency of cue, the data collected online. These stringent criteria most often led to disagreements centered upon the following cues that were often difficult to view via videotape: silent phonemic cues, graphemic cues versus whole words, and gestures performed by the experimenter. Despite the challenges, intrajudge reliability for each week ranged from 90.34-94.29%.

Thirty-three percent or more (range 33-50%) of CIAT data sheets containing syntactic hierarchy movement decisions were also randomly selected for recoding, and the same computations and stringent criteria were applied. Intrajudge reliability for each week of treatment ranged from 84-96.67%.

After the experiment, a graduate clinician (Judge 5) was selected to perform interjudge reliability computations for treatment fidelity. Judge 5 was a second-year graduate clinician nearing completion of her master's degree requirements. She was provided a copy of Appendix T (codes for cues), and she participated in guided instruction of recoding via video with the experimenter, where a discussion of the types and frequency of cues took place. Twenty-three percent or more (range 23-25%) of all CIAT data sheets were randomly selected for recoding, as were 33-75% of those involving syntactic hierarchy movement. Interjudge reliability ranged from 86.67-93.1%

for the former, and 80-90.7% for the latter. Most disagreements arose from the same difficulties encountered when calculating intrajudge reliability, not from lack of correct implementation according to the method.

Table 1

Participant Characteristics

Characteristic	P1	P2	P3	P4	P5	P6
Gender	M	M	M	F	M	M
Age	63	52	70	83	57	55
MPO	13	22	15	16	7	5
Years of education	16	16	16	16	12	16
Premorbid handedness	R	R	R	R	R	R
Aphasia classification						
Type	Broca's	Broca's	Anomic	Anomic	Wernicke's*	Broca's
Severity	Severe	Moderate	Moderate	Mild	Severe	Moderate
Apraxia of Speech	Severe	Mild	Moderate	Mild	Moderate	Moderate-Severe
Cognitive profile						
BJLO	17	25	25	22	22	22
CTT 1	79	70	<55	<55	67	<55

CTT 2	<55	67	<55	<55	<55	<55
ISRT	100%	100%	100%	100%	100%	100%
WAB-R AVC points	125	128	196	176	61	177

Note. MPO = months post onset; BJLO = Benton Judgment of Line Orientation; CTT = Color Trails Test; ISRT = Iconographic Symbol Recognition Task; WAB-R AVC = Western Aphasia Battery-Revised Auditory Verbal Comprehension

* Atypical presentation of deficits

Table 2

Interjudge Reliability Scores for Naming and Discourse Probes

	Experiment 1				Experiment 2		
Judge	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3
2 (Naming)	94.4%[a]	95.2%[b]	93.4%[a]	95.8%[a]	98.9%[a]	100%[a]	100%[a]
3 (CIUs)	95.7%[c]	94.8%[d]	95.3%[e]	94.5%[f]	88.1%[c]	92.6%[c]	91.2%[c]
3 (Words)	96.4%[c]	98.5%[d]	96.8%[e]	95.6%[f]	96.3%[c]	93.2%[c]	98.7%[c]

Note. CIUs = correct information units; a = 100%; b = 92%; c = 50%; d = 67%; e = 44%; f = 58%

Table 3

Intrajudge Reliability Scores for 20% of Naming and Discourse Probes

	Experiment 1				Experiment 2		
Judge	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3
1 (Naming)	95.1%	95.8%	96.5%	96.5%	100%	97.2%	100%
1 (CIUs)	96.8%	96.7%	99.2%	98.7%	94.3%	98.3%	95.2%
1 (Words)	99.5%	99.5%	99.6%	99.3%	97.3%	99.0%	99.2%
2 (Naming)	92.6%	92.4%	95.1%	95.1%	100%	98.6%	100%
3 (CIUs)	89.2%	97.3%	93.5%	95.8%	84.1%	89.4%	96.4%
3 (Words)	91.4%	96.9%	96.9%	94.3%	97.0%	98.6%	96.1%

Note. CIUs = correct information units

Table 4

Procedural Reliability

Judge	Experiment 1 Week 1	Experiment 1 Week 2	Experiment 2 Week 1	Experiment 2 Week 2
Intrajudge				
Judge 1				
all data sheets	91.6%[a]	90.3%[b]	92.1%[c]	94.3%[a]
movement decisions	93.3%[d]	91.5%[e]	84.0%[e]	96.7%[e]
Interjudge				
Judge 1 and 5				
all data sheets	93.1%[a]	89.7%[b]	86.7%[f]	89.7%[a]
movement decisions	90.7%[d]	88.0%[g]	80.0%[e]	86.4%[e]

Note. a = 25% of samples; b = 23% of samples; c = 28% of samples; d = 33% of samples; e = 50%; f = 29%; g = 75%

CHAPTER 3

RESULTS

Standardized Measures

Table 5 lists the pre- and post- treatment assessment results for WAB-R subtests and AQ, CADL-2, ASHA-QCL, and GDS-15. Adherence to Robey's (1998) criterion reveals three practically significant improvements ($d > .60$): WAB-R AQ for P3 (d = 1.39), ASHA-QCL for P3 (d = 1.27), and ASHA-QCL for P4 (d = .69). All participants increased WAB-R AQ profile scores. No clear patterns are revealed upon closer examination of WAB-R subtests that were expected to change as a result of treatment (i.e., Spontaneous Speech, Naming and Word Finding). All participants made slight improvements on the Spontaneous Speech subtest, with the exception of P4, who was performing at near normal levels at the onset of this study. Four participants (P2, P3, P4, and P6) improved slightly on Naming and Word Finding subtests, whereas the remaining participants (P1, P5) declined.

All participants increased CADL-2 raw scores by at least 2 points, except for a decrease of 6 points by P2. All participants also increased ASHA-QCL scores. Four participants increased their rating of the item that states "People understand me when I talk." Three participants increased their ratings of the following items: "I meet the communication needs of my job or school," "People include me in conversations," "I use the telephone," "I keep trying when people don't understand me," and "I get out of the house and do things." At both pre- and post- treatment assessments, all participants scored between 1 and 3 points on the GDS-15.

Repeated Measures

Results for all probe data for all participants are presented in Figures 1, 2, and 4 through 13. The probe session number is represented on the x-axis and the response measurement on the y-axis. Scales on the y-axis for discourse measures differ based on each participant's unique ranges of performance, but the scales are uniform in that they share the same difference between minimum and maximum values for all participants. Data are presented for baseline, treatment, and maintenance phases of the experiment.

All participants demonstrated stable baselines for the dependent measure controlling the phase changes of the study, %CIUs, in that no more than 30% fluctuation occurred across the baseline values, and no more than a 10% rise was observed at the last baseline point (Edmonds & Kiran, 2006; Kiran, 2008). No other baseline measures were monitored for stability before initiation of the intervention phase, but stability according to these criteria was also achieved for all naming probes, with the following exceptions: N-T for P1 (31.35% fluctuation during baseline), N-GT for P3 (20% rise in last baseline probe) and P4 (45% fluctuation during baseline), and N-GUT for P3 (15% rise in last baseline) and P4 (45% fluctuation during baseline).

Trained Behaviors

Naming

Figures 1 and 2 depict naming scores (out of 32 total points) on N-T probes for all participants. There was no overlap of data points between baseline and treatment phases for participants P2 through P6 (100% PND). P1's data is marked by a peak on probe 2 that exceeded any other value achieved during the experiment, resulting in 0% PND. Examination of Table 6, however, reveals that all participants demonstrated increases in mean performance during treatment relative to baseline, and all maintained gains in mean performance. The combination of visual inspection and PND show that positive changes in naming of trained items were observed during the treatment phase for most participants. Change of practical significance (*SMD3* > 3.9) was observed for P2, P3, P4, and P6 by the end of treatment and during maintenance sessions.

Levels of Syntactic Complexity

Figure 3 shows progression for levels of syntactic complexity during the ten CIAT sessions. Although no comparison to baseline can be made for levels of syntactic complexity, all participants progressed at least one level. The greatest increases in syntactic complexity were observed for P2 (Level 2 to 5) and P3 (Level 3 to 6).

Generalization

Naming

In order to facilitate comparison with other aphasia treatment studies that examined generalization to naming of untrained items, a performance criterion utilized by Kiran and colleagues (Kiran, 2005, 2008; Kiran & Thompson, 2003) was employed. Generalization was thus defined as an increase in performance accuracy by 40% over maximum baseline performance. Figures 4 and 5 depict naming scores (out of 20 total points) on N-GT probes for all participants. Most participants met the stability criteria for this study, with the exception of P3 and P4. As in naming of trained items, baseline data for P1 are marked by a peak on probe 2 that exceeded any other value achieved during the experiment; similarly, P3 demonstrates a peak in baseline that exceeds all points in treatment phase but not the maintenance phase. Variable performance was common during the treatment phase. There was complete overlap of data points between baseline and treatment phases for P1 and P3 (0% PND) for naming of N-GT items, and approximately half of data points for all other participants overlapped (43-50% PND). Examination of Table 6 reveals that participants P2 through P5 demonstrated increases in mean performance during treatment relative to baseline, and maintained increased means after CIAT was terminated. P1's performance declined throughout the phases. P6 demonstrated improved average performance during treatment, but declined to below baseline measures during maintenance. CIAT did not effectively lead to generalization to naming of N-GT items and no participants met the criterion for generalization or change of practical significance.

Figures 6 and 7 depict naming scores (out of 20 total points) on N-GUT probes for all participants. All participants but P3 and P4 met the stability criteria for this study. Complete overlap of data points (0% PND) between baseline and treatment phases for P1 was observed for naming of N-GUT items, as was considerable overlap (range 33-57% PND) for P2, P3, P4, and P6. The least overlap (67% PND) occurred for P5. Examination of Table 6 reveals that all participants demonstrated improved mean performance during treatment relative to baseline, and all but P1 maintained improvements. No participants demonstrated change of practical significance or met criterion for generalization. One data point for P5 during the maintenance phase was 40% above the maximum achieved in baseline, but this was not maintained for more than one probe session.

Discourse

Of special interest in this investigation was to determine if CIAT leads to improvements in measures of discourse. We looked specifically at the dependent variables %CIUs, TCIUs, and CIUs/min. It should be noted that Dyad 1 data for probe session 7 was constructed from online data only due to corrupted video files. Therefore, reliability judgments were not performed for this session, and the experimenter was unable to time the discourse samples, resulting in a missing data point for CIUs/min.

Percent CIUs. Figures 8 and 9 provide %CIUs data for all participants. All participants met the stability criteria for this study, because this was the primary dependent variable used to drive the phase changes for this experiment. There was no overlap of data points between baseline and treatment phases for P2 and P3 (100% PND), less overlap for P1 and P6 (67-71% PND), and more than 50% overlap for P4 and P5. Examination of Table 7 reveals that all participants demonstrated increased mean performance during treatment relative to baseline, and maintained increased means following CIAT. The combination of visual inspection and PND show that positive changes in %CIUs occurred upon administration of CIAT for P1, P2, P3, and P5. However, change of practical significance was only observed for P2 by the end of treatment (*SMD3* = 6.86) and after treatment supports were removed (*SMD3* = 7.18).

Total CIUs. Figures 10 and 11 portray results for TCIUs. Baselines were relatively stable for this probe, with the exception of P4's decelerating trend and P6's near peak performance. No overlap of data points between baseline and treatment phases occurred for P1, P2, or P3 (100% PND). Some overlap was noted for P5 (67%

PND), and even more (0-29% PND) for P4 and P6. Examination of Table 7 reveals that all participants demonstrated improved mean performance in TCIUs during treatment relative to baseline, and maintained the improved means during the follow-up probes. In sum, positive changes in TCIUs during the treatment phase were observed for P1, P2, P3, and P5. Moreover, P1, P2, and P3 demonstrated change of practical significance by the end of treatment and after treatment supports were removed, with effect sizes (*SMD3*) ranging from 4.63 to 12.44.

CIUs per minute. Results for CIUs/min are presented in Figures 12 and 13. Baselines were relatively stable for most participants, except for a rapidly accelerating trend for P3, and marked variability for P4. There was no overlap of data points between baseline and treatment phases for P1 and P2 (100% PND), some overlap for P3 (86% PND), and much overlap (0-50% PND) for P4-P6. Examination of Table 7 reveals that all participants demonstrated improved mean performance on CIUs/min during treatment relative to baseline, and maintained above baseline performance following termination of CIAT. Positive changes in CIUs/min were observed for all participants by the end of the study. Practically significant change for this dependent variable occurred for P1 and P2 by the end of treatment and during maintenance, with effect sizes (*SMD3*) ranging from 4.9 to 23.37, and also for P5 during the maintenance phase (*SMD3* = 4.42).

All participants increased their mean performance for %CIUs, TCIUs, and CIUs/min during treatment and/or maintenance phases, meaning that the accuracy and the efficiency of spoken language during discourse probes increased for all participants in this study, though not consistently to the level of practical significance. Several participants made impressive gains in TCIUs, specifically P3, who increased his mean for TCIUs by more than 100 words. However, this improvement did not meet criterion for practical significance because of baseline variability.

Participant Profiles

Participant 1

In response to CIAT, P1 increased mean performance for all probe measures relative to baseline, with the exception of N-GT. For those measures that increased during treatment, he was able to maintain improvements after treatment supports were removed for all dependent variables except N-GUT. P1 also demonstrated increases in performance on 3 of 4 WAB-R subtests as well as the CADL-2. The only practically significant findings were observed in discourse measures (TCIUs, CIUs/min). His most impressive improvement involved a tripling of mean TCIUs over the course of the study, with means increasing from 5.67 to 16.86 (*SMD3* = 10.02) and finally to 17.67 TCIUs (*SMD3* = 7.84). A quick note on the decline observed during TCIUs on probe 7 is warranted because data for that session for Dyad 1 was reconstructed from online data only due to corrupted video files. Because of his reduced intelligibility, whether or not it was a true decline is questionable, as review via video usually assisted understanding and revealed more CIUs and real words than were recorded online.

Participant 2

P2 demonstrated an increase in means for all probe measures relative to baseline and maintained increased means after treatment supports were removed. P2 also demonstrated increases in performance on all WAB-R subtests, but CADL-2 performance declined. Eight of the 24 practically significant improvements in this study are attributed to P2. It is difficult to determine which finding is more impressive – the near doubling of a naming score for N-T, a 19% increase in the mean of %CIUs, or going from an average of 58.67 TCIUs during baseline sessions to peaks upwards of 140 TCIUs. Again, however, data from probe 7 was reconstructed from online data. It is plausible that the data point for TCIUs is lower than it should be, and that the %CIUs is inflated. His rate and intelligibility were such that the experimenter generally had no difficulty capturing all CIUs online, but occasionally failed to record many of his frequently occurring non-CIU words (e.g., yes, wow) that were usually later realized upon video review.

Participant 3

In response to CIAT, P3 demonstrated an increase in means for all probe measures relative to baseline, and maintained increased means after treatment supports were removed. P3 also demonstrated increases in performance on the two WAB-R subtests expected to change as a result of CIAT – a 5 point increase on the Spontaneous Speech subtest, and a 1.3 point increase on the Naming and Word Finding subtest. Though other subtest scores decreased, the increases were of a magnitude great enough to lead to practically significant improvement on the WAB-AQ, serving to move him from moderate to mild severity. P3 demonstrated improvement on all other standardized assessment measures, with nearly a full point change on the ASHA-QCL that was also determined to be practically significant. Improvements by P3 were noted for many probe measures, and two improvements (N-T and TCIUs) met the criterion for practical significance by the end of treatment and during maintenance.

Participant 4

Though P4 began this study with a high level of ability, she still demonstrated an increase in her mean performance on all probe measures in response to CIAT, and maintained increased means after treatment supports were removed. P4 also demonstrated increased performance on three of four WAB-R subtests, the largest point change on the CADL-2, and change of practical significance on the ASHA-QCL. The only practically significant finding for repeated measures was for N-T, observed by the end of treatment and during maintenance. Naming performance for both N-T and N-GUT increased to 100% accuracy on more than one occasion. Peaks during baseline for all discourse measures rival those visualized in treatment or maintenance phases, but the greatest numbers were observed during the latter phases.

Participant 5

In response to CIAT, P5 demonstrated an increase in means for all probe measures relative to baseline, and means during maintenance exceeded those of baseline as well. P5 also demonstrated increased performance on 3 of 4 WAB-R subtests, as well as a 7 point improvement on the CADL-2. The only practically significant finding was for CIUs/min, observed in the comparison of maintenance phase to baseline phase performance. A quick comment about the peak in naming probes on session 7 followed by the sharp decline on session 8 is warranted. Review of transcriptions revealed that probe 7 was a day of relatively little perseveration, whereas perseveration during probe 8 was notably worse. For example, he produced the word “bicycle” at least 10 times during picture naming (out of 36 pictures), and perseverated on other words as well. The same pattern was apparent for CIU probes, but examination of the transcript did not reveal perseveration on a particular word, just nearly completely empty speech (e.g., “it will be like this and like this and like this in the morning like this”).

Participant 6

P6 demonstrated an increase in means for all probe measures relative to baseline in response to CIAT. For those measures that increased during treatment, he maintained improvements after treatment supports were removed for all dependent variables except N-GT. P6 also demonstrated slight increases in performance on 2 of 4 WAB-R subtests, as well as an 8 point improvement on the CADL-2. The only practically significant finding occurred with his improved naming of trained items (N-T).

Turns

A final aim of this study was to quantify practice intensity during the daily 3-hour protocol utilized in this study. Turns were identified by procedures described in the method, with special attention paid to major turns that occurred in relation to treatment stimuli, the percentage of those turns out of all major turns, and the total number of turns (minimal plus major) taken. This information is presented in Table 8. Data from all participants reveal that they participated in an average of 151.4 turns per hour (range 82 – 244) that related to treatment stimuli, which represented an average 96.1% of all major turns, and 79% of total turns.

Table 5

Pre- and Post- Treatment Assessment Results

	Participants					
Measure	P1	P2	P3	P4	P5	P6
WAB-R						
SS						
pre	3	10	13	19	7	12
post	6	11	18	19	8	14
AVC						
pre	6.25	6.4	9.8	8.8	3.05	8.85
post	5.2	7	9.65	9.3	5.4	8.45
REP						
pre	1.1	4.8	7.3	9	4.8	3.4
post	1.4	5	7	9.2	6.3	3.4

NWF						
pre	4	6.5	6.3	8.1	3.3	4.3
post	2.4	7.6	6.6	8.3	3	5.4
AQ						
pre	28.7	55.2	72.8	89.8	36.3	57.1
post	30	61.2	82.5	91.6	45.4	62.5
(d =)	*(0.06)*	*(0.29)*	*(1.39)*	*(0.26)*	*(0.56)*	*(0.27)*
CADL-2						
pre	58	90	87	88	45	77
post	60	84	89	96	52	85
(d =)	*(0.11)*	*(-0.33)*	*(0.11)*	*(0.44)*	*(0.38)*	*(0.44)*
ASHA-QCL						
pre	3.88	3.29	3.375	4.41	4.47	3.88
post	4	3.625	4.235	4.875	4.64	3.94
(d =)	*(0.18)*	*(0.50)*	*(1.27)*	*(0.69)*	*(0.33)*	*(0.09)*

GDS-15						
pre	2	2	3	2	0	2
post	3	3	1	2	2	1

Note. WAB-R = Western Aphasia Battery – Revised; SS = Spontaneous Speech Score; AVC = Auditory Verbal Comprehension Score; REP = Repetition Score; NWF = Naming and Word Finding Score; AQ = Aphasia Quotient; *d* = effect size; CADL-2 = Communication Activities of Daily Living - 2; ASHA-QCL = American Speech-Language Hearing Association Quality of Communication Life Scale; GDS-15 = Geriatric Depression Scale Short Form

Table 6

Mean and Standard Deviation per Phase for Naming Probes for All Participants

		N-T		N-GT		N-GUT	
		Mean	(SD)	Mean	(SD)	Mean	(SD)
P1							
	A1	4.00	(5.29)	3.00	(3.00)	0.67	(1.16)
	B	5.29	(2.22)	1.86	(1.57)	1.14	(1.07)
	SMD3	*0.57*		*-0.67*		*0.00*	
	A2	6.33	(2.52)	1.33	(1.16)	0.67	(1.16)
	SMD3	*0.44*		*-0.56*		*0.00*	
P2							
	A1	14.33	(1.53)	7.00	(2.65)	12.00	(2.65)
	B	22.43	(3.82)	9.29	(1.80)	14.43	(2.94)
	SMD3	*7.41*		*0.63*		*1.63*	
	A2	27.33	(0.58)	10.00	(2.00)	17.67	(0.58)
	SMD3	*8.50*		*1.13*		*2.14*	
P3							
	A1	5.00	(2.92)	2.60	(2.41)	7.20	(2.39)
	B	19.71	(4.79)	4.14	(1.35)	9.86	(2.12)
	SMD3	*5.94*		*0.55*		*1.67*	
	A2	25.33	(3.06)	6.67	(2.31)	11.33	(1.33)

	SMD3	*6.51*	*1.52*	*1.67*
P4				
	A1	19.40 (2.19)	6.80 (3.42)	14.40 (3.36)
	B	27.29 (1.89)	10.57 (1.99)	18.00 (1.73)
	SMD3	*4.72*	*1.07*	*0.79*
	A2	32.00 (0.00)	11.33 (1.16)	18.33 (1.53)
	SMD3	*6.24*	*0.88*	*0.60*
P5				
	A1	3.00 (3.46)	4.50 (1.00)	1.50 (1.00)
	B	13.00 (4.60)	6.33 (2.34)	3.67 (1.51)
	SMD3	*3.18*	*0.66*	*2.00*
	A2	8.33 (2.08)	6.00 (4.00)	4.33 (4.51)
	SMD3	*1.83*	*1.33*	*3.00*
P6				
	A1	9.55 (1.29)	2.75 (1.71)	6.00 (2.94)
	B	16.67 (3.78)	5.00 (2.00)	8.00 (3.41)
	SMD3	*4.00*	*0.23*	*1.13*
	A2	18.00 (3.00)	2.67 (2.08)	9.00 (1.73)
	SMD3	*6.46*	*0.00*	*0.79*

Note. N-T = probe for naming of trained items; N-GT = probe for naming of generalization items within a trained category; N-GUT = probe for naming of generalization items within an untrained category; *SMD3* = standardized mean difference utilizing only the final three data points of each phase.

Table 7

Mean and Standard Deviation per Phase for Discourse Probes for All Participants

		%CIUs Mean (SD)		TCIUs Mean (SD)		CIUs/min Mean (SD)	
P1							
	A1	7.06	(2.40)	5.67	(1.53)	1.40	(0.19)
	B	9.96	(1.86)	16.86	(5.31)	2.55	(0.42)
	SMD3	*1.54*		*10.02*		*6.79*	
	A2	10.17	(1.69)	17.67	(2.52)	2.33	(0.37)
	SMD3	*1.30*		*7.84*		*4.90*	
P2							
	A1	27.79	(2.59)	58.67	(6.51)	8.80	(0.19)
	B	42.37	(5.19)	121.14	(25.63)	11.77	(1.09)
	SMD3	*6.86*		*12.44*		*19.90*	
	A2	46.38	(6.36)	135.67	(9.29)	13.24	(2.02)
	SMD3	*7.18*		*11.83*		*23.37*	
P3							
	A1	45.73	(4.56)	99.00	(20.81)	15.18	(5.01)
	B	57.32	(3.61)	171.71	(43.85)	23.34	(3.02)
	SMD3	*2.96*		*4.63*		*1.52*	
	A2	60.58	(0.97)	212.00	(3.61)	26.12	(2.98)

SMD3	*3.06*	*4.73*	*1.68*
P4			
A1	56.17 (9.15)	169.20 (29.27)	30.36 (6.36)
B	64.94 (7.88)	214.00 (16.82)	35.80 (3.41)
SMD3	*1.37*	*2.34*	*0.95*
A2	68.45 (2.81)	214.00 (3.61)	37.50 (4.55)
SMD3	*1.38*	*2.11*	*1.20*
P5			
A1	1.25 (1.28)	3.00 (3.16)	1.34 (1.31)
B	3.45 (2.87)	10.83 (8.98)	3.09 (2.44)
SMD3	*2.28*	*2.85*	*1.56*
A2	4.18 (2.40)	14.67 (8.39)	6.73 (3.99)
SMD3	*2.67*	*3.80*	*4.42*
P6			
A1	36.76 (4.34)	61.25 (29.13)	5.13 (2.22)
B	40.28 (7.10)	69.83 (21.61)	5.57 (1.60)
SMD3	*2.14*	*0.60*	*0.70*
A2	45.05 (8.56)	89.67 (16.04)	6.85 (0.49)
SMD3	*2.05*	*0.32*	*0.55*

Note. %CIUs = percent CIUs; TCIUs = total CIUs; CIUs/min = CIUs per minute; *SMD3* = standardized mean difference utilizing only the final three data points of each phase.

Table 8

Major Turns Related to Treatment Stimuli per Hour

	CIAT Session												
ID	1	2	3	4	5	6	7	8	9	10	M	SD	Range
P1	188	178	164	134	208	130	160	172	212	220	176.6	31.1	130-220
(% of MT)	(97)	(99)	(89)	(97)	(97)	(99)	(93)	(99)	(91)	(92)	(94.9)		
(% of TT)	(85)	(87)	(79)	(85)	(83)	(84)	(83)	(89)	(86)	(82)	(84.3)		
P2	216	182	232	170	142	140	174	168	154	178	175.6	29.5	140-232
	(98)	(97)	(91)	(94)	(86)	(88)	(96)	(93)	(83)	(91)	(91.8)		
	(76)	(72)	(76)	(79)	(72)	(68)	(84)	(83)	(73)	(75)	(75.5)		
P3	160	140	130	120	114	110	110	112	110	94	120	18.8	94-160
	(98)	(100)	(100)	(98)	(100)	(97)	(100)	(97)	(92)	(92)	(97.4)		
	(69)	(77)	(72)	(83)	(84)	(72)	(76)	(88)	(86)	(80)	(77.7)		
P4	124	100	126	102	86	136	124	104	116	98	111.6	15.8	86-136
	(95)	(100)	(98)	(94)	(98)	(99)	(95)	(95)	(92)	(85)	(95.1)		

	(72)	(71)	(77)	(69)	(64)	(72)	(65)	(68)	(59)	(56)	(67.1)		
P5	244	230	158	226	224	212	194	208	178	244	211.8	28.1	158-244
	(96)	(96)	(95)	(99)	(100)	(99)	(100)	(97)	(99)	(100)	(98.2)		
	(84)	(89)	(85)	(95)	(91)	(83)	(81)	(87)	(84)	(91)	(86.9)		
P6	148	110	82	112	82	156	108	90	106	134	112.8	25.9	82-156
	(99)	(98)	(100)	(100)	(100)	(98)	(98)	(100)	(100)	(100)	(99.1)		
	(85)	(81)	(91)	(93)	(80)	(86)	(76)	(78)	(72)	(86)	(82.6)		
Group											151.4	45.9	82-244
											(96.1)		
											(79.0)		

Note. ID = participant identification number; % of MT = major treatment turns / all major turns; % of TT = major treatment turns / total turns (major + minimal)

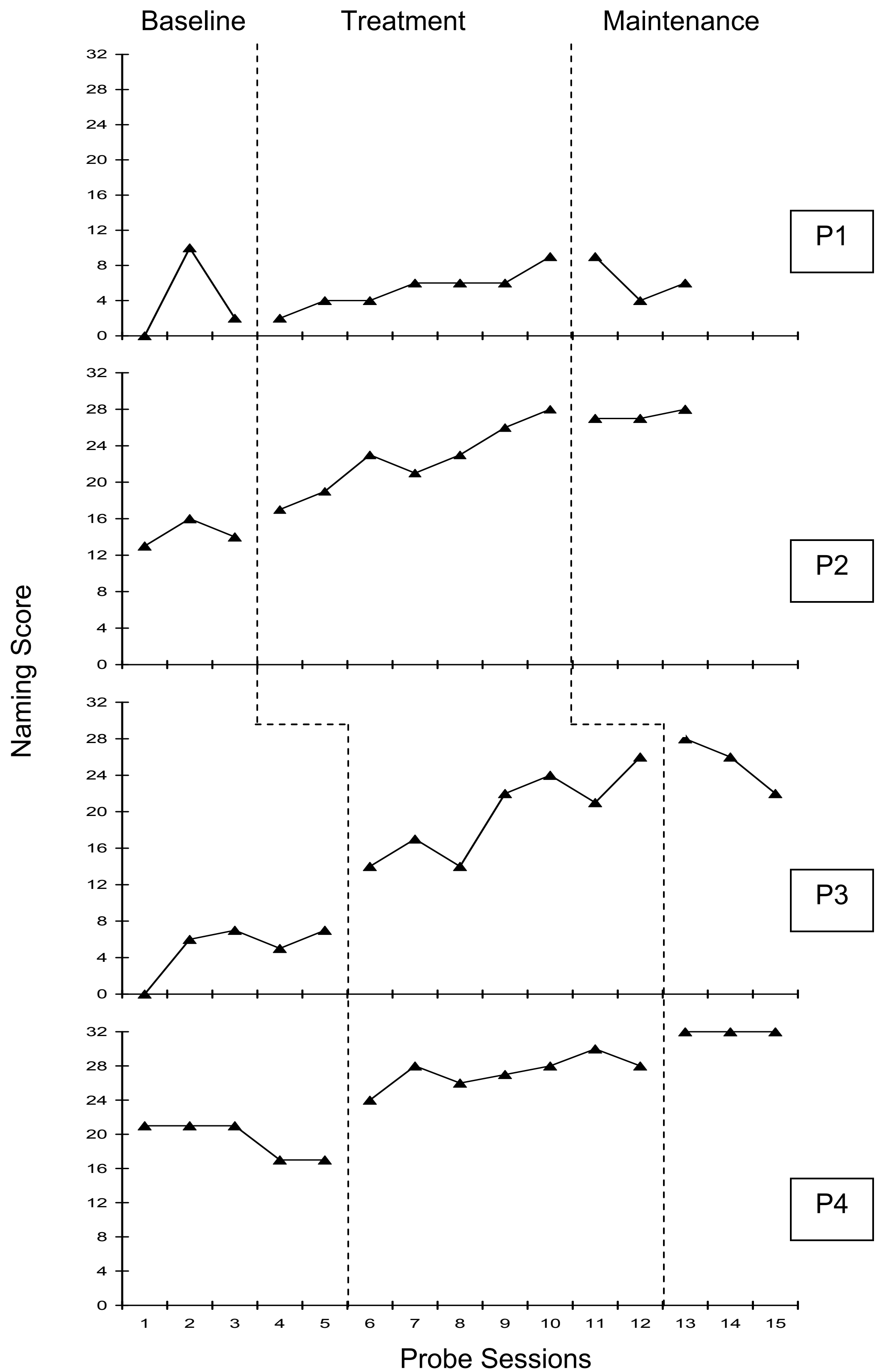

Figure 1: Naming score (number correct out of 32) for participants P1 through P4 on N-T (trained) items during baseline, CIAT, and maintenance.

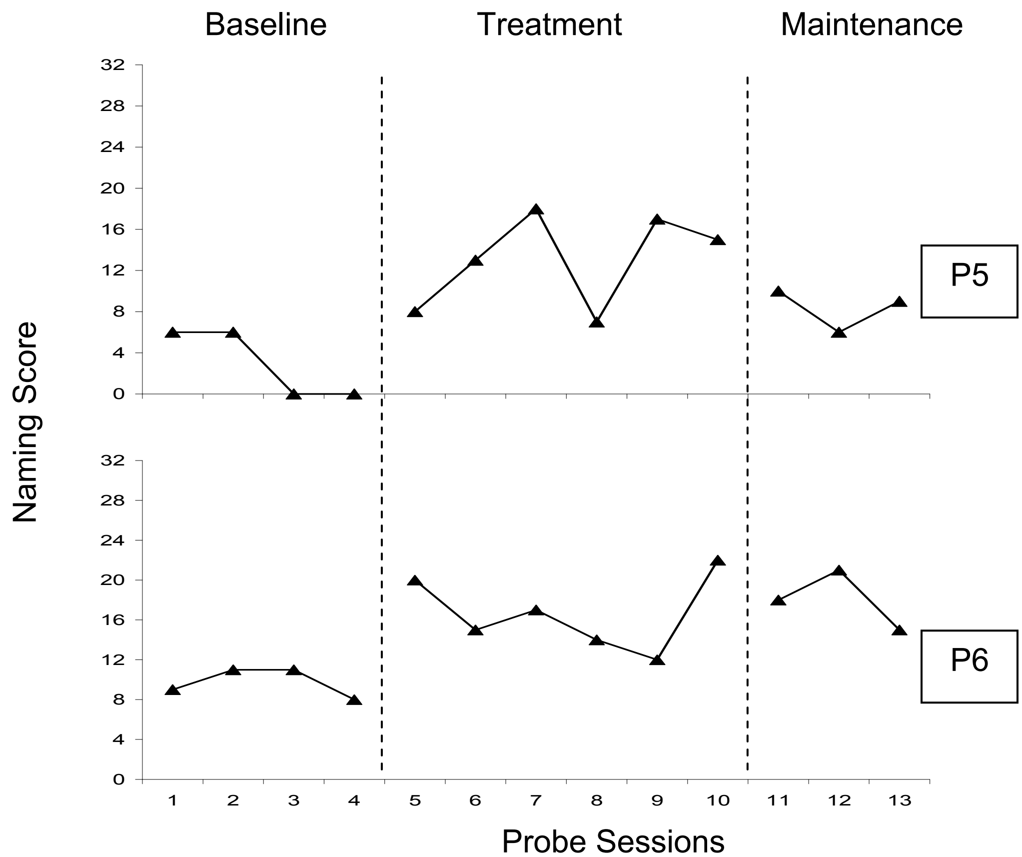

Figure 2: Naming score (number correct out of 32) for participants P5 and P6 on N-T (trained) items during baseline, CIAT, and maintenance.

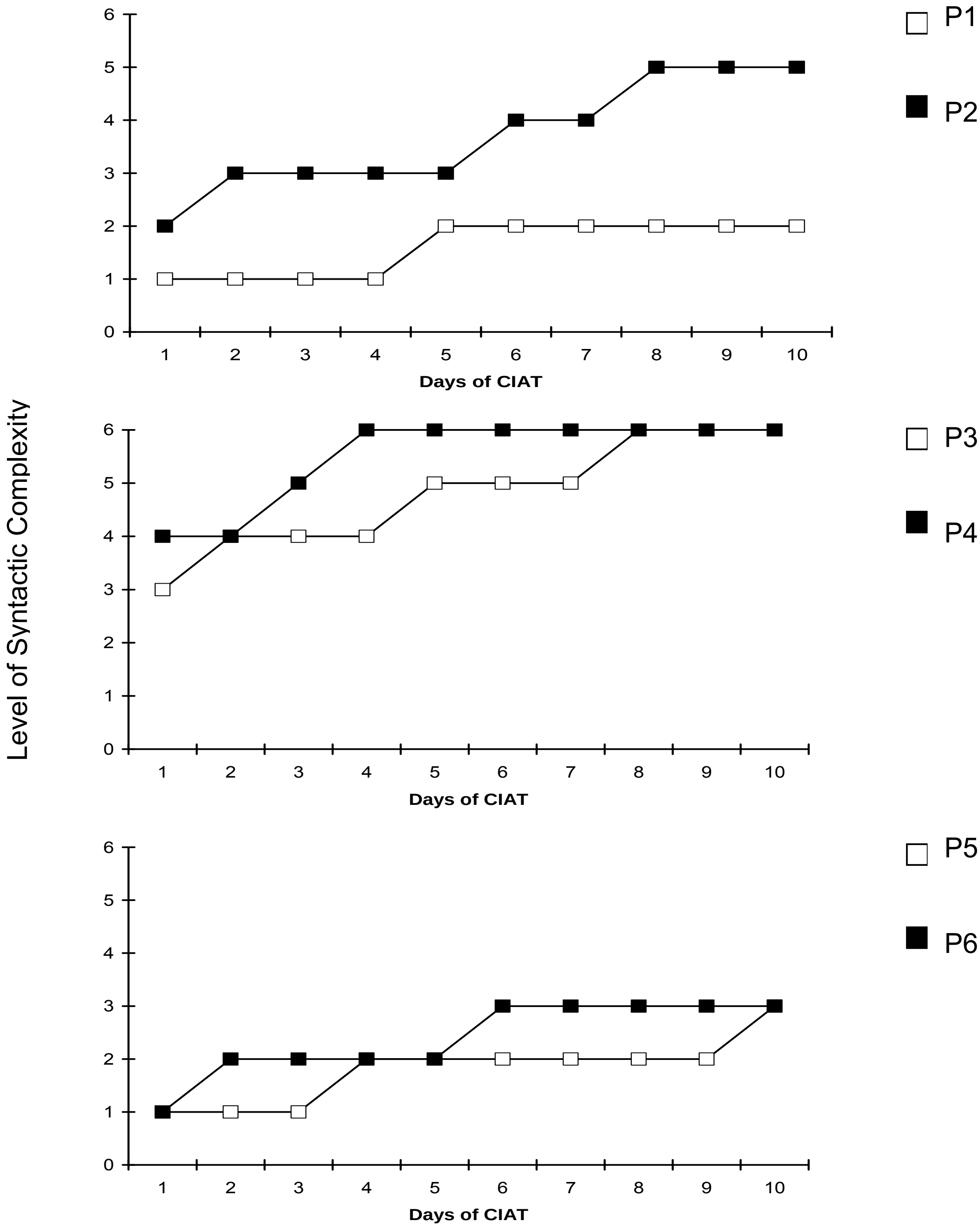

Figure 3: Progression through levels of syntactic complexity for each dyad.

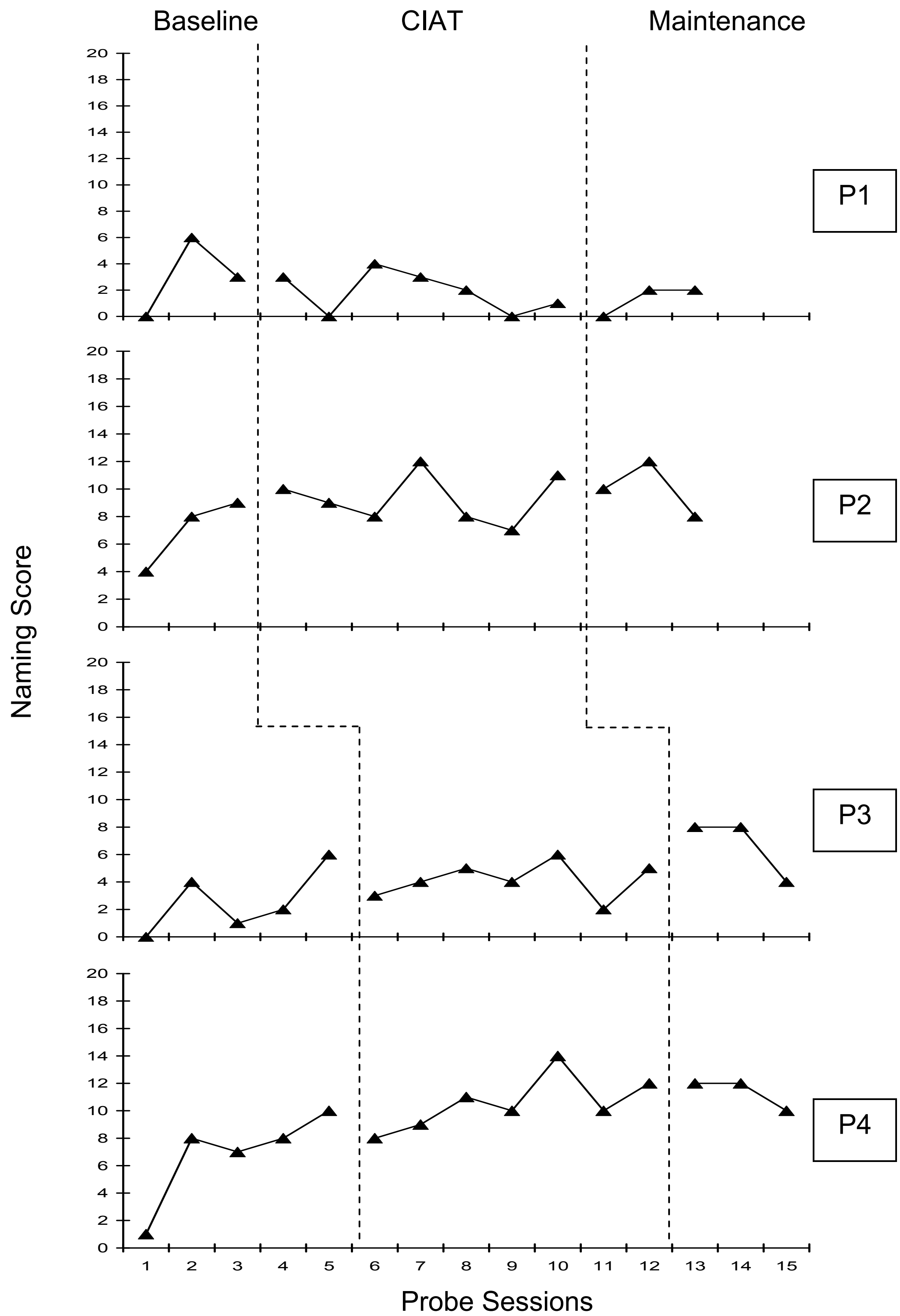

Figure 4: Naming score (number correct out of 20) for participants P1 through P4 on N-GT (generalization items within a trained category) during baseline, CIAT, and maintenance.

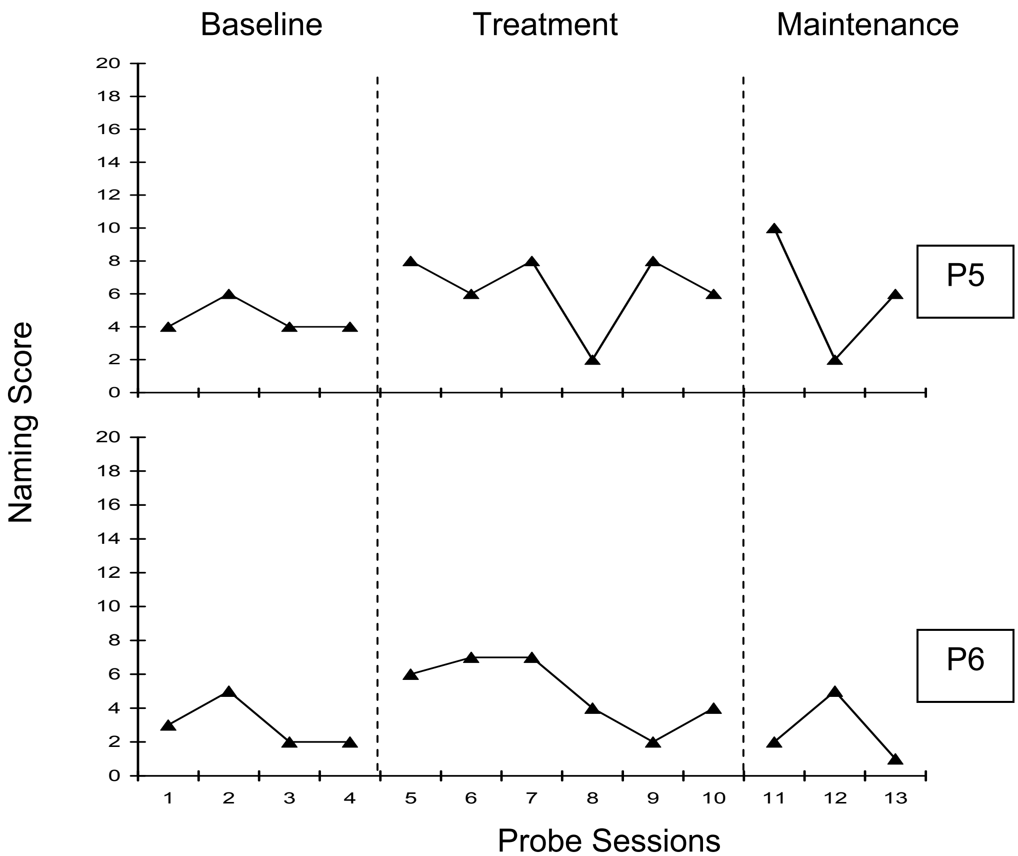

Figure 5: Naming score (number correct out of 20) for participants P5 and P6 on N-GT (generalization within a trained category) items during baseline, CIAT, and maintenance.

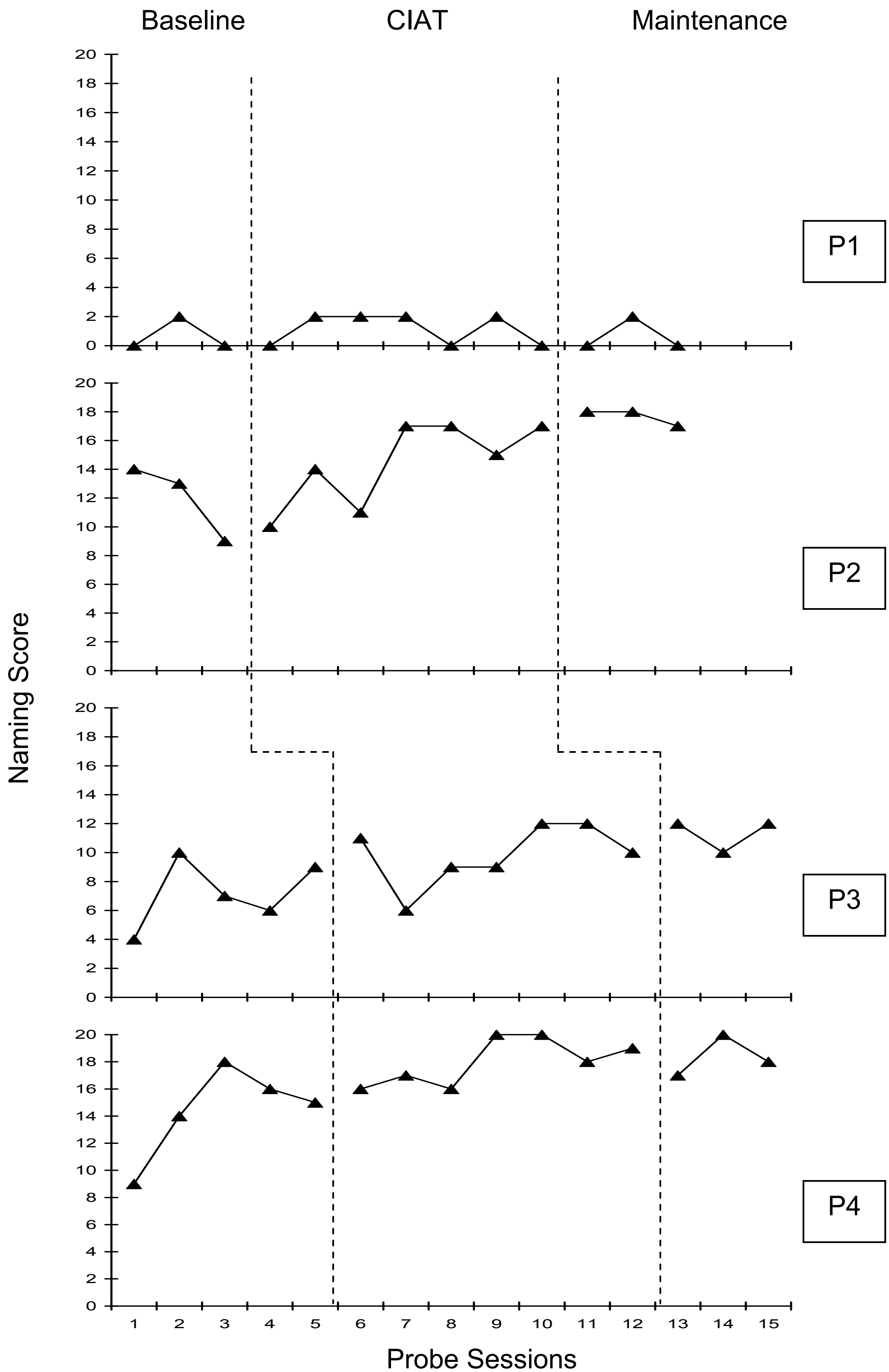

Figure 6: Naming score (number correct out of 20) for participants P1 through P4 on N-GUT (generalization within an untrained category) items during baseline, CIAT, and maintenance.

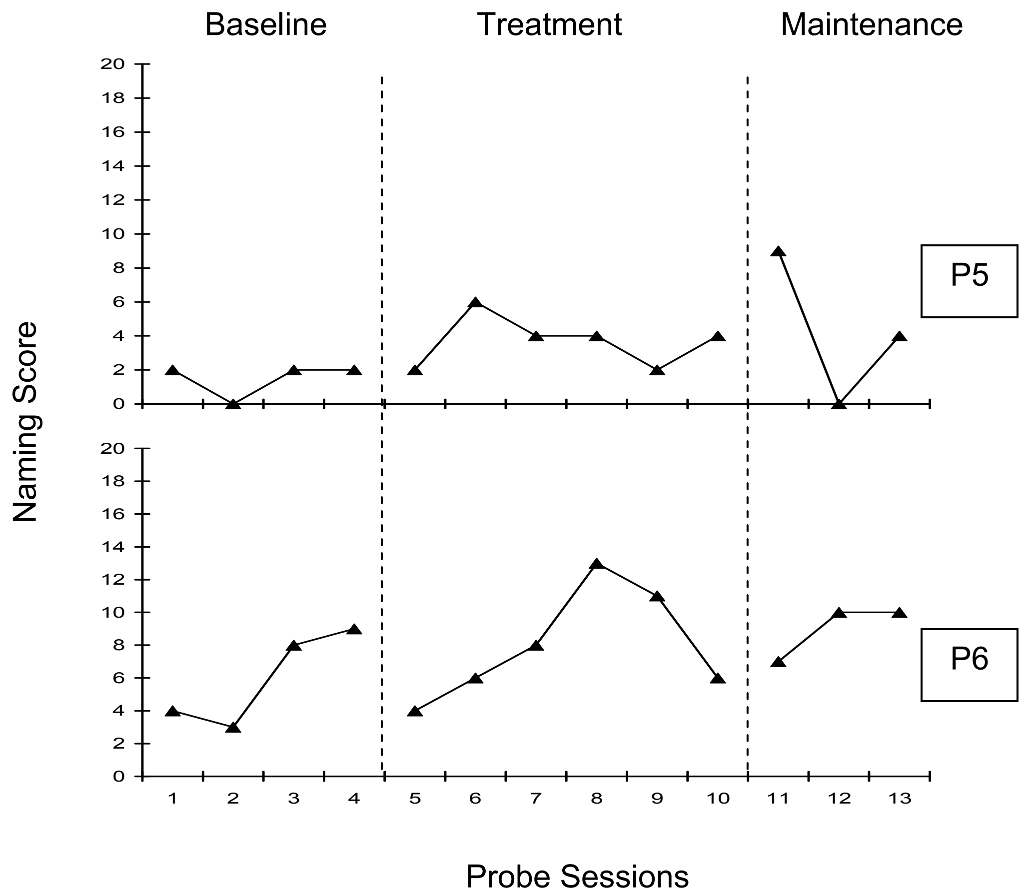

Figure 7: Naming score (number correct out of 20) for participants P5 and P6 on N-GUT (generalization within an untrained category) items during baseline, CIAT, and maintenance.

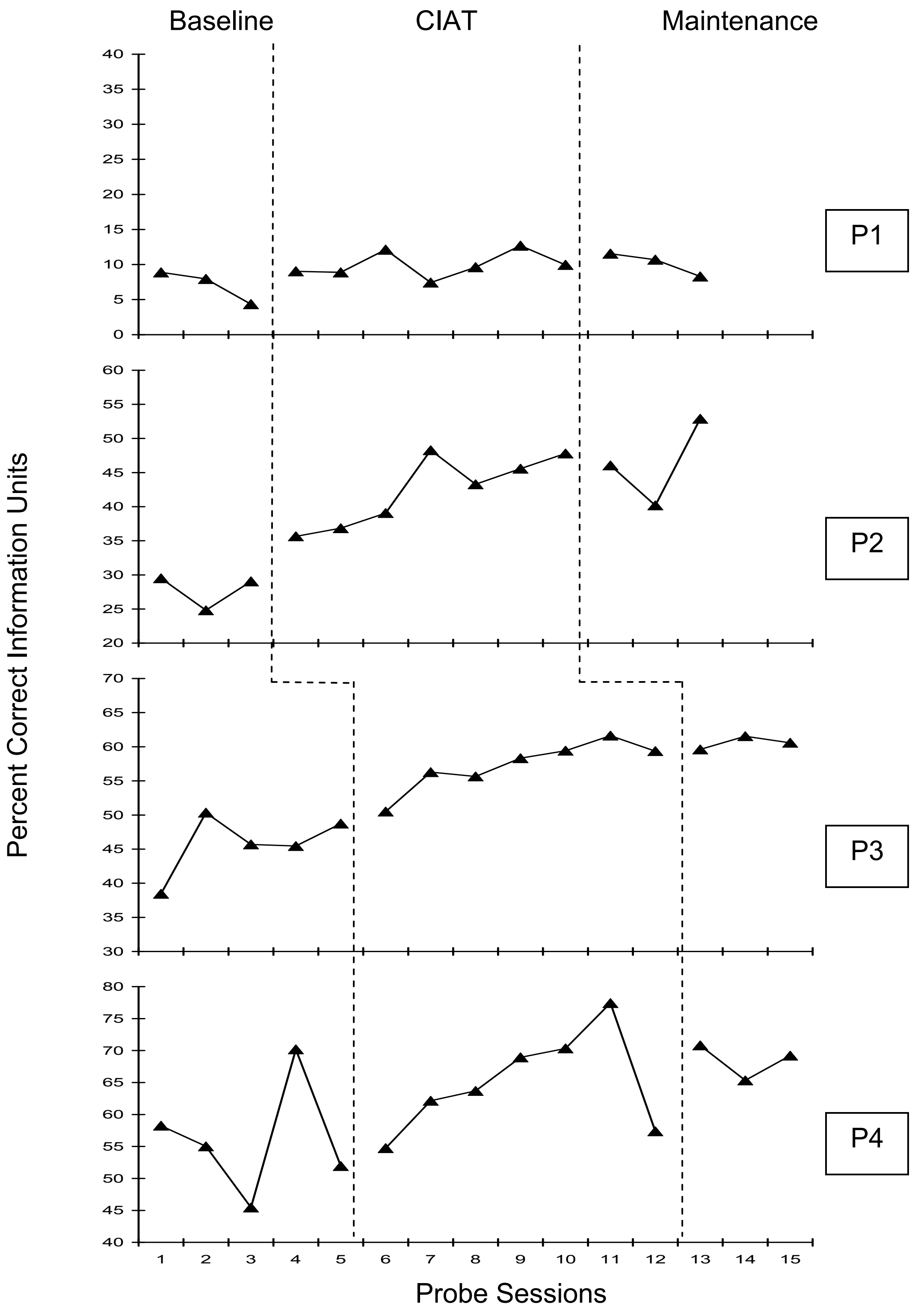

Figure 8: Percent CIUs (correct information units / total words) for participants P1 through P4 during baseline, CIAT, and maintenance.

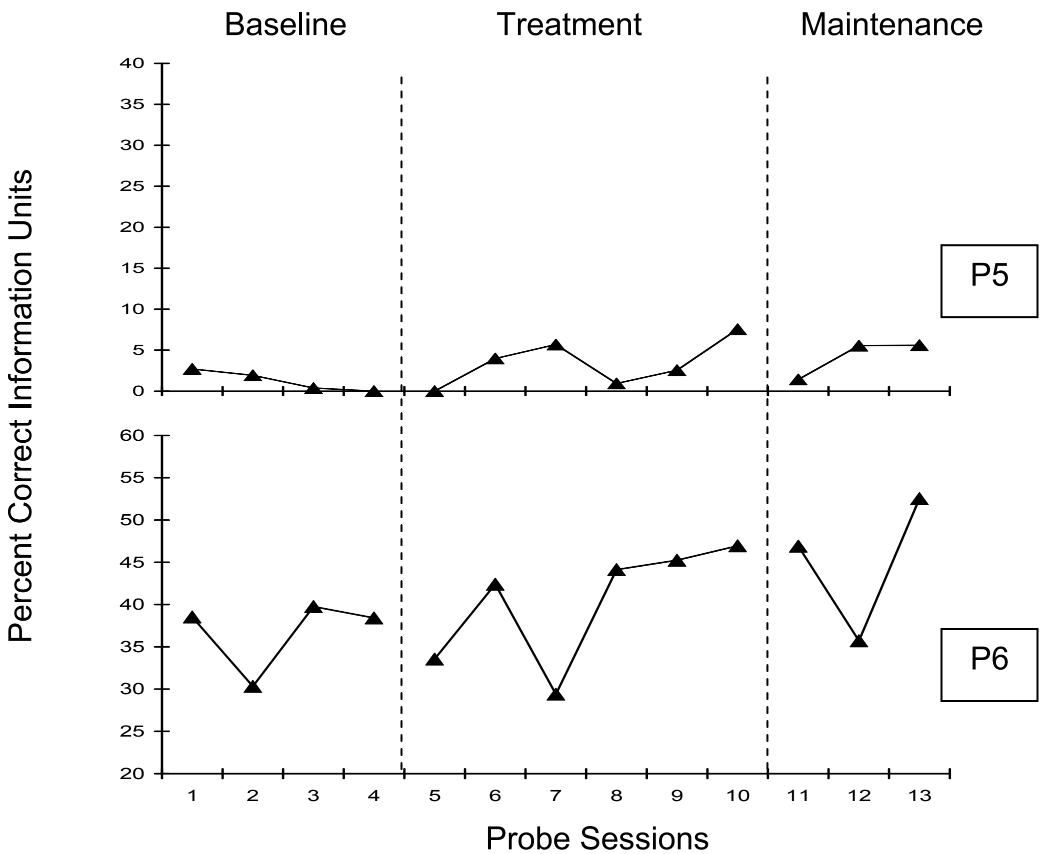

Figure 9: Percent CIUs (correct information units / total words) for participants P5 and P6 during baseline, CIAT, and maintenance.

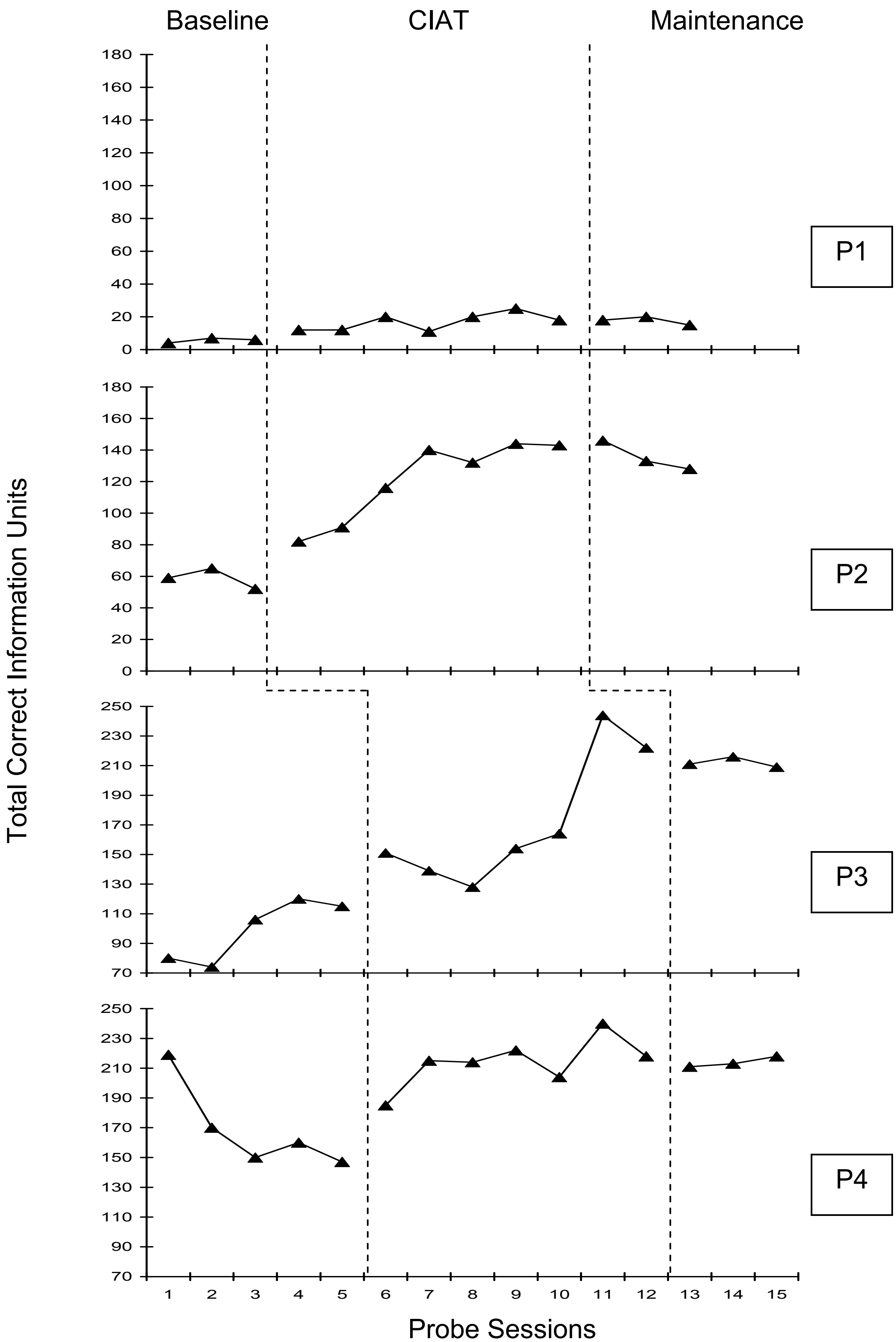

Figure 10: Total CIUs (TCIUs) per session for participants P1 through P4 during baseline, CIAT, and maintenance.

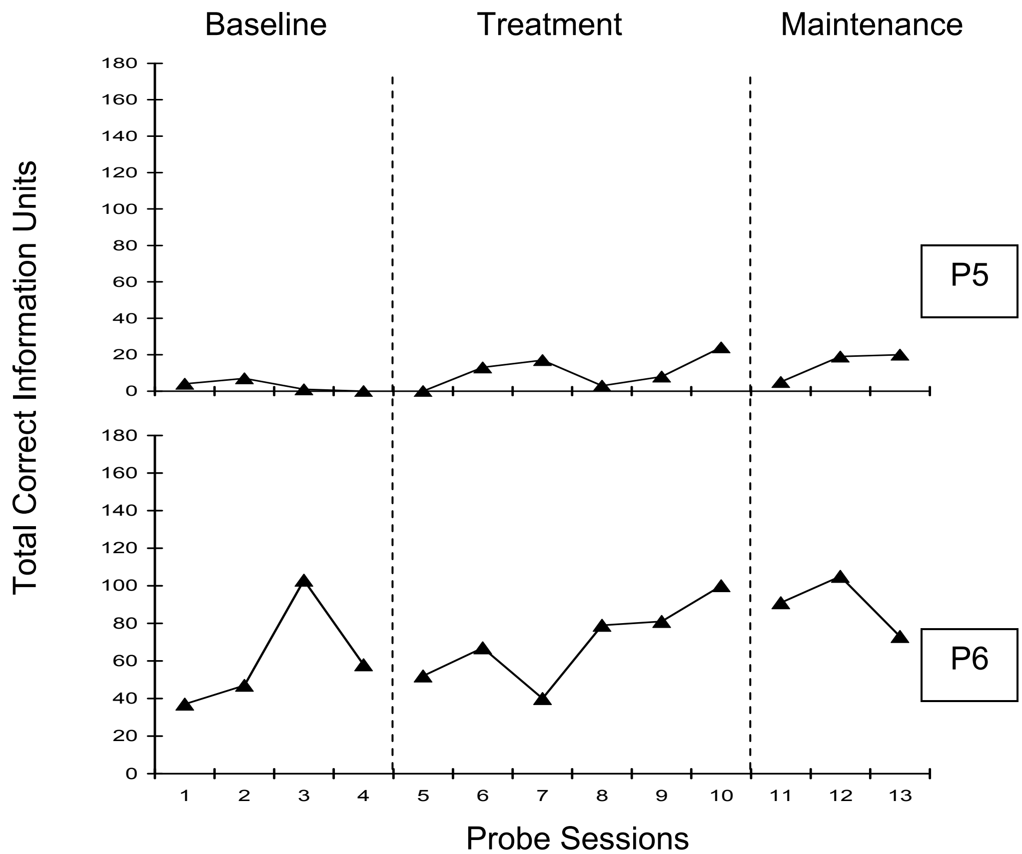

Figure 11: Total CIUs (TCIUs) per session for participants P5 and P6 during baseline, CIAT, and maintenance.

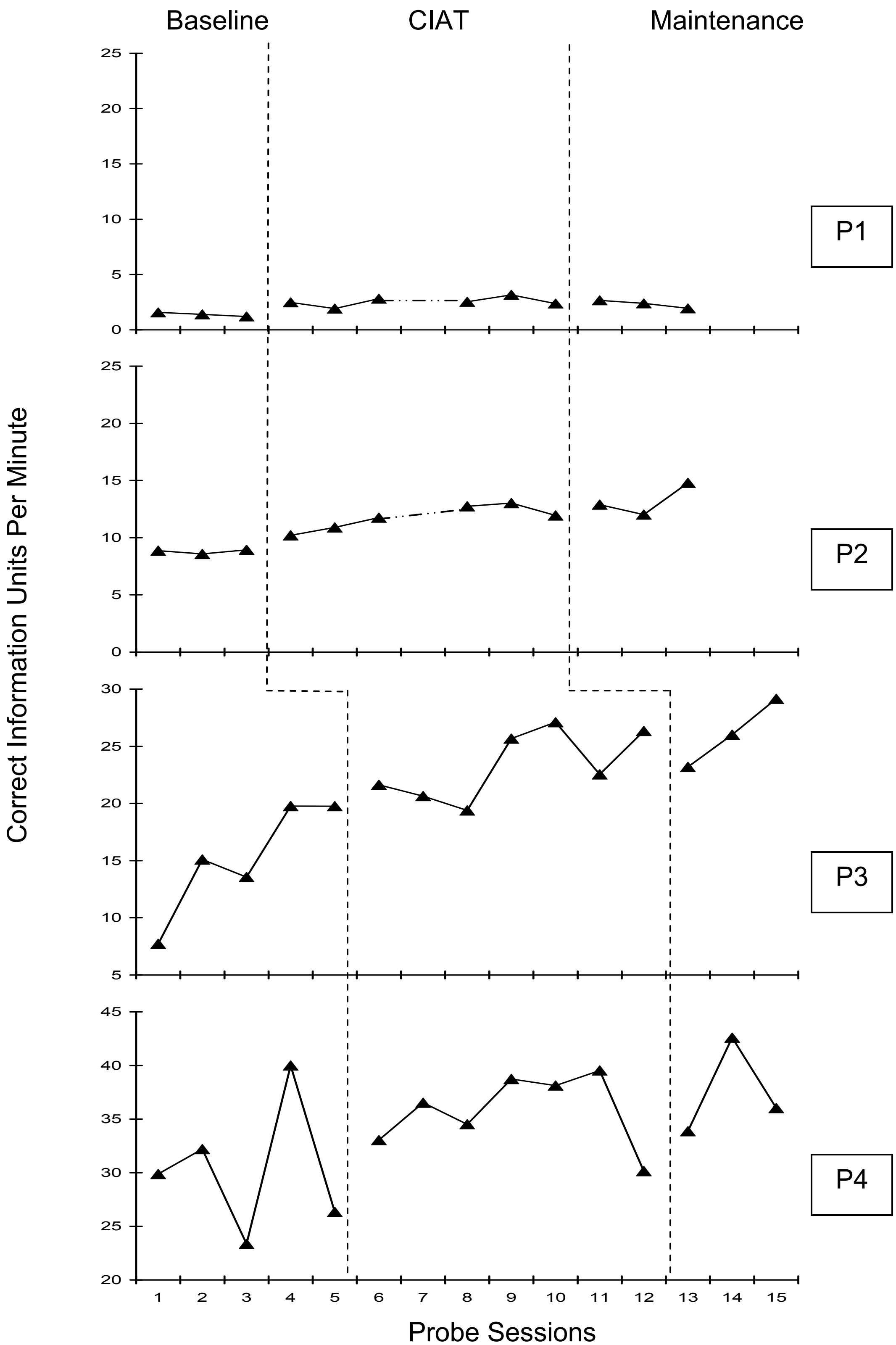

Figure 12: CIUs per minute (CIU/min) for participants P1 through P4 during baseline, CIAT, and maintenance.

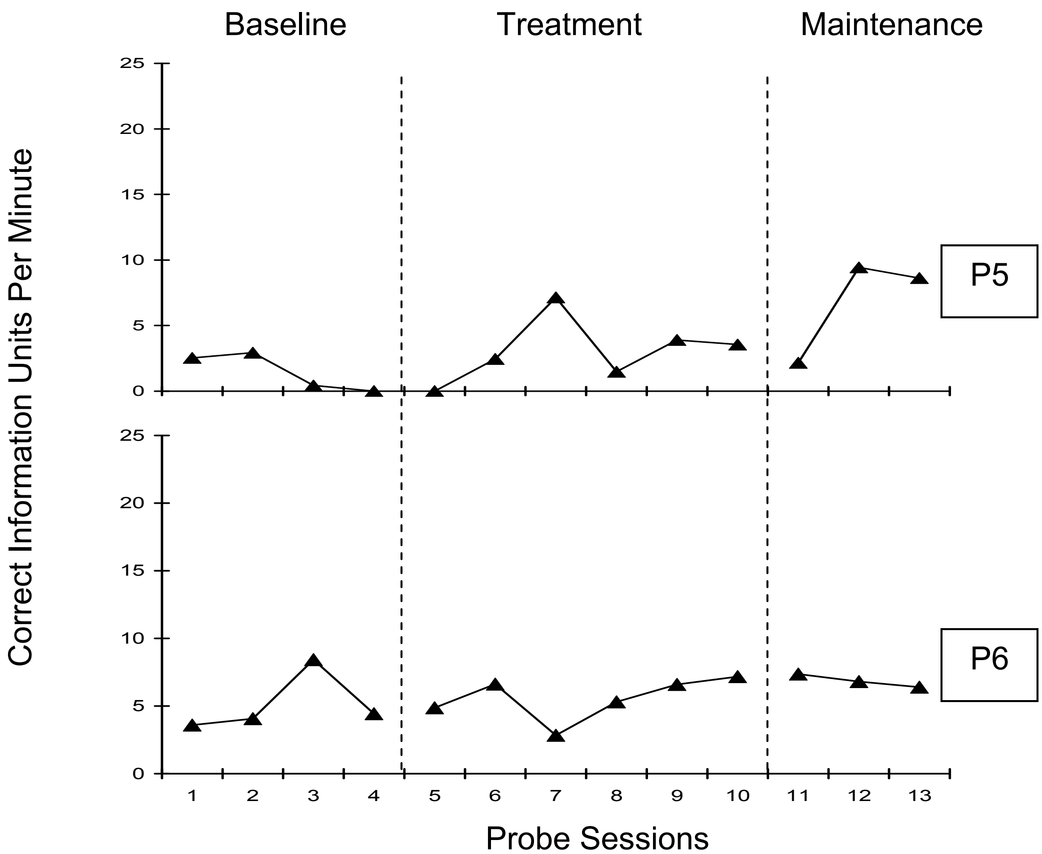

Figure 13: CIUs per minute (CIU/min) for participants P5 and P6 during baseline, CIAT, and maintenance.

CHAPTER 4

DISCUSSION

Standardized Measures

One aim of this study was to determine the impact of CIAT within the context of the WHO-ICF via administration of standardized measures of language ability, functional communication, quality of communication life, and depression. Results from this study replicate the existing body of research that claims clinician-administered CIAT is an effective method of improving speech-language abilities in adults with chronic aphasia. Specifically, these findings supported the claim that improvement on standardized measures of language ability occurs following CIAT (Breier et al., 2006, 2007; Maher et al., 2006; Meinzer et al., 2004, 2005, 2006; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001; Pulvermüller, Hauk, Zohsel et al., 2005; Richter et al., 2008), as all participants increased WAB-R AQ profile scores. Maher et al. (2006) reported that three of four participants who received CIAT improved by 5 points or more on the WAB-AQ post-treatment, determining that those changes were meaningful. Similarly, four participants in this study improved AQ scores by 5 points or more (5.4, 6.0, 9.1, and 9.7), though the determination of “meaningfulness,” or practical significance, was attributed only to a single participant (P3) because of the application of a more stringent criterion (Robey, 1998). Any improvement on standardized measures of impairment should be interpreted with caution, as no aphasia treatment study to date, including the present study, has incorporated procedures to guard against practice effects. Current speech-language assessment measures are not intended to undergo repeated administration in such a short span of time, despite good test-retest reliability.

Several measures have been used in an attempt to provide evidence for transfer of skill to real-world settings following CIAT, primarily the CETI and the CAL. Because of the weaknesses of those measures (i.e., proxy and psychometrically unproven, respectively), this study utilized the CADL-2. Five of 6 participants increased CADL-2 raw scores by 2 or more points (range 2-8) following CIAT, though none represented a change of practical significance because of the large standard deviation of the instrument (18.38). This property of the CADL-2 reduces the weight of the claim that the burden of activity limitations was decreased following CIAT, and future studies would benefit from continued exploration for improved methods of measuring this construct.

Changes in quality of communication life and depression were assessed with the ASHA-QCL and GDS-15. All participants increased their mean ASHA-QCL scores, two participants to a practically significant level, indicating improvement in quality of communication life. A closer examination of the responses revealed that at least half of the participants increased their rating on items that related directly to participation in life activities (e.g., being included in conversations, using the telephone, getting out of the house to do things). Though not compelling evidence, it was corroborated by the following informal reports provided by participants and caregivers of events that occurred during the experiment: P2 ordered his first delivery pizza over the phone while his spouse was out of town; P3 called his grandson for the first time since his stroke; P4 dined out alone for the first time since her stroke; caregivers reported that P1, P5, and

P6 were persisting more with their communicative attempts; and P5 was less withdrawn in the company of friends and family. Results from the depression measure are fairly uninformative. No participants were depressed before CIAT, nor did they demonstrate depression post-treatment. Following CIAT, movement of 0-2 points per individual was observed in increasing or decreasing directions, and no one scored above a 3 at any point during the experiment.

Repeated Measures

Naming

Another goal of the study was to examine the effects of CIAT on naming of trained and untrained items. This was the first known study to employ a multiple-baseline single-subject design to more clearly demonstrate the effect of CIAT on naming of trained items. The utilization of non-specific social interaction baseline sessions establishes that results can be attributed to CIAT and did not arise from increased social interaction. Specifically, four participants exhibited stability according to preset criteria during the 2-hour baseline sessions described in the method and also made practically significant (*SMD3* > 3.9) improvements in naming of trained items by the end of treatment that were maintained during the follow-up probes. Contrary to predictions, CIAT did not enhance generalization to untrained items, as the generalization criterion was not met and variability prevented the perception of clear changes in level and trend. Additionally, although most participants did improve performance on these items throughout the study, change of practical significance was not achieved. It should be noted that overall performance for N-GUT items was greater for most participants than N-GT items. This could be due in part to differences in storage, access, and processing of animate (e.g., animals and body parts) versus inanimate items (e.g., household items, transportation, etc.), since a dissociation between the two categories has been established (Forde & Humphreys, 1999; Moore & Price, 1999).

Informativeness of Speech

This study was the first to answer the call by Maher and colleagues (2006) to examine discourse via repeated administration of probes so the effects of CIAT on discourse could be described in more detail. A measure of informativeness and efficiency of speech, %CIUs, was the dependent variable used to make phase change decisions for this study. As discussed in the results, positive changes in %CIUs during CIAT was observed for all participants, with change of practical significance observed via large effect sizes (*SMD3* > 5.8) for one participant by the end of treatment and during the maintenance phase.

More encouraging results surface if the variable of interest is TCIUs instead of %CIUs, because the two variables are not necessarily related (i.e., individuals may increase total CIU production in the absence of a reduction of nonCIU words). Three participants demonstrated change of practical significance for TCIUs, with one participant tripling his average CIUs observed in baseline, albeit a low baseline. The remaining participants more than doubled their mean performance, and medium to large effect sizes were noted for all three (range = 4.63 to 12.44). These data are contributing to the emerging body of research examining the effects of CIAT on discourse, which is a collection of varied analyses thus far. As illustrated in the literature review (Goral & Kempler, 2008; Maher et al., 2006; Szaflarski et al., 2008), CIAT can lead to increases in number of total words and utterances during discourse. The present study extends these findings by establishing that participating in CIAT can also lead to improvement in the informativeness and efficiency of discourse during structured elicitation discourse tasks.

Comparison to Other Aphasia Treatment Approaches

Aphasia treatment literature was examined for studies that addressed discourse via CIU analysis. Excluding those that provide support via AAC devices during discourse sampling (e.g., Bartlett, Fink, Schwartz, & Linebarger, 2007; Fink, Bartlett, Lowery, Linebarger, & Schwartz, 2008; Linebarger, McCall, Virata, & Berndt, 2007), three treatment approaches emerged: modified Response Elaboration Therapy (mRET), Semantic Feature Analysis (SFA), and Treatment of Underlying Forms (TUF; formerly titled Linguistic Specific Treatment [LST]). Wambaugh and Martinez (2000) administered mRET, which involved training a specific set of picture description or personal recount tasks while withholding similar tasks for generalization. All three participants increased TCIUs per picture, and generalization to other untrained picture description or personal recount tasks occurred in some cases. Comparison of this present study's findings to mRET results is difficult because authors present their data in terms of TCIUs per picture, and individual picture data are not available so that TCIUs for each set (across all pictures) can be determined.

Across three SFA studies (Boyle, 2004; Boyle & Coelho, 1995; Coelho, McHugh, & Boyle, 2000), one individual increased %CIUs relative to the baseline mean following treatment, but inferences are problematic due to an unstable baseline. Other participants demonstrated no change in response to SFA treatment, or steadily increasing but unremarkable trends. Boyle (2004) was the only one to address the effect of SFA on TCIUs, with one participant demonstrating a steady increase over the course of the study; the other participant evinced no change. When examined in these studies, performance on the variable CIUs/min was described as unchanging, steadily increasing, or modestly increasing. The most notable findings for this variable were increases of 15-23 CIUs/min observed following SFA treatment in two separate studies (Boyle, 2004; Coelho et al., 2000).

Examination of two studies (Ballard & Thompson, 1999; Murray, Ballard, & Karcher, 2004) in which TUF was administered to individuals with aphasia reveals weak support for the effect of TUF on discourse, as most participants (6 of 9) demonstrated little, none, or negative change in %CIUs. However, increases in CIUs/min in response to treatment were reported for four participants. When the TUF protocol was modified to directly address discourse with the addition of a discourse training module (Murray, Timberlake, & Eberle, 2007) and was administered to a single individual, an increase from 25.5 to 58.35 %CIUs and an increase of 6.1 CIUs/min was observed. Jacobs (2001) reanalyzed discourse samples from previous studies (Jacobs & Thompson, 2000; Thompson, Shapiro, Tait, Jacobs, & Schneider, 1996), finding that four of the five individuals increased %CIUs while one individual maintained pre-treatment performance, for an average increase of 10.2 %CIUs across the entire group. An increase of CIUs/min by an average of 17.5 was reported for the entire group of reanalyzed discourse samples.

The present study most closely replicates the Jacobs (2001) findings, as the individuals in the present study increased an average of 10.1 %CIUs, compared to the average 10.2 percentage increase apparent in the Jacobs (2001) reanalysis. The weakness of the majority of findings reviewed are that they are usually a result of pre- and post- treatment measures, and do not result from comparisons of multiple data points throughout the course of the study. Comparison of this current study to those reviewed demonstrates that CIAT is at least as effective in increasing discourse measures as TUF and mRET, and seemingly more effective than SFA. This is encouraging, as the pictures, narrative, or vocabulary related to either were never trained in this study. With the majority of treatment time devoted to the card game described in the method, the achievement of gains comparable to treatment protocols that deliberately set out to train narratives and personal recount tasks (Murray et al., 2007; Wambaugh & Martinez, 2000) is promising. The added benefit of the gains observed in this study, of course, is that it occurred following participation in 30 hours of CIAT administered within two weeks versus months of treatment provided at a traditional practice schedule.

It has been established that performance during structured discourse tasks is a valid measure that predicts communicative ability in interpersonal discourse situations. Additionally, changes in these measures predict listener judgments of ability and severity more reliably than performance on standardized measures (Doyle et al., 1996; Ross & Wertz, 1999). Given these qualifications, perhaps discourse measures should be researched further to determine their appropriateness for serving as measures of activity limitations (i.e., transfer of skill to real-world settings), and this is the subject of future research.

Preliminary Dosage Findings

This study provided preliminary evidence regarding dosage of CIAT in the form of average major turns related to treatment stimuli per hour. The means across all participants are problematic because of the variation between participants, but these data can be expanded and refined through systematic experimentation and replication. There was no apparent relationship between dosage and severity, but there did seem to be a relationship between dyad membership and number of turns for Dyads 1 and 2. The expected relationship between dosage and magnitude of improvement was not obtained, but the present data do reveal some of the complexities behind this intuitive prediction. For example, one participant (P5) who participated in more turns than all other participants, and therefore might have been expected to make greater gains, demonstrated little change on repeated measures. Conversely, P3 and P4 participated in fewer turns but still made gains comparable to, or of greater magnitude, those of the other participants. One complicating factor is that P3's and P4's turns were longer, as a function of the length of their utterances and of the types of cues they were given, such as the imposed time delay. In addition, when a time delay was imposed for these participants, they were instructed to mentally assemble the sentence elements during the delay. It is impossible to speak with authority on the effects of mental practice in this study, but the positive effects of mental practice have been established (Pascual-Leone et al., 1995) in other rehabilitation literature. Comparison of CIAT administered with and without a mental practice element would inform this issue and should be the topic of future research. If mental practice leads to greater benefit, then it could be used as a way to install more practice into current aphasia treatment schedules and potentially improve treatment outcomes.

Limitations and Implications

Methodological Weaknesses

Stability Criteria

Six repeated measures were tracked throughout all phases of this study, but baseline stability was monitored only for the dependent variable %CIUs. This resulted in several instances of steep baseline slopes for other dependent variables (e.g., P3 for CIUs/min), so that the effects of CIAT on those behaviors cannot be confidently determined, despite information to the contrary provided by PND or practical significance calculations. To ensure more powerful assessment of the impact of CIAT while avoiding protracted baselines, future studies could track a lesser number of dependent variables and require stability on all variables before treatment is applied.

Even with those safeguards in place, results can be called into question if the definition of stability is not stringent enough. The dual criteria for determination of a stable baseline for this study required less than 30% fluctuation across baseline values, and less than a 10% rise at the last baseline point (Edmonds & Kiran, 2006; Kiran, 2008). As discussed, all participants demonstrated stable baselines according to these criteria for %CIUs, and though no other baseline measures were monitored for stability before initiation of CIAT, these criteria were met for most naming probes. It would thus seem safe to confidently attribute improvement to CIAT and not to social interaction alone. However, these criteria did not prevent the occurrence of accelerating trends in baseline data, which reduces the impact of the conclusions presented in this study. For example, several performances that were practically significant and that also had a large percentage of nonoverlapping data could have been predicted by baseline trends (e.g., P2 and P3 on N-T, P2 on %CIUs). This weakness highlights the need for researchers to present data for visual inspection to allow consumers of research to draw their own conclusions about the meaningfulness of the data given their individual definitions of stability, since 100% PND and even large effect sizes can occur with steadily rising data points throughout consecutive phases of an experiment. Future studies should incorporate more stringent criteria. Less than 5% fluctuation has been suggested as a criterion for stability (Barlow & Hersen, 1984). Interestingly, three participants (P1, P2, and P5) demonstrated less than 5% fluctuation during baseline sessions for %CIUs, as did P3 if his first data point is removed as an outlier. Findings from this study should not be too quickly discounted for %CIUs or other variables because of the weaknesses presented here, especially since similar patterns of improved response during the treatment phase were replicated across several participants.

Maintenance Probes

Overtraining of behaviors. Another limitation in the interpretation of the results is that because the dependent variable did not reverse during the maintenance phase for some participants, experimental control might need to be further questioned. This is a pervasive problem within the aphasia treatment literature, since the goal of treatment is often to discover or establish methods of improving language functioning with long-lasting effects (Thompson, 2006). In this study, the massed practice schedule perhaps facilitated overtraining of behaviors, which is actually recommended for inducing neural reorganization and developing long-term treatment gains (Raymer et al., 2008). For example, a closer look at naming performance on Figures 1 and 2 shows that the participants (P2 and P4) who were trained above 80% correct for more than one probe session were the individuals that did not demonstrate decreasing performance during maintenance, whereas all others who were not trained to the same level show the decrease in performance. Thus, this limitation should not discredit the findings fully and should, in fact, lead to more research examining the optimal dosage of CIAT that leads to retention of gains.

Lasting effects? The need for dosage research is further highlighted by examination of the performance of participants with steadily decreasing data points during maintenance. Unfortunately, only three maintenance probes were collected over the course of 4-5 nonspecific control sessions, adhering to the minimum requirement for establishing trends in data (Barlow & Hersen, 1984; Beeson & Robey, 2006), and also to minimize the time and financial demands placed upon the participants and their families. A greater number of follow-up probes is recommended for future studies to determine if the drop-off of performance following termination of CIAT would occur, as is suggested by a portion of these data. If so, the utility of the demanding schedule of this approach should be questioned.

The Disadvantage of Replicating

One aim of this study was to replicate previous CIAT research by administering the CIAT package at one of the more frequently utilized practice schedules. A modified single-subject experimental design (SSD) was employed to accomplish this aim, but the modifications came with a price. One strength of SSD is that, by definition, it is driven by the response of the participants. Adherence to a preset practice schedule limited the ability of the present study to obtain quality data and prevented the flexibility generally afforded by SSD to determine which independent variables are controlling changes in behavior. In addition, application of a treatment package violated another cardinal rule of SSD, that of changing one variable at a time (Barlow & Hersen, 1984). As long as CIAT is administered as described in the literature and in this method, determination of the differential contribution of specific treatment elements (i.e., massed practice, group interaction, practice of a limited set of discourse acts, scaffolding, feedback, constraint, etc.) will never occur; researchers will only be able to make claims about the effect of the treatment package as a whole. Yet, it is the responsibility of researchers to pull apart these elements to determine which elements are superfluous and which elements are essential for improved treatment outcomes. The literature base would benefit from systematic investigations of singular treatment elements in classic data-driven SSD experiments to address this issue.

Individual Differences

Another limitation of this study is that when improvements were noted, they were not replicated across all participants. For example, the positive results for naming of trained items were more prominent for P2, P3, P4, and P6, whereas the outcomes for P1 and P5 often did not align with predictions. Other disparities to be discussed include the differential performance of P2 and P6 despite nearly equal severity ratings, and also P2's performance for all probes relative to other participants.

P1 and P5

Severity. Severity and perseveration were the main factors that distinguished P1 and P5 from other participants. Previous studies have not addressed these issues. Eight studies within the CIAT literature document involvement of individuals with severe (or moderate-severe) aphasia. Comparison of outcomes can only be accomplished with impairment scores because no studies have administered repeated probe measures of naming or discourse, or the CADL-2, ASHA-QCL, or GDS-15. Two of these studies (Pulvermüller et al., 2001; Szaflarski et al., 2008) included individuals with severe aphasia, but no individual data was provided. The Richter et al. (2008) study included two individuals with global aphasia, and both improved on unspecified language assessment measures, although the magnitude of improvement is difficult to discern given vague data. Three participants with severe global aphasia improved by 0.6, 1.6, and 1.9 points on an unspecified profile score, all changes that were considered statistically significant via *t*-tests. Two individuals with severe aphasia in the Pulvermüller, Hauk, Zohsel et al. (2005) study increased AAT subtest scores by 1 to 3 points.

It is more informative to compare results from the present study to previous studies that have utilized the same impairment measure, the WAB or WAB-R. In the Maher et al. (2006) study, the individual with severe aphasia demonstrated an increase of 10.6 points on the AQ profile score, the largest change made by any member of either CIAT or PACE groups in the study. The Breier et al. (2006) study included three individuals with severe Broca's aphasia, with two increasing their AQ scores by 1.6 and 2.2 points, and the other showing a decrease of 7.2 points. This was much poorer performance compared to the individuals with moderate aphasia in the same study, who increased their AQs by 1.6, 7.4, and 7.8 points. Raw scores are not reported in the Breier et al. (2007) study, but the individual with severe aphasia improved his AQ profile and the majority of his subtest scores. The participants with severe aphasia in this study are comparable with the review of variable CIAT findings, since P1 increased his WAB AQ by 1.3 points, and P5 increased by 9.1 points. Still, this does not inform us as to why their patterns of response on the probe measures differ so much from other participants.

It is noteworthy that the participant who demonstrated one of the largest increases on the WAB-R AQ in this study (P5) did not respond to probe measures with similar magnitude. This is likely due to the fact that the greatest increase in his WAB-R scores was on the Auditory Comprehension Subtest, and none of the probe measures in this study assessed gains in this area. Still, this simple illustration supports the argument against overreliance upon standardized measures administered pre- and post- treatment to prove outcomes, as they do not tell the entire story of response to treatment.

Perseveration. Perseveration is another distinguishing characteristic shared by P1 and P5 that could have contributed to their reduced response to CIAT relative to other participants. The moderate and severe perseveration exhibited by these participants meant that many of their responses during treatment were often real words and in the preferred spoken language modality, but were incorrect. The short but intense therapy schedule utilized in CIAT for the purposes of capitalizing upon activity-dependent plasticity was likely less effective for these participants because of their frequently occurring errors. They just did not get as much practice with correct productions relative to incorrect productions as their fellow participants, reducing the likelihood that synaptic connections associated with the desired behavior would attain a competitive advantage over other connections associated with less desired behaviors. A more detailed analysis of turn data would likely reveal that even though they may have participated in a large number of turns, indicating that they received a higher dose of therapy, that the number of correct turns would be a lesser number.

Modifications to existing CIAT protocols are indicated when individuals exhibit moderate to severe perseveration. One approach could involve manipulating the treatment stimuli so that decks of cards contain semantically, lexically, and phonemically dissimilar items to reduce the probability of perseveration. It could also be as simple as incorporating elements of programs designed to specifically address this behavior, such as Treatment for Aphasic Perseveration (TAP; Helm-Estabrooks & Albert, 2004b). However, if these modifications are not successful in ensuring that they receive the treatment as intended (i.e., massed practice of the desired behavior), other options should be explored.

In this study, TAP principles were incorporated initially when working with P5 with no apparent success. Therefore, an errorless learning approach was decided upon and applied with more success. Despite the resultant increased frequency of cues, withdrawal of cues was still possible so that P5 was able to move from Level 1 to Level 3 of the syntactic hierarchy. An errorless learning approach is not at odds with CIAT, as they both claim to capitalize on Hebbian principles (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003; Pulvermüller & Berthier, 2008) and an error-reduction approach has already been incorporated into a previous CIAT study (Maher et al., 2006). The merging of errorless learning and CIAT has not been addressed, and future research initiatives might benefit from incorporating errorless learning principles into CIAT protocols modified for individuals with severe perseveration.

Sensitivity of the probe measures. The fact that P1 and P5 did not make improvements on the probe measures with the magnitude of other participants in this study could be a result of the sensitivity of the measures used. This is particularly true in the case of P1, who made notable improvements in naming behaviors that were not captured by the probe measure utilized. Because points were not granted unless productions were intelligible without context, subtle improvements and productions of lexical and semantic paraphasias that occurred throughout the course of the study were not reflected in the results. For example, pre-treatment production of the target "dress" was either unintelligible, or was produced as / t ɪ s / or "desk." Following treatment, P1 reliably produced / p ɛ s / or / p ɛ s ɪ s / when presented with this picture. Similar examples are listed in Appendix X. Also, P5 produced predominantly program-in-action, phonemic carryover, and lexical perseverative errors at the onset of this study. By the end of treatment, he evidenced a reduction of phonemic carryover errors, and an addition of semantic perseverative errors, comparable in frequency to his lexical errors. Such error evolutions, from unrelated errors to more related errors, are considered improvement.

P2 and P6

Visual inspection of data for P6 does not reveal clear patterns of behavior in response to treatment, and it is believed that at least a portion of this variability can be attributed to the participant's level of discomfort as well as his level of frustration. Regarding the former, frequent breaks were required during assessment and treatment sessions to readjust his arm sling, stretch out his hand and extremities, etc. This led to assessment sessions that were longer than the rest of the participants. His physical discomfort could have also contributed to his protracted retrieval times, as research has demonstrated that individuals with chronic fatigue and/or discomfort present with longer reaction times in motor tasks, reduced attention, prolonged latency of correct responses during pattern recognition tasks, and less efficient search strategies during working memory tasks (Craft et al., 1995; Majer et al., 2008; Marshall, Forstot, Callies, Peterson, & Schenck, 1997). In addition, P6 seemed more aware of his deficits than all other participants (excluding P4), and exhibited high levels of frustration that often led to reduced persistence during assessment and treatment tasks.

Still, it is interesting that P6 had such a different response to the probe measures given the similarity of his AQ score with P2. Much of their experience was the same – time of day, experimenter, materials and activities, snacks, environment, etc. Differences included time post stroke, individualized cueing hierarchies, auditory comprehension, motivation, and physical discomfort, any or all of which could have played different roles in outcomes. However, one glaring difference between these two participants that can be quantified and discussed objectively is dosage.

Comparison of turn data. An examination of the turn data demonstrates that although P2 and P6 were both in therapy for three hours a day, P2 participated in an average of 175.6 turns per hour (SD 29.5) while P6 participated in an average of 112.8 turns per hour (SD 25.9). In addition to this difference, the number of utterances within turns frequently varied between these participants. One turn for P2 often included several correct utterances, as he was observed to repeat his utterances within a turn, in part or in their entirety (e.g., “Do you have…Do you have….hat. [Name], [Name], do you have a hat?”). Turns for P6 rarely included more than one utterance, and the time it took to produce the singular utterance was much longer than that evidenced by P2. The implication of this comparison is that less attention should be centered upon the number of hours of therapy provided and more attention paid to how many repetitions of the target behavior they are performing, if optimal gains are to be realized. This seems intuitive and obvious, but this is the first inquiry into the topic in the CIAT literature.

What Makes P2 Special?

P2 demonstrated change of practical significance on all probe measures except for N-GT and N-GUT. Though this did not translate to practically significant change on standardized measures, the probe measures are relied upon more fully because they arose from careful tracking of target behaviors following stable baseline performance. Two immediately apparent characteristics upon meeting this individual and spending time with him were his jocularity and motivation. His favorite phrases were “Life is good” and “Work work work, play play play,” indicating with hand gestures for the latter that they should be one and the same. He was also driven by an intense desire to return to the work force, and continually seeks out aphasia treatment opportunities in hopes of achieving that goal. The influence of his motivation and positive mood state on treatment outcomes cannot be determined, but it could have engaged neuromodulatory mechanisms to higher levels than other participants. Such increased attention and arousal levels can facilitate plastic mechanisms that in turn increase opportunities for modification of neural circuitry (Kaas, 2002; Turkstra, Holland, & Bays, 2003), supplying him with an advantage compared to his peers.

P2's treatment history could have also played a role. No participants were receiving other therapeutic services during this study, but all had received previous services that may have influenced their response patterns. There is no way to rule out order effects or priming effects of previous treatments for any of the participants. Examination of magnitude of change and time since previous treatment does not reveal a clear pattern, with the following exception: P2 and P3 experienced the longest drought in services before enrollment in this study and also demonstrated more improvements of greater magnitude. Perhaps a period of time without services for these individuals helped them to realize the value and impact of previous therapy so that they were more intent than others to get the most out of this opportunity.

Recall also that P2 had previously been enrolled in research studies at the University of Georgia. One of the studies involved contact with the experimenter during an investigation of the impact of massed traditional speech and language services. Assessment and treatment materials differed between that study and this present study, with the exception of a shared discourse probe. In the former study, the experimenter did not act as the clinician, but rather supervised graduate clinicians who carried out treatment that she designed. P2 completed that experiment with good results, in that he demonstrated several notable changes on subtests of the Aphasia Diagnostic Profile and improved on most probe measures, although he did not meet practical significance criteria for the latter. His outcome expectations could have contributed to his impressive results since factors such as provider contact, perceived credibility of the provider, and perceived utility of treatment have been reliably associated with clinical improvement (Greenberg, Constantino, & Bruce, 2006; Joyce & Piper, 1998) in the psychology literature.

Future Directions

New Perspectives

Dynamic Systems Perspective

The stated goal of CIAT is to facilitate the development of an intentional bias to use language (Nadeau et al., 2008). Many types of gains across multiple participants occurred in this study, and subjective remarks regarding participant behavior can be provided (e.g., he never tried to use gestures for speech) in an attempt to answer whether or not the goal was achieved. An examination of the CIU measures, predictors of conversational abilities, can be undertaken as well. Still, the difficulty lies in the use of the nebulous term “bias.” “Bias” brings to mind other terms, such as “preference,” a term used often in discussions of dynamic systems. This next section will briefly discuss dynamic systems perspective (DSP), its current applications, and the potential benefit that might be reaped from application of this framework.

DSP describes complex systems and organisms as being in a constant state of chaos, described as a constant readiness to shift from behavior to behavior according to changes in task demands and environmental conditions (Gleick, 1987; Kelso, 1995; Thelen & Smith, 1994). Behaviors do not reside in singular cortical centers, though specific cortical areas are recognized as playing key roles in behaviors. Rather, behaviors emerge from cooperative interaction between neural networks involved in the behavior, and a landscape analogy is used to illustrate this emergence (Kelso, 1995).

The landscape is referred to as the phase space, and it represents all of the potential behavioral solutions over time for an organism. The attractor basins (valleys on the landscape) represent behavioral patterns, and the depth of the attractor represents the relative stability of the attractor. Shallow attractor basins are meant to represent a less reliable and more easily disrupted behavioral pattern, whereas deeper attractor basins represent stable behavioral patterns that persist in the face of variability. Complex systems are said to be in a constant state of flux between three different phase states (Gleick, 1987): fluctuating but relatively steady state within an attractor basin; unstable and highly variable behavior when moving from one attractor to another; and assumption of a steady state within a new attractor basin. DSP is frequently utilized to study emerging motor behaviors throughout development, but application of its constructs is also appropriate in the study of acquired disorders and recovery.

Spatiotemporal index (STI). Evans (2001) recently designed and conducted an investigation of children with language impairment utilizing a DSP framework, but the most notable application within the field of communication sciences and disorders has been the development of the spatiotemporal index (STI; Kleinow & Smith, 2000; Smith & Goffman, 1998; Smith, Johnson, McGillem, & Goffman, 2000). The STI arises from kinematic measurement of articulators in which movement trajectories of trials of the same motor movement are averaged after some normalization of time and amplitude of movement. Standard deviations are then computed to determine the degree of convergence, or lack thereof, of the movement trajectories onto one underlying trajectory. A large STI indicates more variability, interpreted as “greater variability in the nervous system command signals generated to control muscle activity” (Smith &

Goffman, 1998, p. 26). It follows that a lower STI, resulting from less variability of articulator motion during a designated speech task, would reflect a greater stability in the signals generated to those structures. The STI is thus used as a measure to indicate the depth of an attractor basin (Smith & Goffman, 1998).

Many interesting findings relevant to motor speech abilities have emerged from this field of study. Higher STIs, indicating higher levels of variability and instability, are consistently reported in children, which is adaptive, as they are constantly experiencing changes in size, shape, and mass of vocal tract structures. STIs slowly become more adult-like throughout development, but are affected by task demands. For example, higher STIs are observed in nondisordered speakers when performing speech tasks that are not at their habitual rate (i.e., twice as fast, half as fast; Kleinow & Smith, 2000; Smith, Goffman, Zelaznik, Ying, & McGillem, 1995), indicating that an alteration in habitual motor trajectories leads to instability. Also, increases in the linguistic complexity of an utterance also leads to increased STIs, with the interpretation that increased processing demands lead to less stable patterns of activity when issuing motor commands (Maner, Smith, & Grayson, 2000). The STI has been used clinically with individuals with dysarthria to provide support for pacing approaches (McHenry, 2003). Research showed that, unlike normal speakers, habitual rates in this population approximated fast rates (i.e., twice as fast), and unsurprisingly, the STIs for both rates were both high, indicating that habitual and fast rates of speech are unstable and nonpreferred behaviors. Slowing of the speech rate to half of the habitual rate led to a reduced STI, indicating a more stable behavior.

Application to aphasia treatment. One of the most interesting findings stems from longitudinal studies that have shown that children exhibit a period of increased variability (high STI) before acquisition of new sounds, possibly reflecting a necessary and adaptive imposed flexibility in the system to enable exploration and learning of novel sounds (Grigos, 2009; Smith, 2006). Translated to DSP jargon, this would represent the phase state of instability and turbulence that is necessary when moving from one attractor basin to another, that is, from one stable behavior pattern to another. This would become particularly important if considering the assertions of Christman (2002). The author asserts that aphasia is actually a state of non-flexibility and over-control, which is not adaptive. She further proposes that many behaviors observed in individuals with aphasia (e.g., perseveration, agrammatism, paraphasias, etc.) are a result of the system maladaptively residing in a stable attractor, lacking the necessary flexibility to move to a more adaptive attractor. Though the STI is derived from the motor trajectories of readily accessible articulators (e.g., lip, jaw), which is certainly difficult to translate to language processes, the underlying idea is intriguing – can a comparable language measure that is sensitive to stabilities and instabilities of the language system be developed? If so, and if Christman's presupposition is true, can it be used to learn which methods successfully push the system into instability and therefore into another adaptive attractor state? Much proof of concept work would need to be accomplished first, but the clinical implications of such a measure are promising. It could potentially be used to detect the stability of maladaptive behaviors of individuals with aphasia; to predict how much work (intensity of practice) is required to move individuals with aphasia to states of instability; to inform the clinician when to capitalize upon moments of instability; and to guide duration of therapeutic services, terminating only when the desired behavior demonstrates stability. The stated goal of CIAT and other therapeutic approaches could then be to facilitate the development of a *preference* to use language, which could actually be measured.

Complexity Account of Treatment Efficacy

Manipulation of stimuli for the purposes of enhancing generalization is another issue that should be explored. Thompson and colleagues have developed the complexity account of treatment efficacy approach (CATE), which shows that training more complex language elements results in generalization to less complex language elements, whereas training less complex language elements does not result in generalization to more complex language elements (Thompson, 2007; Thompson, Shapiro, Kiran, & Sobecks, 2003; Thompson & Shapiro, 2007). This account is supported by findings from the apraxia (Ballard, 2001) and child phonology literature (Gierut, 1998; Gierut, Elbert, & Dinnsen, 1987; Gierut, Morrisette, Hughes, & Rowland, 1996; Tyler, Edwards, & Saxman, 1990; Tyler & Figurski, 1994) that demonstrate that training targets higher in difficulty or complexity (e.g., non-stimulable sounds, complex syntactic structures, etc.) results in greater improvements in treatment outcomes as well as generalization to untrained words, sounds, and structures. Specifically regarding apraxia treatment, Ballard (2001) asserted that “much evidence speaks against employing the traditional hierarchy of working from less to more complex behaviors…When more complex behaviors are selected, the treatment becomes more difficult but response generalization is more likely to occur to related behaviors that are of similar or lesser complexity” (p. 12). Administration of CIAT currently involves movement from simpler levels of syntactic and linguistic (e.g., 1-word utterance, high-frequency nouns) to more complex levels (e.g., 6-word utterance, low-frequency nouns). The literature base would benefit from researching these topics.

High versus low frequency. High frequency and low frequency stimuli derived from the MRC Psycholinguistic Database were used for this study. This database is in need of updating, as many frequently occurring words of this era (e.g., computer, car) are missing from the database, resulting in stimuli that may not be as salient or relevant to the individuals receiving CIAT. Overall, there is some question as to whether or not a database constructed from frequency of occurrence in written English in the 1960s and 1970s is the most appropriate database for current treatment approaches that target spoken language abilities. However, the difference in frequency seems to be validated in part by the fact that the individuals in this study with higher WAB-R AQ profile scores demonstrated ceiling effects with high frequency items, encountering difficulty only with low frequency items.

Syntax and verbs. Missing from the CIAT literature are well-designed studies that include verbs, which is surprising since many individuals with different types of aphasia demonstrate more difficulty using verbs than nouns. It would be interesting to address both the absence of verbs and the idea of training more complex syntactic structures by incorporating insights from the Treatment of Underlying Forms (Murray et al., 2004; Thompson, 2001, 2008; Thompson & Shapiro, 2005). Developers have demonstrated that syntactically complex sentences are directly related to the verb and the number of arguments (i.e., agent, theme, etc.) it requires. For example, sentences involving obligatory two-argument verbs in which both an agent and theme are required (e.g., brush) are syntactically simpler than those that contain three-argument verbs that require an agent, theme, and location (e.g., put). These stimuli could easily be incorporated into CIAT via barrier tasks and picture description. This would also effectively increase the variety of communicative acts practiced in CIAT, which are currently restricted to affirmative responses, denials, requests, comments, and requests for clarification. Since the hierarchy of complexity has already been established by Thompson and colleagues, research to confirm the CATE account in the context of CIAT could easily be conducted.

Incorporating More Motor Learning Principles

As discussed in several examples, not all hours of therapy are created equal in terms of turns. In addition, not all turns are created equal in terms of number of utterances, or correctness of utterances. Future studies should look closely at factors such as number of utterances per hour, specifically either the number of correct utterances per hour or error rates (see Fillingham, Sage, & Lambon-Ralph, 2006), and relate them to treatment outcomes in order to provide more informative dosing information. However, overreliance on results of such analyses should be used as guidelines, and not as the new arbitrary standard for scheduling of services. Adherence to a preset schedule (e.g., 3 hours/day for 10 consecutive weekdays) in the clinical setting should not be the rule, and treatment should always be driven by the performance of the individual receiving it.

Discussion of this idea of quantification of repetitions (i.e., dosage) leads to a related discussion from the motor learning literature – the benefits of knowledge of performance (KP) feedback. As described in the method, KP feedback was provided to several participants, and was very effective. For example, when given feedback about voiced versus voiceless distinctions, or missing sentence elements, participants were able to develop awareness, apply the knowledge, and monitor their behaviors online to self-correct production of target utterances. The use of KP feedback is a well-studied concept in the motor learning literature, but has yet to be studied or translated effectively into the aphasia treatment literature.

Clinical Significance

Treatment outcomes are most often discussed in terms of statistical significance, though a focus on the magnitude of change in response to treatment, referred to as practical significance, is emerging. If reports of practical significance were to become as commonplace as reports of statistical significance, it would certainly enhance interpretation of treatment outcomes. However, even combining these two methods of reporting would still fall short of determining whether or not improvement is clinically significant, or clearly evident in the individual's everyday communicative functioning (Kazdin, 1982). There is no agreed upon method of determining when change is clearly evident, thus suggestions for exploring this topic will now be discussed.

One of the more popular distribution-based approaches that has proven effective is the Jacobson and Truax (1991) method of reporting reliable and clinically significant change (RCSC). First, it must be determined if change observed following treatment is real and not due to unreliability of the measurement instrument. This determination is accomplished by calculating the reliable change index (RCI) as follows:

$$\frac{(\text{post-test score}) - (\text{pre-test score})}{SE_{diff}}$$

In cases when decreased post-test scores represent improvement, the subtraction is reversed. The SE_{diff} is the standard error of the difference, and is calculated as follows:

$$SE_{diff} = (SD_1)\,(\sqrt{2})\,(\sqrt{1-r})$$

in which SD_1 is the standard deviation of the baseline observation and r is the reliability of the measurement (Beal & Duckro, 2003; Evans, Margison, & Barkham, 1998; Jacobson & Truax, 1991). If the obtained RCI is greater than 1.96 (the critical z value; Keppel & Wickens, 2004), then it can be concluded at a 95% confidence level that a reliable change has occurred (Beal & Duckro, 2003). The RCI is synonymous with the term minimal detectable change (MDC) and is easy to compute with standardized instruments that offer test-retest or internal consistency reliability estimates (Haley & Fragala-Pinkham, 2006). Within the updated RCSC paradigm, when the RCI meets the criterion z value and the individual moves within or into a normal range, they are considered *recovered*. Reliable change in the direction of the normal range is considered *improved*. No change is considered *unchanged*, and reliable change in the direction opposite of the normal range is considered *deteriorated* (Beal & Duckro, 2003; Hageman & Arrindell, 1999; Tingey, Lambert, Burlingame, & Hansen, 1996). When WAB-R AQ results from this study are calculated within this paradigm, participants P2 through P6 can be considered to be improved, as they demonstrated reliable change ($z > 1.96$) in the direction of the normal range. Unsurprisingly, because this computation relies on the underlying sampling distribution, no changes on the CADL-2 met the criterion for reliability. Reinterpreted in this light, no individuals in this study made practically or clinically significant improvements on the standardized measure of functional communication.

The application of RCSC to standardized measures is well characterized, but extension to repeated measures is unexplored. Agreement estimates, a form of reliability, could potentially be utilized in place of reliability measures to determine if change observed on probe data is reliable. The most intuitive similarity is between test-retest reliability and intraobserver agreement, and if utilized, the translation of the equation might be as follows:

$$\frac{M_{\mathrm{A2}} \quad - \quad M_{\mathrm{A1}}}{(SD_{A1})\,(\sqrt{2})\,(\sqrt{1\text{-intraobserver agreement}})} \quad = \quad \text{RCI for probe data}$$

in which SD_{A1} is the standard deviation of the averaged baseline observations and intraobserver agreement serves as the reliability measure. As an exercise, quick application of this equation to N-T and %CIUs data reveals the following interesting findings: participants P2 through P6 demonstrated reliable change in mean performance on N-T probes, with RCIs above 11.29 (range 11.29 to 48.04); P1 did not demonstrate reliable change on N-T probes; and all participants demonstrated reliable change in mean performance on %CIUs, with RCIs ranging from 6.25 to 34.62. Coupled with findings of practical significance in this study, the revised conclusion would be that four participants made improvements that were practically and clinically significant, and that one participant made practically significant and reliable changes on

%CIUs, though all demonstrated reliable improvement on this measure. Still, the question remains – is RCI, and therefore RCSC, just another mathematical equation that determines when change is real and not due to instrument or observer error, but does not provide information about the "meaningfulness" of a treatment to the individual who received it?

Perhaps utilization of an anchor-based approach would be more informative. The minimal clinically important improvement (MCII) and the minimal clinically important difference (MCID) are examples of this approach (Haley & Fragala-Pinkham, 2006; Jaeschke, Singer, & Guyatt, 1989; Kvien, Heiberg, & Hagen, 2007). These measures are determined by identifying the smallest change on an objective measure that corresponds with what individuals with aphasia describe as "meaningful" change via subjective measures. However, development of a valid and reliable measure that captures "meaningful" change for individuals with aphasia would have to occur before such computations become within reach. If that were to occur, perhaps a hybrid approach to reporting clinically significant change could be utilized, so that change must be reliable, in the direction of improvement, and be a MCID before claims of clinical significance can be made.

Summary

Generalization is common theme running through many of the implications and future directions sections of this chapter. Continued assessment of transfer to discourse has been recommended in order to assess the impact of CIAT on a measure that is a proven predictor of interpersonal communication abilities. Along these lines, future analyses might look beyond informativeness and also look to the coherence of discourse via the application of cohesion analysis (Armstrong, 2000; Hasan, 1985). The benefits of overtraining could be explored by continuing to administer CIAT until performance becomes asymptote on a variable of interest. This variable should be closely aligned with nervous system functioning and sensitive to the stabilities and instabilities of the language system, and could be developed following application of DSP. Future research should also determine the optimal dosage of correct utterances for facilitating retention, and should also look to other motor learning principles (i.e., KP). Lastly, incorporation of the CATE account could readily be accomplished to determine if treatment geared towards training more complex structures provided at a massed practice schedule leads to statistically and practically significant generalization of untrained structures.

Conclusion

Results from this study provide the new information that the CIAT protocol utilized in this study resulted in a reduction in activity and participation limitations, as demonstrated by improvements in standardized measures of functional communication and quality of communication life. Furthermore, this was the first study to demonstrate the effect of CIAT on naming of trained items and on untrained discourse tasks, though the stability criteria used in this study did not prevent the occurrence of accelerating trends in baseline data and therefore reduces the impact of these claims. Careful monitoring of procedural reliability ensured adherence to the treatment protocol described in the method so that effects observed in this study can be confidently attributed to the administration of CIAT, an issue that had not been addressed in previous research. Preliminary information regarding temporal considerations (e.g., dosage) of CIAT was also provided and will serve as a platform for future research. Finally, suggestions for future research geared towards refining aphasia treatment were provided to promote the continued search for strategies that enhance opportunities for recovery for individuals with aphasia.

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APPENDIX A

APHASIA SUBTYPES AND CHARACTERISTICS

Subtypes	Auditory Comprehension	Verbal Expression	Repetition	Suspected Lesions
Expressive				
Broca's	Slightly impaired to (WNL)	Nonfluent: telegraphic, sound distortions and substitutions	Impaired	Left frontal operculum, often inferior frontal gyrus; also insula, basal ganglia, and inferior portion of precentral gyrus
Transcortical Motor	WNL	Nonfluent: atypical delays in initiation, reduced length of utterances, paraphasias, perseveration	WNL	Variable: anterior to the frontal horn of the left lateral ventricle, prefrontal and premotor cortices
Receptive				
Conduction	Slightly impaired to WNL	Fluent: sensical with paraphasias	Impaired to slightly impaired	Supramarginal gyrus and underlying arcuate fasciculus
Transcortical Sensory	Impaired	Fluent: empty, with paraphasias and neologisms	WNL	Angular gyrus, posterior sector of middle temporal gyrus Primary auditory cortices and Wernicke's areas spared
Wernicke's	Impaired	Fluent: empty with paraphasias and neologisms; logorrhea	Impaired	Posterior portion of superior temporal gyrus, primary auditory cortices, other temporal gyri, supramarginal gyrus, angular gyrus
Other				

Anomic	Slightly impaired to WNL	Fluent: sensical, usually with category-specific word-retrieval deficits	WNL	Variable: for example, left temporal pole lesion leads to problem w/ retrieval of "persons", whereas left anterior portion of inferior temporal lobe leads to problem w/ "animals" retrieval
Atypical	Variable	Variable	Variable	Basal ganglia, thalamus
Crossed	Variable	Variable	Variable	Right hemisphere lesions in homologous language areas
Global	Impaired	Nonfluent: if present, with paraphasias and verbal stereotypies	Impaired	Occlusion of middle cerebral artery, so extensive damage to frontal, parietal, and temporal regions

Note. From Brookshire, 1997; Damasio, 2008; Hallowell & Chapey, 2008

APPENDIX B

REVIEW OF APHASIA TREATMENT OUTCOMES LITERATURE

Type of treatment	Study	Participant characteristics N Age	Aphasia characteristics Type Severity MPO/YPO	Description	Results
Melodic Intonation Therapy (MIT)	Marshall & Holtzapple, 1978	N=3 Age=49-53	Fluent, Nonflluent Mod→Sev --	Traditional MIT administered to P1. M-modification administered to P2 and P3. Unknown treatment duration or frequency.	• P1: Improvement on trained items. PICA Overall scores unchanged immediately post-MIT, though improvement noted at follow-up. • P2 and P3: Improvement on one or more PICA subtests
	Dunham & Newhoff, 1979	N=2 Age=61, 53	Nonfluent -- 8 YPO, 7 MPO	MIT administered for unknown treatment duration or frequency. Authors utilized ISUs (intoned sequence units).	• P1: Increased length and complexity of utterances. Increased PICA subtest scores. Positive caregiver feedback. • P2: Increased vocabulary.
	Bonakdarpour, Eftekharzadeh, & Ashayeri, 2003	N=7 Age=45-61	Nonfluent --	MIT adapted for Persian-speaking patients. Administered 3-4 sessions/wk for 1 month.	• Significant differences for group for phrase length, content units, naming, repetition, and auditory

			14-57 MPO		comprehension.
Visual Action Therapy (VAT)	Helm-Estabrooks, Fitzpatrick, & Barresi, 1982	N=8 Age=37-70	Global -- 12-144 MPO	VAT administered to individuals who were previously minimally or non responsive to other therapy approaches. Administered 30 min/session, 5 sessions/wk, for 4-14 wks.	• Significant improvements in ability to perform pantomimes w/ trained and untrained PICA items. • Significantly improved auditory comprehension subtest score on PICA.
	Ramsberger & Helm-Estabrooks, 1989	N=6 Age=34-63	Global Sev 2-103 MPO	Administration of Bucco-Facial VAT (2-4 sessions/wk, for 4-30 sessions) to individuals who continued to have extremely reduced verbal output despite previous therapy approaches.	• Significant improvements on PICA Overall and subtest scores.
Voluntary Control of Involuntary Utterances (VCIU)	Helm & Barresi, 1980	N=3 Age=56-59	Global Sev 2-36 MPO	Administered VCIU for 3-6 months.	• All participants increased index card vocabulary. Improvement on BDAE subtests, specifically confrontation naming.
Treatment of Aphasic Perseveration (TAP)	Helm-Estabrooks & Albert, 2004b	N=1 Age=55	Transcortical sensory -- 2 MPO	Case study. Participant exposed to two treatments in alternating BCBC design, with 5 sessions per phase.	• Percentage of perseveration increased during other (unspecified) treatment, decreased only with presentation of TAP.
Promoting Aphasics Communicative	Li et al., 1988	N=1 Age=66	Conduction --	Single-subject comparison of PACE to traditional (Schuell) stimulation	• More improvements in picture naming and description abilities during the PACE

Effectiveness (PACE)			--	approach in ABCBC design.	phases of therapy than the traditional phases of therapy. • Participant utilized multiple communication modalities during treatment, but verbal expression still improved.
	Davis, 2005	-- --	-- -- --	Review of research comparing PACE to traditional stimulation approaches.	• Small gains in PICA measurements and role-playing probes observed during PACE sessions but not traditional treatment.
Cueing					
Cueing Verb Treatment (CVT)	Loverso, Prescott, & Selinger, 1988	N=2 Age=59, 68	Fluent Mod 8, 84 MPO	CVT administered 1h/session, for 3 sessions/wk until mastery criterion met.	• Reports of "statistically significant" differences post treatment on PICA Overall scores and/or subtests for both individuals.
Personalized cueing	Freed, Marshall, & Nippold, 1995	N=30 Age=42-70	-- -- 7-200+ MPO	Participants divided into a personalized "self" cue v. provided cue groups. Participated in 8 training trials distributed over 2 sessions to learn how to pair real English words with abstract symbols.	• Both cueing methods resulted in significant improvement on naming of trained items. • Visual inspection supports personalized cueing as being slightly more advantageous.
Semantic cueing	Lowell, Beeson, & Holland, 1995	N=3 Age=66-76	Anomic, Conduction Mod	Semantic cues, to be later used as self-cues, developed with aid of SFA diagram. Training for List	• Two participants improved naming of trained and untrained items.

			9-30 MPO	1 occurred approximately 3 sessions/wk, for 2 wks or until criterion. Training for List 2 followed.	
Personalized cueing	Marshall et al., 2002	N=30 (15 w/ aphasia, 15 non-brain-damaged [NBD]) Age=32-73	-- Mild→Mod 12-193 MPO	Participants asked to provide personalized cues for 20 photographs of rare/unknown dog breeds. Participated in 3 sessions/wk for 4 wks.	• No significant difference among cue forms in NBD group. • Recall of dog breeds significantly improved if personalized cue contained semantic information in the group of individuals with aphasia.
Phonological v. Semantic cueing hierarchy	Wambaugh, 2003	N=1 Age=44	Anomic Mod 15 MPO	Exposed to both phonological and semantic cueing treatments in an alternating treatment design. Treatment provided 3-4 sessions/wk for 4-5 wks.	• Naming increased for items trained for both PCT and SCT, but superior performance for SCT. • Difference b/w treatments also noted at follow-up.
Cueing hierarchy	Linebaugh, Shisler, & Lehner, 2005	N=5 Age=46-72	-- -- 1-36 MPO	Participants trained with 5 high and 5 low frequency words with 10-level cueing hierarchy until program termination criteria met.	• 4 of 5 participants demonstrated improved naming of trained items. • 3 of 5 participants demonstrated generalization to untrained items.
Personalized cueing	Marshall & Freed, 2006	-- --	-- --	Summary of personalized cueing studies.	• Greater short-term durability of personalized cueing v. phonological cueing for word-

			--		symbol associations and naming dog breeds. • No significant difference in durability of personalized v. provided cues for word-symbol associations. • Naming accuracy and durability significantly higher in personalized cueing condition v. phonological cueing condition. • Cues that contain semantic information are more effective than rhyme or combination cues.
Written cueing	Wright, Marshall, Wilson, & Page, 2008	N=2 Age=76	Conduction -- 12-14 MPO	CART-like treatment administered for 1 h/session, 2-3 sessions/wk, until Lists 1-3 mastered.	• Improvement on trained items • One participant improved performance on WAB, BNT, and untrained items.
Syntactic approaches					
Sentence Production Program for Aphasia (SPPA)	Helm-Estabrooks & Albert, 2004a	-- --	-- -- --	Review of literature: 1 – Group studies of chronic agrammatic patients 2 – Case study	• Significant improvements observed for conversational phrase length, word production for BDAE “Cookie Theft” picture description, and expressive language scores.
Response Elaboration	Kearns, 1985	N=1	Broca’s	RET administered for 3 sessions/wk until mastery	• MLU increased from 1-2 content words to 5+ content

Treatment (RET)		Age=50	Mod-sev 36 MPO	criteria met (~20 sessions) for 2 successive sets of training items. Forward chaining, involving expansion, modeling, reinforcement, and request for repetition of expansion was utilized.	words when presented with picture stimuli. • Some improvement noted on untrained items and on PICA Verbal subtest.
Modified RET	Wambaugh & Martinez, 2000	N=3 Age=62-64	Broca's -- 12-25 MPO	RET modified to address needs of individuals with apraxia of speech. Administered 1 h/session, 3 sessions/wk, until criterion met on all sets of stimuli.	• Increased CIUs for trained picture description tasks for all participants. • Increased CIUs for trained personal recount tasks for 2/3 participants. • All participants demonstrated some generalization to untrained items.
Mapping therapy	Rochon, Laird, Bose, & Scofield, 2005	N=5 (3 experimental, 2 control) Age=31-82	Broca's -- 24-108 MPO	Mapping treatment targeting 4 sentence structures administered 1 h/session, 2 sessions/wk, for 9-10 wks.	• All participants demonstrated significant improvement on trained sentence structures, and maintained at 1 month follow-up. • No significant generalization to untrained sentence structures, and no improvement observed on sentence comprehension tasks. • Some improvement on narrative retelling task.
	Wierenga et	N=2	Nonfluent	Mapping treatment	• P1 – Behavioral: No

	al., 2006	Age=72, 58	-- 53, 8 MPO	targeting sentence production was administered 90 min/session, 3-4 sessions/wk, for 32 total sessions. The first 16 sessions utilized an errorless learning mapping (ELM) approach, and the latter 16 sessions utilized an errorful mapping (EFM) approach.	generalization to untrained sentences. Increased number of well-formed sentences in narrative discourse. • P1 – fMRI: Significant expansion in the extent of activity in Broca's area. Deactivation of temporal areas. Recruitment of regions responsible for semantic processing. • P2 – Behavioral: Rapid improvement on treated and untreated items, but did not maintain accuracy throughout treatment. • P2 – fMRI: Little change in location of activity except for a significant reduction in activity for left inferior frontal sulcus.
Treatment of Underlying Forms (TUF)	Thompson, 2001	-- --	-- -- --	Literature review.	• Decreased production of simple sentences and increased production of complex sentences. • Increased MLU. • Increases in the proportion of verbs produced with correct argument structure. • Generalization of trained complex forms to untrained

					simple and complex forms.
	Murray, Ballard, & Karcher, 2004	N=4 Age=49-78	Fluent, Nonfluent Mod→Sev 13-63 MPO	Modified TUF administered 60-90 min/session, 1 session/wk, for 4-15 wks.	• Improved spoken production of at least one trained sentence structure across subjects. • One subject demonstrated generalization to related forms. • No generalization to sentence comprehension. • Some change in written production of trained sentences.
	Thompson & Shapiro, 2005	-- --	Agrammatic Broca's Mild→Mod-sev --	Review of findings from previous single-subject experiments.	• Improvement of trained and related untrained sentence structures. • Generalization enhanced when treatment begins w/ more complex structures. • Improvements in performance accompanied by neural change.
Semantic approaches					
Decision-based semantic treatment	Davis, Harrington, & Baynes, 2006	N=1 Age=55	Wernicke's -- 5 MPO	Treatment administered 60-90 min/session, 5 sessions/wk, for 4 weeks. No overt responses were required.	• Improvement on trained items and untrained items within a trained category. • Increased WAB score resulted in movement from diagnosis of Wernicke's

					aphasia to conduction aphasia. • Increased BNT score by 43%. • Shift of RH activation to greater activity in LH ROIs (BA 44-47, 22, 39) following treatment.
Semantic Feature Analysis (SFA)	Boyle & Coelho, 1995	N=1 Age=57	Broca's Mild 65 MPO	Single-subject AB design. SFA administered 60 min/session, 3 session/wk until reached 100% accuracy on both few and many exemplar word lists (16 total sessions).	• Improved naming of trained items, maintained at 1- and 2-months post-treatment. • Improved naming of untrained items but no generalization to connected speech. • Clinically important change on CETI.
	Coelho, McHugh, & Boyle, 2000	N=1 Age=52	Fluent Mod 17 MPO	Single-subject AB design. SFA administered 60 min/session, 3 session/wk, until reached 80% accuracy on both few and many exemplar word lists (20 total sessions).	• Improved naming of trained items, relatively maintained at 1- and 2-months post-treatment. • Variable performance on untrained items. • Reports of generalization to connected speech, but not apparent in visual inspection.
	Rose & Sussmilch, 2008	N=3 Age=45-55	Broca's -- 3-7 YPO	Each individual participated in 4 phases of the experiment: pre-treatment assessment, simultaneous administration of all treatments (semantic,	• 2 of 3 participants demonstrated improvements on trained items, and significant improvement on VAST Action Naming and OANB Action Naming. • All participants significantly

				gesture, combined semantic + gesture, repetition), administration of the treatment deemed most effective, and post-treatment assessment. Treatment administered 60 min/session, 2-3 sessions/wk, for 20 total sessions.	improved communicative ability via LCQ.
Model-based semantic treatment	Drew & Thompson, 1999	N=4 Age=47-59	Broca's -- 30-79 MPO	Treatment administered 2 sessions/day, 2-3 days/wk, until criterion met.	• 2 of 4 participants improved naming of trained items for semantic only treatment. Further improvement observed when semantic + phonological treatment introduced. • Remaining 2 subjects improved only w/ semantic + phonological treatment. • No significant improvement on naming of untrained items.
	Doesborgh et al., 2004a	N=55 Age=20-85	Anomic, Broca's, Wernicke's, Other -- 3-5 MPO	Participants randomly assigned to semantic treatment condition or the "control" phonological treatment condition. Treatment administered 1.5-3h/wk for approximately 7 months.	• Both groups demonstrated significant improvement on ANELT score. • Both treatments resulted in training-specific improvement.

	del Toro et al., 2008	N=14 Age=38-81	Fluent, Nonfluent -- 4-120 MPO	Semantic-phonological treatment administered to 6 participants. Gestural-verbal treatment administered to 8 individuals. 10 sessions/phase, 3-4 sessions/wk, with 1 month break between phases.	• Non-significant improvement in noun production, and significant decrease in verb production. • Significant improvements in both grammatical sentences and UNI.
Circumlocution-Induced Naming (CIN)	Francis, Clark, & Humphreys, 2002	N=1 Age=78	Fluent -- 2 MPO	CIN administered for 15-30 min/session, for a total of 13 total sessions distributed over 4 wks.	• Significant improvement in picture naming of untrained items.
Phonological approaches					
Phonologically based treatment	Thompson, Raymer, & le Grand, 1991	N=2 Age=75	Broca's -- 18, 14 MPO	Training included rhyming, phonemic cues, and repetition. Successive training of 2 word lists for at least 20 training trials/session, for 15 sessions or until criterion met.	• P1: Improved naming of target items, generalization to untrained items during Set 2 but not Set 1, improved oral reading of trained and untrained items, some improvement in written naming. • P2: Improved naming of target items, generalization to untrained items, improved oral reading of trained and untrained items, no generalization to written naming.

Phonological naming therapy	Robson, Marshall, Pring, & Chiat, 1998	N=1 Age=56	Fluent Sev 24 MPO	Therapy tasks included syllable judgment, initial phoneme judgment, dual judgment, and judgment tasks with naming. Treatment administered 20 min/session, for 40 sessions distributed over 6 months.	• Significantly improved naming of trained and untrained items. • Significant improvement on on PALPA naming subtests. • Informal observations of improved spontaneous speech. • No evidence of self-cueing w/ phonological knowledge post treatment
Letter naming	Greenwald & Gonzalez-Rothi, 1998	N=1 Age=72	Anomic Sev 13 MPO	Successive training of 2 sets of letters for 15 min/session, 2 sessions/day, 5 days/wk, for 5 wks. Training focused on teaching participant to read letter by letter.	• Significantly improved oral naming of trained letters and reading of written words letter-by-letter. • No generalization to untrained letters. • Observed to use new ability outside clinical environment.
Grapheme-to-Phoneme Conversion	Kiran, Thompson, & Hashimoto, 2001	N=2 Age=62, 67	Conduction -- 13, 27 MPO	Treatment administered 1h/day, 2days/wk, for 15-18 wks. Protocol involved oral reading, repetition, oral spelling, letter selection from distractors, identification of randomly presented letters, and reading letters.	• Improvements on oral reading and writing to dictation of trained items. • Generalization to oral reading and writing to dictation of untrained items as well as to oral naming of trained items. • No improvements with irregular words. • Improvement on WAB, BNT, and PALPA observed.

Phoneme-to-Grapheme Conversion	Kiran, 2005	N=3 Age=59-67	Anomic, Broca's, Transcortical Motor -- 24-200+ MPO	Treatment administered 1h/day, 2days/wk, for 5-10 weeks. Protocol involved writing to dictation, copying, oral reading, selecting and writing sounds of target words, writing phonemes of target word when presented auditorily, and writing to dictation.	• Statistically significant improvements on writing to dictation of trained words in 2 of 3 participants. Visual inspection does not support statistical claims. • Participants demonstrated varying degrees of improvement on WAB AQ, BNT, and PALPA.
Group treatment					
	Aten, Caligiuri, & Holland, 1982	N=7 Age=45-67	Nonfluent -- 9-262 MPO	Functional communication group treatment administered 2h/wk for 12 wks.	• Significant improvement on CADL, maintained at 6 weeks follow-up. • No improvement on PICA.
	Bollinger, Musson, & Holland, 1993	N=10 --	Nonfluent -- --	Group treatment 3h/wk for 40 wks.	• Significant improvement on CADL and PICA. • No improvement on test of auditory comprehension.
	Elman & Bernstein-Ellis, 1999	N=28 (5 dropouts, 1 late addition) Age=38-80	Anomic, Broca's, Conduction, Transcortical Motor, Unclassified	Comparison of immediate v. delayed treatment group. Those in delayed treatment group participated in 3 h/wk social activities while awaiting treatment.	• Significant improvements on WAB AQ and CADL, but not SPICA. • Severity main effect noted for CADL • Delayed treatment group did not show significant changes

			Mild→Sev 7-336 MPO	Treatment administered 5h/week (plus 1h/wk social breaks) for 4 months.	after social stimulation period. • Immediate treatment group had 6/12, 7/12, and 5/12 individuals demonstrate clinically significant change on SPICA, WAB AQ, and CADL respectively. The delayed treatment group, following social stimulation, had 1/11, 3/11, and 2/11 individuals demonstrate clinically significant changes on the same respective measures. • Improvements noted at both 2 months and 4 months during treatment for both groups. • No significant decline at 6 and 8 wks follow-up.
	Marshall, 1993	N=25 (5 dropped out) Age=39-68	-- Mild 2-400 MPO	Groups of 6-10 individuals participated in clinician facilitated "problem-focused" therapy 1h/week for 6-12 months.	• 14 participants demonstrated improved overall PICA scores. • 5 participants returned to work on a part-time basis.
	Wertz et al., 1981	Group A N=35 Group B N=32 (33 dropped out throughout course of study)	-- -- 1 MPO at beginning of study	Group A: Received traditional stimulus-response individual treatment. Group B: Received group treatment. Treatment administered	• PICA Overall scores significantly improved for both groups at 15, 26, 37, and 48 WPO. • Token Test, Word Fluency Measure, and Raven's scores significantly improved for both

		Age=40-79		8h/wk for up to 48 wks.	groups at different WPOs, but the most significant improvement occurred before initiation of treatment. • Few significant differences between A and B, though Group A outperformed Group B.
Partner training					
Conversational coaching	Hopper, Holland, & Rewega, 2002	N=2 dyads (person w/ aphasia + family member) Age = 39-76	Broca's Sev 2-3 YPO	Participants with aphasia watched videotaped stories and attempted to share content with spouse during baseline sessions. Same procedure utilized in treatment, but clinician coached both individual with aphasia and spouse on conversational strategies.	• Positive outcomes for both couples, in that increases in percentage of main concepts successfully communicated. • One individual w/ aphasia also improved on the CADL-2.
Supported Conversation for Adults (SCA)	Kagan, Black, Duchan, Simmons-Mackie, & Square, 2001	N=80 [40 dyads (person with aphasia + volunteer conversation partner); 20 control dyads, 20 experimental dyads Age=Mean 70	Broca's, Conduction, Global, Transcortical, Wernicke's Sev 12-178 MPO	Single-blind, randomized, controlled, pre/post design. Volunteers participated in initial interview session with an individual with aphasia. Experimental group participated in SCA training workshop. All volunteers (control and trained) participated in a 1.5 hour hands-on session	• Experimental volunteers scored higher on measure of ability to acknowledge and reveal competence of individuals with aphasia. • Experimental individuals with aphasia scored higher on measure of levels of participation. • Correlations observed b/w improvements in volunteers performance and

		years, +/- 11		with another individual with aphasia.	improvements in individuals with aphasia. • More control volunteers and control individuals with aphasia performed "same" or "worse" during the second interview relative to the experimental volunteers and individuals with aphasia, more of whom performed "better"
Computer	Katz & Wertz, 1997	N=55 Age=48-83		Participants randomly assigned to the following groups: Computer Reading Treatment (CRT), Computer Stimulation Treatment (CST), and No treatment (NT). Treatment groups received 78 hours treatment.	• CRT group demonstrated significant improvement of 5 language measures on standardized tests (WAB, PICA subtests). • CST group demonstrated significant improvement on 1 language measure. • NT group did not improve.
	Aftonomos, Appelbaum, & Steele, 1999	N=60 Age=24-86	Anomic, Broca's, Conduction, Global, Transcortical Motor, Transcortical Sensory, Wernicke's --	Participants enrolled in community-based LingraphiCARE centers. Received 1-4 individual sessions/wk for 4-47 weeks. Program also included homework assignments.	• Significant differences for group noted at post treatment for WAB AQ and subtests and CETI. • Significant differences noted regardless of time post onset (i.e., acute v. chronic), type of aphasia, or severity of aphasia.

			1 week-12 years PO		
	Adrian, Gonzalez, & Buiza, 2003	N=1 Age=77	Fluent -- 6 MPO	CARP (computer-assisted anomia rehabilitation program) administered 45 min/day for 12 consecutive days.	• Significant improvement on naming of trained items and untrained items within a trained category. • Significant improvement on PALPA Oral Picture Naming test performance. • Significantly reduced score on depression measure.
	Laganaro, Di Pietro, & Schnider, 2003	N=11 Age=32-80	Anomic, Broca's, Conduction, Mixed, Transcortical Motor, Wernicke's -- 2-120 MPO	Acute group received computer-assisted treatment (CAT) daily for 2 weeks, then individualized clinical therapy for anomia (ClinT) for 2 weeks, and finally CAT for additional 2 wks. Chronic group received ClinT for 2-3 sessions/wk for 2 weeks, followed by CAT administered on the same schedule.	• No obvious conclusions re: differences between acute v. chronic, intensity of sessions, or Clint v. CAT. • 10 or 11 individuals demonstrated improvement on trained items.
	Doesborgh et al., 2004b	N=18 Age=20-86	-- -- 11-17 MPO	Compared no treatment (NT) group to Multicue treatment group, who received 30-45 min/session, 2-3	• Significant improvement of Multicue group on BNT, but not ANELT. • NT group demonstrated no

				sessions/wk, for ~2 months.	significant improvements.
	Mortley, Wade, Enderby, & Hughes, 2004	N=7 --	-- -- 2-12 YPO	Individuals participated in home-based computerized treatment tasks of word-to-picture matching, naming, repetition, etc. Clinicians tracked practice via the internet. Frequency of practice not specified.	• All participants demonstrated improved picture naming abilities. • 4 of 7 participants reported satisfaction w/ improved everyday communication. • All participants reported increased confidence and participation in communicative activities.
Other					
Attention and Intention treatment	Peck et al., 2004	N=3 Age=46-79	Nonfluent -- 8-74 MPO	Participants exposed to the following treatments designed to engage right hemisphere mechanisms: 1) naming treatment in which participants turn head to left and name picture (attention), and 2) naming treatment in which participants use left hand mouse click to access pictures to name (intention). Treatment administered 30-60 min/day, 5 days/wk, for 6 wks.	• All participants demonstrated significant improvements in naming, though unclear if includes trained and untrained items. • 2 of 3 participants demonstrated improved naming of untrained items utilized in fMRI naming task. • Those who demonstrated improved performance on both trained and untrained items (N=2) had more rapid responses in the following RH ROIs: auditory cortex, IFG, M1, and pre-SMA.
Errorless	Fillingham,	N=11	Anomic,	Individuals participated in	• 2 of 11 participants did not

learning	Sage, & Lambon Ralph, 2006	Age=40-80	Fluent, Global, Nonfluent Mild→Sev --	the following cycle of events: Pre-treatment assessment, 5 weeks (2 sessions/wk) of errorless learning treatment, reassessment, 5 wks of errorful learning treatment, reassessment, 5 wks of no treatment, and final assessment.	improve naming of trained items. Errorless and Errorful Items • 8/11 participants demonstrated equivalent significant improvements on trained items taught in errorless and errorful sessions. 7 of these participants maintained gains at follow-up. Errorless Items Only • 1 of 11 participants significantly improved on items trained during errorful learning sessions v. errorless learning sessions. Errorful Items Only • 2 of 11 participants demonstrated significant improvement on errorful items at follow-up.
Memorization of articulatory gestures	Léger et al., 2002	N=1 Age=42	Global Sev 24 MPO	Participant trained to memorize articulatory gestures via drawings for phonemes for 30 training words. Therapy tasks included repetition, reading aloud, and picture naming.	• Significant improvement on trained and untrained items. • Therapy induced activation (via 1.5T fMRI) observed in L supramarginal gyrus and L IFG.

Note. N = number of participants; MPO = months post onset; YPO = years post onset; Mod = moderate; Sev = severe; P = participant; PICA = Porch Index of Communicative Ability; BDAE = Boston Diagnostic Aphasia Examination; CART = Copy and Recall Treatment; WAB = Western Aphasia Battery; BNT = Boston Naming Test; Mod-sev = moderate-severe; MLU = mean length of utterance; CIUs = correct information units; fMRI = functional magnetic resonance imaging; RH = right hemisphere; LH = left hemisphere; ROIs = regions of interest; BA = Brodmann areas; CETI = Communicative Effectiveness Index; VAST = Verb and Sentence Test; OANB = Object and Action Naming Battery; LCQ = La Trobe Communication Questionnaire; ANELT = Amsterdam-Nijmegen Everyday Language Test; UNI = utterances with new information; PALPA = Psycholinguistic Assessments of Language Processing in Aphasia; WAB-AQ = Western Aphasia Battery Aphasia Quotient; CADL = Communication Activities of Daily Living; SPICA = short version of the PICA; IFG = inferior frontal gyrus, Broca's area; M1 = primary motor cortex; pre-SMA = pre-supplementary motor area.

APPENDIX C

VARIETY IN CIMT – CONSTRAINT, ACTIVITIES, TIME COMMITMENT, AND MODIFICATIONS

<table>
<tr><th>CONSTRAINT</th><th>ACTIVITIES</th></tr>
<tr><td>Lightweight fiberglass cast (DeLuca, Echols, Ramey, & Taub, 2003)
Mitt (Fritz et al., 2005 ; Lum et al., 2004; Shaw et al., 2005 ; Wolf et al., 2006)
Resting hand splint and armsling ensemble (Sterr et al., 2002; Wittenberg et al., 2003)
Specially designed half glove (Sterr et al., 2002)</td><td rowspan="3">Arc-and-Rings (Lum et al., 2004)
Brushing teeth (simulated) (Taub et al., 1994)
Building towers/stacking blocks (Fritz et al., 2005; Taub et al., 1994)
Cleaning (N!deau et al., 2004)
Crawling up and down stairs (DeLuca et al., 2003)
Dot-to-dot drawing (Taub et al., 1994)
Fingertapping (Lum et al., 2004)
Meal preparation (Nadeau et al., 2004)
Moving a ball (Taub et al., 1994)
Object-flipping (Lum et al., 2004)
Pat powder puff to face(Taub et al., 1994)
Peg board (Lum et al., 2004)
Picking up cotton balls and placing in containers (Shaw et al., 2005)
Picking up pencils (Fritz et al., 2005)
Placing rings on prongs (Shaw et al., 2005; Taub et al., 1994)
Placing weights on boxes (Taub et al., 1994)
Pouring beans into containers of different sizes (Fritz et al., 2005; Shaw et al., 2005)
Reaching (DeLuca et al., 2003; Lum et al., 2004)
Ring toss (Shaw et al., 2005)
Rotation of a Rolodex file (Taub et al., 1994)
Shaving (simulated) (Taub et al., 1994)
Shuffleboard (Taub et al, 1994)
Stacking cups (Shaw et al., 2005)
Supination/pronation (rotating handle) (Lum et al., 2004)
Tapping telegraph key (Taub et al., 1994)
Threading a shoelace through holes on posts (Lum et al., 2004)
Tracing circles (Taub et al., 1994)
Tracing block letters w/ fingertip or portion of hand (Lum et al., 2004)</td></tr>
<tr><td>TIME COMMITMENT</td></tr>
<tr><td>Constraint for 90% of waking hours for 2 weeks (Fritz et al., 2005; Lum et al., 2004; Nadeau et al., 2004; Shaw et al., 2005; Wolf et al., 2006)
+ 6 hours daily of directed PT for 2 weeks (Wolf et al., 2006)
+ 6 hours on weekdays (Fritz et al., 2005; Nadeau et al., 2004; Shaw et al., 2005)
+ 7 hours on weekdays (Taub et al., 1994)
+ 3 h/d of AutoCITE on weekdays for 2 weeks (Lum et al., 2004)
+ 3 h/d of directed PT for weekdays for 2 weeks (Lum et al., 2004)

Constraint for majority of waking hours for 2 weeks (Sterr et al., 2002; Wittenberg et al., 2003)
+ shaping therapy for 3h/d or 6 h/d during weekdays (Sterr et al., 2002)
+ task-oriented therapy of affected extremity for 6 h/day during weeks and 4 h/ day on weekends (Wittenberg et al., 2003)
+ 6 hour daily for 15 weekdays, + 4 hours weekly play-based PT (DeLuca et al., 2003)</td></tr>
</table>

MODIFICATIONS	Using eating utensils (simulated eating)/ Eating (DeLuca et al., 2003 ; Fritz et al., 2005 ; Nadeau et al., 2004; Taub et al., 1994) Writing (Taub et al., 1994)
Administration of donepezil as an adjuvant to rehab (Nadeau et al., 2004) Assigned homework/home practice exercises during intervention (Wolf et al., 2006) Assigned home program for 30 minutes daily after completion of intervention (Shaw et al., 2005; Wolf et al., 2006) Automated computer workstation w/ 8 tasks (Lum et al., 2004) Encouraged use of more affected extremity outside of clinic w/ bx'al contract and home diary (Fritz et al., 2005; Shaw et al., 2005)	

APPENDIX D

VARIETY IN CIAT – CONSTRAINT, ACTIVITIES, TIME COMMITMENT, AND MODIFICATIONS

CONSTRAINT	ACTIVITIES
Alternative communicative methods not permitted (pointing, gesturing, etc) (Breier et al., 2006, 2007; Goral & Kempler, 2008; Maher et al., 2006; Meinzer et al., 2005; Meinzer, Obleser et al., 2007; Pulvermüller et al., 2001, 2005; Richter et al., 2008; Szaflarski et al., 2008) Material constraints (low -> high frequency/complexity of items to be named/requested) (Breier et al., 2006, 2007; Maher et al., 2006; Meinzer, Streiftau et al., 2007; Meinzer, Obleser et al., 2007; Pulvermüller et al., 2001, 2005; Szaflarski et al., 2008) Shaping/rule constraints (low -> high syntactic complexity requirements) (Breier et al., 2006, 2007; Goral & Kempler, 2008; Maher et al., 2006; Meinzer et al., 2005; Meinzer, Streiftau et al., 2007; Meinzer, Obleser et al., 2007; Pulvermüller et al., 2001, 2005; Richter et al., 2008; Szaflarski et al., 2008) Reinforcement contingencies (individually adjusted according to level of performance) (Breier et al., 2006, 2007; Maher et al., 2006; Meinzer, Streiftau et al., 2007; Meinzer, Obleser et al., 2007; Pulvermüller et al., 2001, 2005; Szaflarski et al., 2008) Barrier b/w participants (Breier et al., 2006, 2007 ; Goral & Kempler, 2008 ; Maher et al., 2006 ; Meinzer et al., 2005 ; Meinzer, Streiftau et al., 2007; Pulvermüller et al., 2001)	Modified “Go Fish” game (Breier et al., 2006, 2007 ; Maher et al., 2006 ; Meinzer et al., 2005 ; Meinzer, Streiftau et al., 2007 ; Meinzer, Obleser et al., 2007 ; Pulvermüller et al., 2001, 2005 ; Szaflarski et al., 2008) 20 questions (Maher & Schmadeke, 2007) Memory game (Maher & Schmadeke, 2007) Repetition, reading, picture description, scripted phone call, picture sequencing, story generation, recounting episodes, conversation (Goral & Kempler, 2008)

TIME COMMITMENT	MODIFICATIONS
3-4 hours of practice w/ therapeutic game activity in group on weekdays for 2 weeks (Pulvermüller et al., 2001) 3 hours of practice on weekdays for 2 weeks (Meinzer et al., 2004, 2005, 2006; Meinzer, Streiftau, & Rockstroh, 2007; Meinzer, Obleser et al., 2007; Pulvermüller et al., 2005; Richter et al., 2008) 3 hours of practice for 4 weekdays, for 2 weeks (Maher et al., 2006) 3 hours of practice for 4 weekdays, for 3 weeks (Breier et al., 2006, 2007) 3-4 hours for 5 consecutive weekdays (Szaflarski et al., 2008) 5 hours a week (four 75-minute sessions per week) for 4 consecutive weeks (Goral & Kempler, 2008)	CIATplus: In addition to CIAT, included stimulus materials included not only pictures but written words and real-world photographs; home exercises to be completed w/ family member; relatives asked to encourage participant to engage in spoken comm. as often as possible; participants and relatives kept diary of communicative activity (Meinzer et al., 2005) Encouraged to use spoken comm. as much as possible outside of therapy (Breier et al., 2006) Gestures allowed if not the primary mode of communication and if used to facilitate spoken language (Meinzer, Streiftau et al., 2007) Laypersons trained to provide CIAT (Meinzer, Streiftau et al., 2007) Focused on use of verbs (Goral & Kempler, 2008)

APPENDIX E

REVIEW OF THE CONSTRAINT-INDUCED APHASIA THERAPY LITERATURE

Study	N	Aphasia Type	Severity	Age	MPO	Results
Pulvermüller et al., 2001	7 received conventional treatment, 10 received CIAT	Amnesic, Broca, Conduction, Transcortical, Wernicke	Mild→ Sev	39-72 (*M* = 54.8)	2-233 (*M* = 67.7)	• CIAT group outperformed conventional group on 3 of 4 standardized measures. • CIAT group also demonstrated improved performance on CAL.
Meinzer et al., 2004	10 received intensive model-based (MB) therapy, 18 received CIAT	Amnesic, Broca, Global, Wernicke, Unclassified	Mild→ Sev	35-80 (*M* = 54.6)	12-156 (*M* = 43.8)	• No significant differences b/w MB and CIAT groups on standardized measures or MEG measures. • 25 of 28 participants demonstrated improvement on 1 or more subtests of the AAT. • The entire group (collapsed) showed improved scores on AAT and Token Test. • Perilesional delta activity (MEG) decreased after therapy in 16 participants, increased in the remaining 12.
Meinzer, Djundja, Barthel, Elbert, & Rockstroh, 2005	12 received CIAT, 15 received CIATplus	Amnesic, Broca, Global, Wernicke, Unclassified	Mild→ Sev	18-80 (*M* = 51.5)	12-116 (*M* = 46.1)	• Significant improvement for entire group on AAT. • Improved communicative effectiveness and communication in everyday life according to CAL and CETI for both groups, but greater improvements noted in CIATplus. • Comprehension improved in the CIATplus group, but not CIAT (according to Token Test of AAT).

						• At 6-months follow-up AAT results remained significantly improved compared w/ baseline for both groups. • Individual AAT improvements remained stable. • Maintenance of most aspects of communicative effectiveness and communication in everyday life according to CAL and CETI for CIAT group, further improvements notes for CIATplus group.
Pulvermüller, Hauk, Zohsel, Neininger, & Mohr, 2005	9 received CIAT	Amnesic, Broca, Transcortical, Wernicke	Mild→ Sev	39-72 (*M* = 54.4)	16-233 (*M* = 90)	• Significant differences for entire group on 3 of 4 AAT subtests (token test, naming, and comprehension, but not repetition). • Despite report of group improvements, were negative changes over therapy in 1-3 instances in each category. • EEG behavioral - Faster response times for words v. pseudowords, faster responses in the 2nd testing v. 1st • EEG neural - More negative-going ERPs following word stimuli observed following therapy, source strength increased for words following treatment (in both hemispheres). • EEG neural results correlated most strongly with improvements on the Token Test.
Breier, Maher, Novak, & Papanicolaou, 2006	6 received CIAT	Broca's, Conduction	Mod→ Sev	53-77 (*M* = 61.3)	27-70 (*M* = 46.8)	• 5 of 6 participants demonstrated increased score on WAB AQ, 2 of which would be considered "clinically" significant. • Improved on sentence production task trained in treatment. • 2 participants improved on BNT, remaining 4 participants demonstrated decreased scores.

						• Only 5 of 6 participants able to participate in imaging portion of study. They were divided into group of responders (N=3) and non-responders (N=2). • Responders demonstrated greater degree of late MEG activation in posterior language areas of left hemisphere and homologous areas of the right hemisphere prior to therapy. After CIAT, they showed an increase in anterior RH activation and a decrease in RH activation. • Response to CIAT correlated w/ degree of pre-treatment activation in RH. • Did not observe increased activation near language areas of LH.
Maher et al., 2006	5 received intensive PACE therapy, 4 received CIAT	NS	Mod	40-73 CIAT only 40-55 (*M* = 48)	14-72 CIAT only 24-48 (*M* = 38)	• Both groups demonstrated improvement on standardized measures and measures of narrative discourse, though CIAT outperformed PACE group following treatment and at follow-up. • 3 of 4 CIAT participants demonstrated “clinically” significant improvement on WAB AQ. • 1 of 5 PACE participants demonstrated clinically significant improvement on WAB AQ. • More clinically significant changes on BNT and ANT in CIAT group relative to PACE group.

Meinzer et al., 2006	1 received CIAT	NS	NS	80	24	• Behavioral – Significantly improved AAT profile score and notable improvement on naming task performed during 1.5T fMRI. • Neural - Words produced correctly post-treatment that were produced incorrectly pre-treatment correlated primarily with increased R IFG and R subcortical activation
Breier, Maher, Schmadeke, Hasan, & Papanicolaou, 2007	1 received CIAT	NS	Mod→ Sev	63	13	• Improved performance on standardized aphasia measures, though cannot determine if statistically significant given available data. • Improved performance on therapeutic task. • Neural - Significant increase in activation (MEG) of RH areas (inferior temporal, SMG) immediately post treatment. Significant increase of R ITG and R mesial temporal areas, activation of L MTG and L mesial temporal areas, and reduced R SMG activation observed 3 months post-treatment.
Meinzer, Streiftau, & Rockstroh, 2007	20 received CIAT (10 via experienced therapists, 10 w/ trained laypersons)	Amnesic, Broca, Global, Wernicke, Unclassified	Mild→ Sev	35-72 (*M* = 56.1)	6-79 (*M* = 38.6)	• Significant improvement on AAT profile scores for 19 of 20 participants in both groups, with the majority of participants improving on at least 1 subtest of the AAT. • No significant differences between groups.

Meinzer, Obleser, Flaisch, Eulitz, & Rockstroh, 2007	1 received CIAT administered in German	Amnesic (German), Global (French)	Mod (German) Sev (French)	35	32	• Behavioral - Improved picture naming and significant improvement on Token Test in German. Little to no improvement observed for French stimuli. • Neural - Increased activation (1.5T fMRI) in perilesional as well as R homologous regions associated with increased picture naming abilities in the German language.
Goral & Kempler, 2008	1 received CIAT	Nonfluent	NS	60	144	• No change noted on standardized measures (BDAE, CLQT), except for increase of 17 percentile points on auditory comprehension subtest • Improved naming of trained verbs. • Generalization to discourse measures, in that new untreated verbs were produced in narratives. • No generalization to nouns observed.
Richter, Miltner, & Straube, 2008	16 received CIAT	Anomic, Broca, Global	NS	43-73 (*M* = 58.3)	NS; at least 12	• Behavioral - Significant improvement on following tests: spontaneous speech, auditory comprehension (both medium size effects), semantic comprehension (small effect). • Neural - No statistically significant differences in activation following treatment. During reading task, a negative correlation between activation change within MTG and composite score on standardized and nonstandardized measures was observed. During completion task, a negative correlation between composite score and activation change in R IFG and IC was observed.

Szaflarski et al. (2008)	3 received CIAT on modified schedule	NS	Mod→ Sev	(58-64)	24-240	• 2 of 3 participants demonstrated marked improvement on standardized auditory comprehension scores. • No change noted on standardized expressive scores. • 2 of 3 participants demonstrated marked improvement in discourse measures (total words, utterances, and root words). • No change noted on mini-CAL.

Note. N = number of participants; MPO = months post onset; Sev = severe; *M* = mean; CAL = Communicative Activity Log; MEG = magnetoencephalography; AAT = Aachen Aphasia Test; CETI = Communicative Effectiveness Index; EEG = electroencephalography ; ERPs = event-related potentials; ARP = aphasia recovery potential; Mod = moderate; WAB AQ = Western Aphasia Battery Aphasia Quotient; BNT = Boston Naming Test; RH = right hemisphere; LH = left hemisphere; PACE = Promoting Aphasic's Communicative Effectiveness; NS = not specified; ANT = Action Naming Test; 1.5T = 1.5 Tesla; fMRI = functional Magnetic Resonance Imaging; IFG = inferior frontal gyrus, Broca's area; SMG = supramarginal gyrus; ITG = inferior temporal gyrus; MTG = medial temporal gyrus; BDAE = Boston Diagnostic Aphasia Examination; CLQT = Cognitive Linguistic Quick Test; IC = internal capsule

APPENDIX F

ICONOGRAPHIC SYMBOL RECOGNITION TASK DATA SHEET

Assessment: Iconographic Symbol Recognition

Administrator:
I'm going to place several cards on the table. You will pick a card from the top of the stack of cards in front of you. Match that card to one of the cards in front of you.
For the teaching trials, use pantomime, facial expressions, gestures, pointing, and a questioning manner to indicate that the card in front of the participant only matches one of the four cards placed on the table. If the participant does not understand, demonstrate by picking up the card in front of the participant and placing it near the matching card on the table. Point back and forth between the matching cards to indicate that they are the same.

Card presented	Option 1	Option 2	Option 3	Option 4
T1. square	bus	square	sun	whale
T2. barn	leg	hanger	barn	stapler

Circle the picture selected by the participant. Then circle "Y" for correct, or "N" for incorrect. Tally the points

Card presented	Option 1	Option 2	Option 3	Option 4	Correct?
1. bird	ball	horse	bird	shoe	**Y or N**
2. cloud	pencil	snake	flower	cloud	**Y or N**
3. light	light	bed	earth	dog	**Y or N**
4. moon	square	key	panda	moon	**Y or N**
5. fish	shoe	fish	bridge	flower	**Y or N**
6. house	computer	house	circle	cloud	**Y or N**
7. earth	earth	car	star	window	**Y or N**
8. boat	tree	playing cards	rabbit	boat	**Y or N**
9. computer	brush	airplane	computer	ball	**Y or N**
10. heart	bear	tree	heart	knife	**Y or N**
11. dog	dog	box	money	pencil	**Y or N**
12. star	circle	pencil	rabbit	star	**Y or N**
13. phone	diamond	cloud	computer	phone	**Y or N**
14. playing cards	football	flower	playing cards	bird	**Y or N**
15. tree	tree	ball	vase	car	**Y or N**
16. rabbit	rabbit	bridge	turtle	heart	**Y or N**
17. shoe	cup	shoe	square	phone	**Y or N**
18. circle	circle	train	key	snake	**Y or N**
19. panda	iron	square	panda	boat	**Y or N**
20. car	moon	car	star	brush	**Y or N**
				Total correct	

APPENDIX G

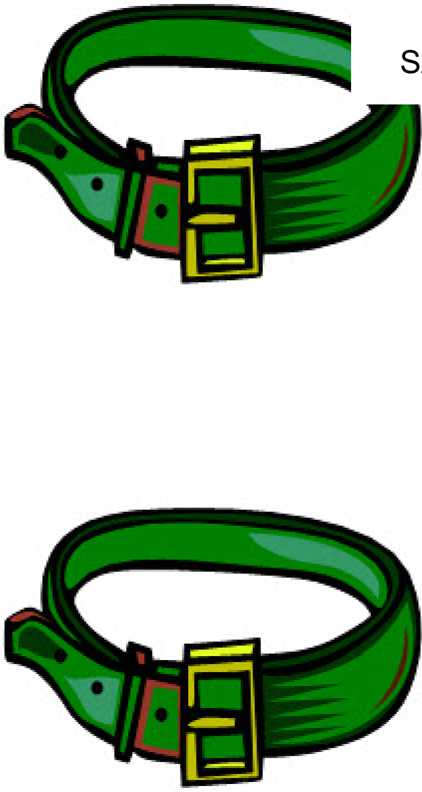
TREATMENT STIMULUS TARGETS

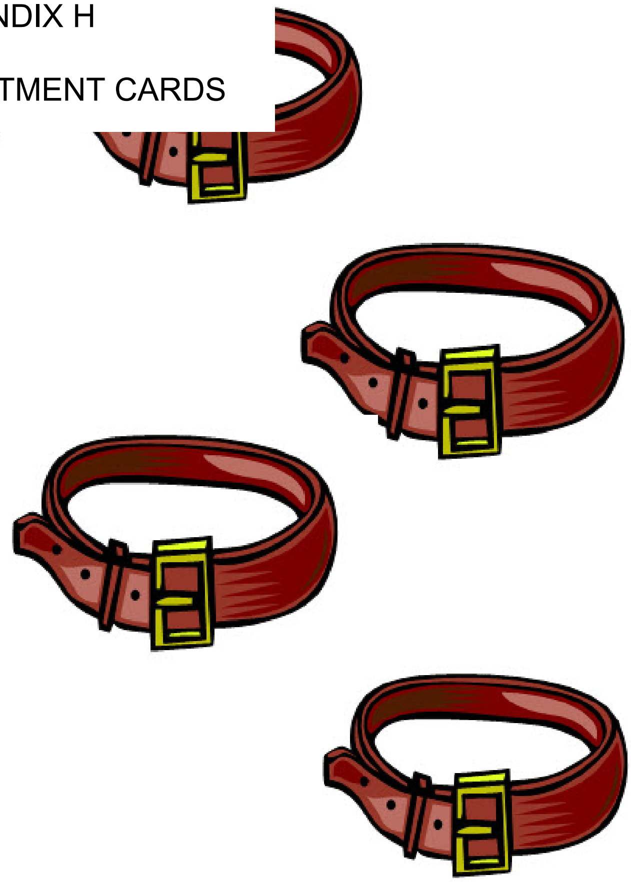
	Category							
	Clothing		Household Items and furniture		Kitchen Items		Transportation and Travel	
High Freq Stimuli	Target Noun (frequency)	Descriptors	Target Noun	Descriptors	Target Noun	Descriptors	Target Noun	Descriptors
	Belt (29)	2 green	Bed (127)	2 purple	Bottle (76)	1 yellow	Boat (72)	1 blue
		4 brown		3 brown		4 green		5 orange
	Coat (43)	2 blue	Blanket (30)	3 green	Cup (45)	1 orange	Car *(50)	1 brown
		3 black		4 pink		5 gray		5 purple
	Dress (67)	1 red	Chair (66)	3 green	Glass (99)	1 blue	Plane (114)	1 white
		3 blue		5 red		2 pink		3 orange
	Hat (56)	4 orange	Desk (65)	1 black	Knife (76)	2 blue	Road (197) or Highway (40)	1 black
		6 gray		3 brown		3 yellow		2 blue
	Pocket (46)	2 gray	Phone (54)	3 red	Plant (125)	1 red	Submarine (27)	1 gray
		4 brown		6 black		3 green		2 black
	Shirt (27)	2 red	Picture (162)	1 green	Plate (22)	2 red	Tractor (24)	2 green
		3 blue		3 pink		5 brown		4 red
	Suit (48)	2 brown	Steps (131)	3 blue	Pot (28)	2 black	Truck (57)	1 red
		3 black		6 brown		3 red		2 green
	Tie (23)	4 orange	Table (198)	1 brown	Refrigerator (23)	1 white	Van (32)	3 green
		6 blue		2 purple		2 green		6 blue
Frequency: Mean SD Range	 42.38 15.25 23-67			 104.13 59.03 30-198		 61.75 38.35 22-125		 71.63 58.59 24-197

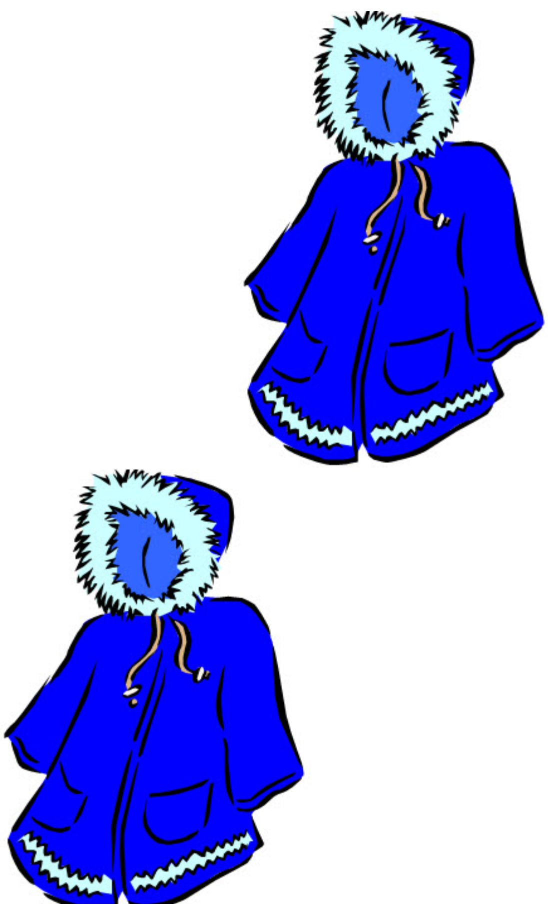
Low Freq Stimuli	Bib (2)	1 blue	Couch (12) or Sofa (6)	1 red	Broom (2)	2 yellow	Ambulance (6)	1 gray
		3 yellow		3 blue		4 black		3 black
	Button (10)	4 red	Lantern (13)	2 blue	Corkscrew (3)	2 black	Canoe (7)	2 brown
		6 blue		4 orange		3 yellow		3 red
	Cleat (1)	4 purple	Pillow (8)	3 green	Hook (5)	1 yellow	Hood (7)	1 blue
		6 red		4 brown		2 black		3 green
	Glove (9)	1 green	Puzzle (10)	4 orange	Mixer (2)	2 blue	Map (13)	1 yellow
		2 orange		6 purple		4 green		2 green
	Helmet (1)	2 blue	Rocker (4)	3 black	Napkin (3)	2 red	Propeller (2)	2 blue
		3 green		5 yellow		4 green		3 orange
	Sleeve (11)	3 gray	Stool (8)	2 brown	Oven (7)	1 black	Pump (11)	2 green
		4 brown		4 red		2 brown		5 yellow
	Slipper (3)	2 red	Toilet (13)	1 white	Sponge (7)	1 yellow	Sail (12)	1 white
		6 brown		2 yellow		4 green		3 red
	Zipper (1)	2 gray	Vase (4)	2 red	Spoon (6)	2 blue	Trolley (5)	1 red
		5 blue		5 green		3 gray		4 blue
Frequency: Mean SD Range	 4.75 4.43 1-11		 9 3.66 4-13		 4.38 2.13 2-7		 7.88 3.79 2-13	

APPENDIX H

SAMPLE TREATMENT CARDS







APPENDIX I

GENERALIZATION STIMULI

High frequency targets for testing generalization within a trained category

Book (193)*	Bowl (23)	Box (70)	Ceiling (31)	Clock (20)	Clothes (89)
Floor (158)	Frame (74)	Gas (98)	Key (88)	Lock (23)	Mirror (27)
Piano (38)	Porch (43)	Radio (120)	Sink (23)	Soap (22)	Train (82)
Wheel (56)	Window (119)				

High frequency targets for testing generalization within an untrained category

Arm (94)	Bear (57)	Bird (31)	Brain (45)	Cat (23)	Chicken (37)
Chin (27)	Cow (29)	Dog (75)	Ear (29)	Eye (122)	Fish (35)
Foot (70)	Fly (33)	Horse (117)	Leg (58)	Mouth (103)	Nose (60)
Sheep (23)	Snake (44)	Teeth (103)	Tongue (35)		

Low frequency targets for testing generalization within a trained category

Boot (13)	Broom (2)	Bucket (7)	Buckle (5)	Canal (3)	Cart (5)
Cradle (7)	Dock (8)	Dresser (1)	Fireplace (6)	Ignition (5)	Laundry (5)
Lighter (12)	Menu (5)	Pants (9)	Pedal (4)	Platter (2)	Rack (9)
Rug (13)	Skillet (2)	Spice (4)	Tank (12)	Trailer (11)	Trash (2)
Trunk (8)	Veil (8)	Vest (4)			

Low frequency targets for testing generalization within an untrained category

Ankle (8)	Armadillo (2)	Beaver (3)	Boar (1)	Butterfly (2)	Camel (1)
Deer (13)	Duck (13)	Elbow (10)	Elephant (7)	Frog (1)	Fur (13)
Heel (9)	Monkey (9)	Oyster (6)	Owl (2)	Pigeon (3)	Rabbit (11)
Ram (2)	Snail (1)	Squirrel (1)	Thumb (10)	Tiger (7)	Toe (9)
Turtle (8)	Walrus (1)	Wolf (6)			

SAMPLE NAMING PROBE CARDS

APPENDIX K

DATA SHEET FOR NAMING PROBE

Confrontational Naming

Administrator:
I'm going to show you some pictures. (Pretend you are telling me what they are for the first time.) Tell me what they are as best as you can. Ready?
Transcribe the response. If the participant produces an intelligible word that can be understood without context even with distortions, omissions, substitutions, and/or additions, mark it as correct. Circle "2" if a correct response given within 5 seconds. A delayed correct response given within 20 seconds earns 1 point. No response or an incorrect response earns 0 points. Tally the points.
( ) – do not use italicized phrase in parentheses for first administration

Example

	Transcribed Response	Correct w/in 5 seconds?	Correct after delay?	Incorrect?
1	/ b /\ b /\ l / (for "bubble")	2	1	0
2	/ t /\ p / (for "star")	2	1	0

	Transcribed Response	Correct w/in 5 seconds?	Correct after delay?	Incorrect?
1		2	1	0
2		2	1	0
3		2	1	0
4		2	1	0
5		2	1	0
6		2	1	0
7		2	1	0
8		2	1	0
9		2	1	0
10		2	1	0
11		2	1	0
12		2	1	0
13		2	1	0
14		2	1	0
15		2	1	0
16		2	1	0
17		2	1	0
18		2	1	0
19		2	1	0
20		2	1	0
21		2	1	0
22		2	1	0
23		2	1	0

24		2	1	0
25		2	1	0
26		2	1	0
27		2	1	0
28		2	1	0
29		2	1	0
30		2	1	0
31		2	1	0
32		2	1	0
33		2	1	0
34		2	1	0
35		2	1	0
36		2	1	0

Total Points: _____________

N-T Points: ______/ 32___

N-GT Points: ______/ 20___

N-GUT Points:______/ 20___

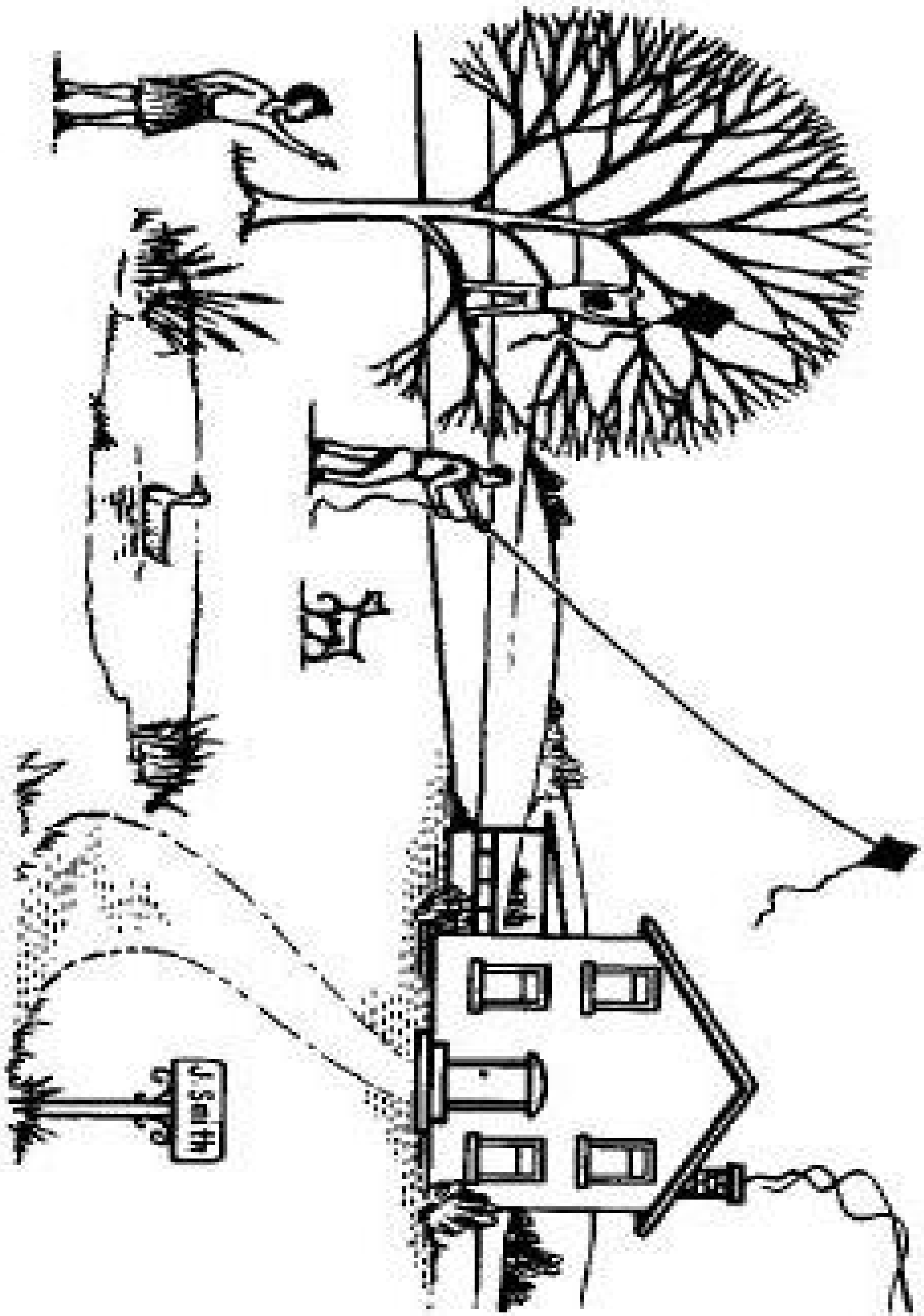
APPENDIX L

DISCOURSE PROBE INSTRUCTIONS AND PICTURES FOR

PICTURE DESCRIPTION TASK

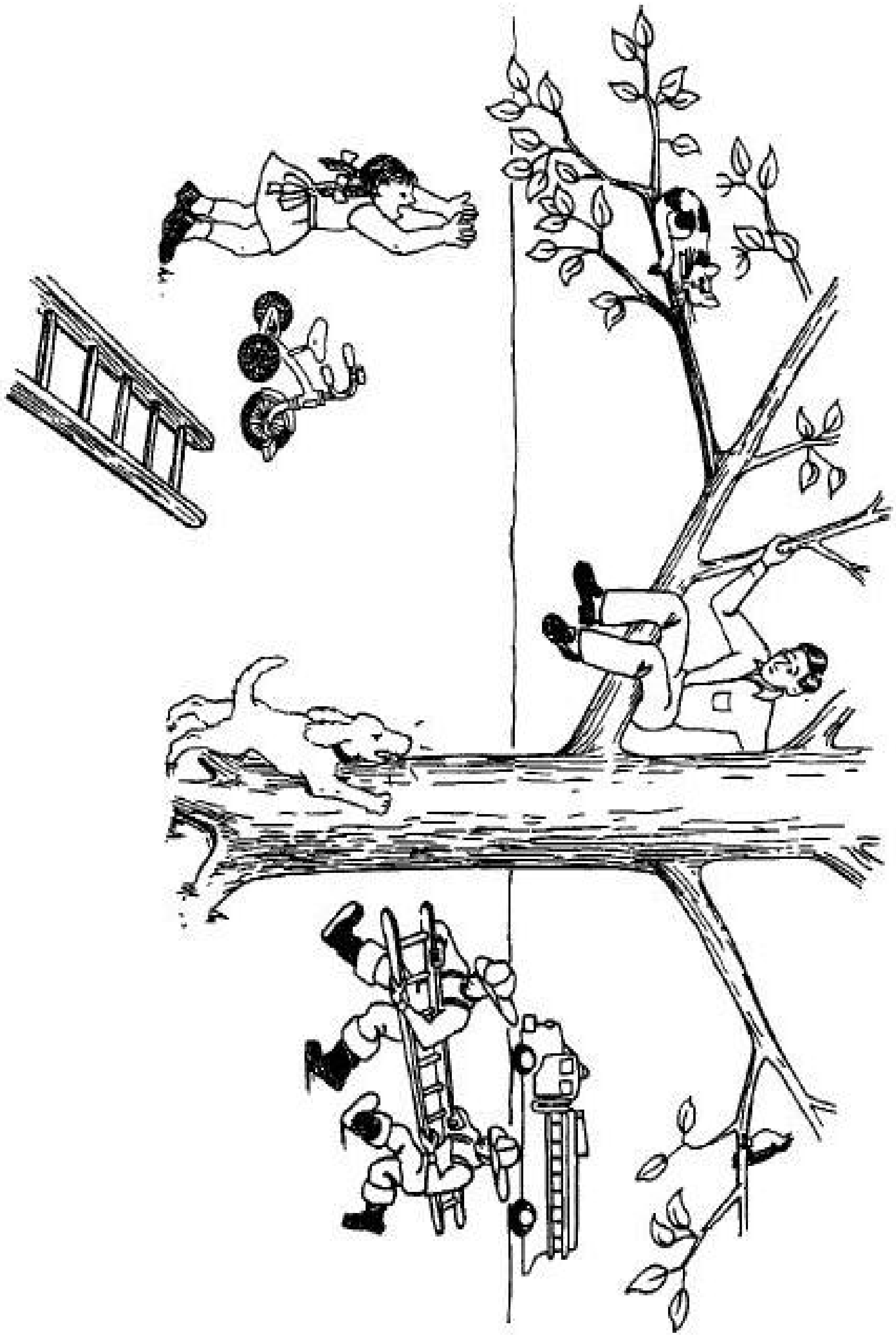
Spontaneous Speech (1)

Administrator:
I'm going to show you a picture. (Despite what you may have told me before about this picture, pretend that you are describing it to me for the first time.) Think about what you see, what happened before, what is happening now, and what may happen in the future. Describe it for me please. Try to elicit at least 5 minutes of conversation. If the participant stops before the end of 5 minutes, attempt to elicit more language with "*Can you tell me more?*", *"Is there anything else you can tell me?"*, etc. Graphically transcribe all words spoken with the following exceptions: phonetically transcribe neologisms and lexical paraphasias; use XXX to denote unintelligible utterances. Conduct CIU analysis according to Nicholas and Brookshire (1993).
( ) – do not use italicized phrase in parentheses for first administration
Selected picture: Kite picture
Response:


J Smith

Spontaneous Speech (2)

Administrator:
I'm going to show you a picture. (Despite what you may have told me before about this picture, pretend that you are describing it to me for the first time.) Think about what you see, what happened before, what is happening now, and what may happen in the future. Describe it for me please. Try to elicit at least 5 minutes of conversation. If the participant stops before the end of 5 minutes, attempt to elicit more language with "*Can you tell me more?*", *"Is there anything else you can tell me?"*, etc. Graphically transcribe all words spoken with the following exceptions: phonetically transcribe neologisms and lexical paraphasias; use XXX to denote unintelligible utterances. Conduct CIU analysis according to Nicholas and Brookshire (1993).
( ) – do not use italicized phrase in parentheses for first administration
Selected picture: Firemen picture
Response:



APPENDIX M

DISCOURSE PROBE INSTRUCTIONS FOR NEW YORK CITY VACATION TASK

Spontaneous Speech (3)

Administrator:
Imagine that you are going on a vacation a week from now. You are traveling to New York City for a 2 week stay. Think about all you will have to do to get ready to go, such as how you will get there, what you will bring, and what you will do. (Despite what you may have told me before), I want you to tell me all of your plans until I ask you to stop.
Try to elicit at least 5 minutes of conversation. If the participant stops before the end of 5 minutes, attempt to elicit more language with "*Can you tell me more?", "Is there anything else you can tell me?",* etc. Graphically transcribe all words spoken with the following exceptions: phonetically transcribe neologisms and lexical paraphasias; use XXX to denote unintelligible utterances. Conduct CIU analysis according to Nicholas and Brookshire (1993).
( ) – do not use italicized phrase in parentheses for first administration
Response:

APPENDIX N

TELEPHONE HISTORY SCRIPT AND QUESTIONNAIRE

"Hello, my name is Jessica Richardson. I am doing a research study under the direction of Dr. Bothe and Dr. Marshall in the Department of Communication Sciences and Special Education at the University of Georgia. This research study is about a new aphasia treatment. It is called constraint-induced aphasia therapy. This therapy focuses on increasing spoken language production. The therapy is intensive, meaning that you will practice talking to other people for several hours a day for several weeks. Studies about this therapy generally show that people who receive this therapy improve more than those who receive traditional aphasia therapy. If you choose to participate, you are likely to benefit more than you would from traditional aphasia therapy. I have obtained your contact information from ____________. I would like to ask you some questions to determine if you might qualify for this study. This will take 10-15 minutes of your time. You do not have to answer any questions you do not want to answer. You may stop this interview at any time. If you meet certain criteria, you will be asked to participate in a speech and language assessment to determine if you qualify for this study. If you do, you will then participate in two weeks of intensive aphasia therapy. After that, you will be assessed again so that we can determine if and how much you improved. The total time commitment for this study will range from four to six weeks. If you do not qualify for this study, the information you give me today will be shredded immediately. Do I have your permission to proceed?"

___ Yes ___ No

If "No": "Thank you for your time. If you have any questions regarding this study, please call me at (706) 247-5402."
If "Yes": "Great. You just said that you agree to answering a few questions to determine if you qualify for an aphasia treatment study. Is that correct?"

___ Yes ___ No

Cut on dotted line. Shred after conversion of PHI to de-identified data on next page.

- -

Name ________________________

➔ **Participant ID:** 1. First initial of last name = ___ First initial of first name = ___

2. Given that A=01, B=02, C=03, D=04, …, X= 24, Y= 25, Z= 26

Last name initial = #__ __ First name initial = #__ __

3. **Participant ID** = __ __ __ __

Age ________________________________

➔ **Participant Chronological Age (CA):** _______

Participant ID: __ __ __ __

Participant CA: __________

Phone # ______________________________

Gender M or F

Native English speaker? Y or N

Handedness (premorbid) R or L

Qualify? ___Yes ___No
If yes, proceed. If no, skip to top of page 3.

"How long ago were you hospitalized with your stroke?"__________________________

Qualify? ___Yes ___No
If yes, proceed. If no, skip to top of page 3.

"Before your stroke, were you ever diagnosed with: (If Yes, have them describe)

Speech or language disability?"____

____

Learning disability?"____

____

Dyslexia?"____

____

Dementia?"____

____

"What was the last grade you completed in school?"_____________________________

Qualify? ___Yes ___No
If yes, proceed. If no, skip to top of page 3.

"Do you have any difficulty reading? If yes, describe."__________________________

____

"Do you have any hearing loss that you know of? Do you wear hearing aids?"_________

"Do you have any vision loss? Is it corrected with glasses or contacts?"_____________

"Thank you for answering my questions today. You **do / do not** (*circle one*) qualify to participate in this research study. (*If qualified to participate*) I would like to arrange a convenient place and time to meet to discuss the study and obtain your consent to participate. Are you interested in participating in this study?"

___ Yes ___ No

If "No": "Thank you for your time. If you have any questions regarding this study, please call me at (706) 247-5402."
If "Yes": "Great. You just said that you agree to participate in an assessment to determine if you qualify for an aphasia treatment study. Is that correct?"

___ Yes ___ No

If "Yes": "Okay, now we need to schedule your assessment. What date and time work for you?"

Date and Time scheduled:___________________

"Great. I will send you a reminder letter and also a parking pass. I will need your address. After I send you this information, I will shred the document that contains your address." (*Write address below dotted line)*

"I look forward to meeting you on ___________________________. If you have any questions regarding this study, please call me at (706) 247-5402 or e-mail me at jdrich@uga.edu. If you have any questions or problems about your rights as a research participant, please call The Chairperson, Institutional Review Board, University of Georgia at 706-542-3199."

Reminder and Parking pass mailed on _____________________

Cut on dotted line. Shred after reminder and parking pass is mailed to participant.

- -

Address:___________________

____

____

APPENDIX O

OUTLINE OF EXPERIMENTAL PROCEDURES

---

1. **Telephone screening**
2. **Pre-treatment assessment**
    a. Day 1-3
        i. Brief explanation of study
        ii. Consent form review and signing
        iii. Administration of assessment measures to determine eligibility
            1. WAB-R (30-45 minutes)
            2. CADL-2 (30 minutes)
            3. ASHA QCL (15 minutes)
            4. BJLO (15 minutes)
            5. Iconographic symbol matching task (10 minutes)
            6. GDS-15 (10 minutes)
            7. ABA-2 (20 minutes)
            8. CTT (10 minutes)
            9. measurement of visual acuity (5 minutes)
            10. pure-tone audiometric screening (10-15 minutes)
        iv. Administration of baseline probes to establish baseline
            1. picture description tasks
            2. naming tasks
    b. Days 4 and following
        i. Administration of baseline probes until behaviors of interest demonstrate stability
            1. picture description tasks
            2. naming tasks
        ii. Participate in nonspecific control sessions for 2 hours daily
            1. Activities include games, discussion, and other activities that require social interaction
3. **Intervention**
    a. Weeks 1-2

i. Participate in constraint-induced aphasia therapy for 3 hours daily, for 10 consecutive weekdays
    1. A frequent activity is a modified form of "Go Fish" played with picture cards.
    2. Participants request, answer, or deny requests while trying to match cards.
    3. All communication must be in the form of spoken words or sentences. No pointing, writing, or gesturing is allowed.

ii. Administration of baseline probes to determine effect of treatment on behaviors of interest.
    1. picture description tasks
    2. naming tasks

4. **Return to baseline**
    a. Days 1-4
        i. Administration of baseline probes to determine effect of treatment on behaviors of interest.
            1. picture description tasks
            2. naming tasks
        ii. Participate in nonspecific control sessions for 2 hours daily
            1. Activities include games, discussion, and other activities that require social interaction

5. **Post-treatment assessment**
    a. Days 1-4
        i. Administration of following standardized measures to determine treatment outcomes
            1. WAB-R (30-45 minutes)
            2. CADL-2 (30 minutes)
            3. ASHA QCL (15 minutes)
            4. GDS-15 (10 minutes)

APPENDIX P

CONSENT FORM

The University of Georgia
College of Education
Department of Communication Sciences and Special Education

I, _________________________ _________________________, agree to participate in the research study entitled, “Response generalization in individual participants receiving constraint-induced aphasia therapy”, conducted by Jessica Richardson, M.S., CCC-SLP, from the Department of Communication Sciences and Special Education at The University of Georgia (706-542-6093).

I understand that my participation is voluntary.

I understand that I can refuse to participate.

I understand that I can stop taking part without giving any reason.

Refusing to participate or ending my participation will not cause me any penalty or loss of benefit that I would normally receive.

NO PARTICIPATION = NO PROBLEM!

Purpose

The **purpose** of this research is to study the possible effects of Constraint-Induced Aphasia Therapy (CIAT) on my speaking and listening abilities, as well as my quality of life. If I choose to participate in this study, I may be asked to do the following things:

1. Undergo assessments to test the impact of CIAT on my speaking and listening abilities and quality of life by being tested two to three times during the course of the study. The initial assessment should last no longer than 3 ½ hours. All testing sessions that follow will last no longer than 2 hours. The time can be spread across several days if I need to rest.

Tests x 2-3

**If I do not qualify after the first assessment, I will not be able to participate in this therapy study. If this should happen, Mrs. Richardson will direct me to therapy opportunities at The UGA Speech and Hearing Clinic or to other clinicians in the area. All data and recordings will be destroyed.*

2. Meet with a clinician everyday for 2-3 hours a day for 3-4 weeks. We will talk and play games during these sessions.

2-3 hours a day for 3-4 weeks

Risk

My participation in this study involves no known physical, psychological, social, or legal risks.

No known risks

I may become tired or frustrated during assessment and therapy. I may also become more aware of my communication problems. I know that I can take a break at any time. If sessions are too long, the length of the sessions will be changed according to my needs.

= "I need a break please!"

Privacy and Confidentiality

The results of this study will be confidential and will not be released in an individually identifiable form without my prior consent unless required by law or in order to protect my welfare. I will be asked to authorize release of my personal health information with an attached document.

- All data used for research purposes will be coded immediately following the telephone interview. Neither names nor birth dates will be used or reported throughout the study.

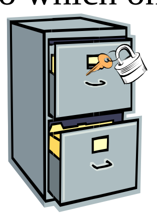
John Smith → #1910

11/23/50 → 58;02

- All of the results of the tests will be kept totally private.

- All assessments and meetings with researchers may be video- and/or audio- taped.

- All audio and videotapes will be locked in a filing cabinet in the Adult Neurogenics Laboratory of the Department of Communication Sciences and Special Education at the University of Georgia, to which only the investigators will have access.

 → 

- These recordings will be kept indefinitely. This is so that Mrs. Richardson and other researchers can use them to improve treatment and assessment techniques for individuals following a stroke. No one except trained researchers will see or hear the tapes unless I agree separately on the next page.

- I can ask for any tape to be destroyed at any time and for any reason.

 → 

Recordings can be shown at meetings of researchers. Audio_____ Video_____ Initials:_____



Recordings can be shown in classrooms to students. Audio_____ Video_____ Initials:_____



Authorization For Release of Protected Health Information (PHI)

I hereby authorize The Adult Neurogenic Laboratory at The University of Georgia to obtain information from:

____
Attorney/Physician/Institution/Agency

____
Street Address

____
City **State** **Zip Code**

____
Telephone/Fax Numbers

____
Dates of Treatment

Unless indicated by specific request checked below, I permit the release of any and all information including, if any, information concerning drug/alcohol abuse records, venereal disease and other statutorily protected diseases, psychiatric records (excluding psychotherapy notes) or AIDS/HIV testing treatment records. Please check specific information requested for release.

____All PHI in Medical Record	____Psychotherapy notes*	____ER Reports
____Discharge summary	____Operative Report	____X-Ray Reports
____History and Physical	____Video/Photo	____Pathology Reports
____Progress Notes	____Laboratory Notes	Other:____________________

*If this is a request for psychotherapy notes, then this is the only item that may be requested on this authorization. You must submit another Authorization for other information.

- I may revoke this authorization at any time in writing and present my written revocation to The Adult Neurogenic Laboratory at The University of Georgia.
- The revocation will not apply to information that has already been released in response to this authorization.
- I may refuse to sign this authorization.

- Disclosure of health information is voluntary.
- I need not sign this authorization to ensure treatment.
- Any Disclosure of information carries with it the potential for an unauthorized redisclosure.
- I may inspect or have a copy of the information described on this form if I ask for it.
- I get a copy of this form after I sign it.

Authorization is valid for 90 days from the date of signature unless otherwise indicated.

Questions
If I have any questions about:

→ The disclosure of my protected health information, contact the office or physician who holds that information.

→ The research, its procedures, risks or benefits, or the alternatives, contact the researcher, Mrs. Jessica Richardson, at (706) 247-5402 at 559 Aderhold Hall, The University of Georgia, Athens, GA 30602.

Voluntary Participation
My participation is entirely voluntary. I can withdraw my consent at any time without penalty or prejudice. I can have the results of the participation, to the extent that they can be identified as mine, removed from research records. I may discontinue participation in a session or in the entire study if I become depressed, frustrated, discouraged, fatigued, or for any other reason. This will not endanger my care.

DOCUMENTATION OF AGREEMENT

I am agreeing by my signature on this form to participate in this research project. I have read and authorize the disclosure of the protected health information as stated. I also understand that I am required to receive a signed copy of this consent form.

Signature of Investigator:__________________________________ Date:______________

Signature of Participant:___________________________________ Date:______________

Signature of Witness:_____________________________________ Date:______________

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, The University of Georgia, 612 Boyd Graduate Studies Research Center, Athens, GA 30602-7411; Telephone (706) 542-3199; E-mail Address IRB@uga.edu

APPENDIX Q

LISTS OF TARGET STIMULI FOR NAMING PROBES

	P1	P2	P3	P4	P5	P6
N-T						
	blanket	belt	ambulance	bib	bed	belt
	chair	blanket	bib	cleat	car	blanket
	coat	boat	canoe	corkscrew	chair	boat
	dress	chair	cleat	helmet	coat	bottle
	glass	coat	corkscrew	hook	desk	cup
	hat	desk	glove	lantern	dress	picture
	knife	glass	hood	map	glass	plate
	picture	knife	hook	mixer	hat	pocket
	plant	picture	lantern	napkin	knife	pot
	pocket	plane	map	oven	phone	refrigerator
	pot	pocket	mixer	propeller	plane	shirt
	refrigerator	road	napkin	pump	plant	suit
	road	steps	propeller	puzzle	road	table
	shirt	table	pump	sponge	steps	tractor
	submarine	tractor	sail	trolley	submarine	truck
	tractor	van	vase	vase	tie	van

N-GT

book	ceiling	boots	cart	book	box
ceiling	clothes	bucket	cradle	bowl	ceiling
clock	floor	canal	dock	clock	floor
frame	frame	cradle	dresser	clothes	lock
gas	lock	laundry	ignition	frame	mirror
porch	porch	lighter	laundry	gas	porch
radio	radio	pants	platter	keys	radio
sink	sink	platter	rack	piano	train
soap	train	skillet	skillet	sink	wheel
wheel	wheel	spice(s)	trunk	soap	window

N-GUT

brain	arm	armadillo	beaver	bear	arm
cow	bird	beaver	boar	cat	bird
ear	brain	camel	camel	dog	brain
eye(s)	chin	elbow	clam/oyster	feet	chicken
feet	eye(s)	fur	monkey	fly	chin
fish	feet	heel	pigeon	leg	cow
fly	knee	tiger	ram	nose	ear
horse	mouth	toe(s)	snail	sheep	fish
leg	sheep	turtle	squirrel	snake	horse
mouth	tongue	walrus	walrus	tongue	teeth

APPENDIX R

SCRIPT FOR INTRODUCING PROBE TASKS

At the beginning of each assessment/probe session: (pre- and during treatment)

"We are going to do several activities where I will ask you to look at pictures and name or describe them. I will not give you feedback about your performance during this time. This means I will not tell you if you are right or wrong. I will not be able to provide answers for you. I will not be able to help you find your words. I know this may be frustrating, but we will give you plenty of feedback and help during the therapy sessions. Okay? [Wait for affirmation.] All right. Then let's get started.

At the beginning of each probe session: post-treatment

We are going to do several activities where I will ask you to look at pictures and name or describe them. I will not give you feedback about your performance during this time. This means I will not tell you if you are right or wrong. I will not be able to provide answers for you. I will not be able to help you find your words. I know this may be frustrating, but we need to see how well you are doing now that therapy is finished. Okay? [Wait for affirmation.] All right. Then let's get started.

APPENDIX S

SAMPLE INTERVENTION SCRIPT

Following introduction of the category, and review of the target stimuli when appropriate, participants will be reminded of the task, with the clinician referring to graphic aids during the explanation. “During this game, we will work on requesting cards and responding to others’ requests. The aim of this game is to help you learn to speak with more words. When requesting, you should try to say the name of the object on the card. For example, when I need to find a match for this card in my hand, I could say ‘(noun)’. Of course, we want to build upon this, so that you eventually say ‘Name, noun’, and ‘Name, can I have noun?’ As you become more skilled, you should begin adding descriptive words, as in ‘Name, can I have color noun?’ and ‘Name, can I have number color nouns?’ Lastly, you can add a ‘please’ at the end for ‘Name, can I have number color nouns please?’

When responding, you will be doing something very similar. Your shortest response will be a simple ‘yes’ or ‘no’. You will build on this also, making sentences like ‘Yes, noun’, ‘Yes, I have noun’. Again, as you become more skilled, you should begin adding descriptive words, as in ‘Yes, I have color noun’ and ‘Yes, I have number color noun’. Lastly, you can add the person’s name to your sentence, so you say ‘Yes, I have number color noun, Name’.

Your way of speaking may be different from others in this group. Your sentences may be longer or shorter. That is perfectly fine. We will work with each of you at your level.”

APPENDIX T

EXPECTED CUES TO UTILIZE DURING TREATMENT

Code abbreviation	Name	Description
US	Unison production	Ask participant to say or sing the word with you
R	Repetition	Say the word, and ask the participant to repeat it
SC+vPhC	Sentence completion + vocalized phonemic cue	Provide an open-ended sentence that might elicit the target word, and vocalize the first phoneme of the target word
SC+sPhC	Sentence completion + silent phonemic cue	Provide an open-ended sentence that might elicit the target word, and move your articulators as if you will make the first phoneme of the target word, but do not vocalize
SC	Sentence completion	Provide an open-ended sentence that might elicit the target word
DS	Descriptive sentence	Provide a descriptive sentence for the stimulus, them prompt to name
NWR	Non-word rhyme	Provide a non-word that rhymes with the target word
vPhC	Vocalized phonemic cue	Vocalize the first phoneme of the target word
sPhC	Silent phonemic cue	Move your articulators as if making the target sound, but do not vocalize
OR	Oral reading	Write the entire target word and ask patient to repeat it aloud
GrC	Graphemic cue	Write the first letter or two of the word and ask the patient to produce the target word
GC	Gestural cue	Provide a pantomime associated with the object
TI	Time interval	Impose a 5- or 10- second time interval b/w presentation of stimulus and participant's verbal response
T	Tap	Tap out the target word, marking stress for multisyllabic words

Adapted from

Helm-Estabrooks, N., & Albert, M.L. (2004). Manual *of aphasia and aphasia therapy* (2nd ed.). Austin, TX: Pro-ed.

Linebaugh, C.W., Shisler, R.J., & Lehner, L. (2005). Cueing hierarchies and word retrieval: A therapy program. *Aphasiology, 19*(1), 77-92.

APPENDIX U

LEVELS OF SYNTACTIC COMPLEXITY

	Request	Response
Level 1:	noun only	yes/no
Level 2:	name+noun	Y/N+ noun
Level 3:	Name+?+noun	Y/N+stmnt+noun
Level 4:	Name+?+adj+noun	Y/N+stmnt+adj+noun
	Name+?+#+noun	Y/N+stmnt+#+noun
Level 5:	Name+?+#+adj+noun	Y/N+stmnt+#+adj+noun
Level 6:	Name+?+#+adj+noun+politeness	Y/N+stmet+#+adj+noun+Name

Sample request sentence elements

Mary,	do you have can I have I would like to have	three	red	Trucks	please
Name	Question	Number Adj	Color Adj	Noun	Politeness

Sample response sentence elements

Yes,	I do have You can have	three	red	Trucks	Sam
No,	I do not have You can't have				
Y/N	Statement	Number Adj	Color Adj	Noun	Name

APPENDIX V

SESSION DATA SHEET

Date: Deck #:

US* R* *I = c or s/c Min=1-2 Mod=3-5 Max=6+**
SC+vPhC SC+sPhC SC DS NWR vPhC
sPhC OR GrC GC T

# Level:		# Level:		# Level:		# Level:	
Q	**R**	**Q**	**R**	**Q**	**R**	**Q**	**R**

APPENDIX W

RULES FOR COUNTING SPOKEN LANGUAGE TURNS

→ **Turns are often identified by:**

1. a period of silence by the speaker signaling the relinquishment of the turn
2. an intonational change by the speaker signaling the relinquishment of the turn
3. an expectant look by the speaker signaling relinquishment of the turn and expectation of a response
4. the taking of a turn, or interruption, in the absence of a signal by the speaker
5. the taking of a turn following a signal by the speaker (e.g., So what is this?, Can you tell me that again?, etc.) if the numbers 1 through 3 are met
6. the completion of an ideational unit or strings of ideational units (does not have to be grammatically correct)
7. 1-2 word utterances used to:
    - answer a question (e.g., yes, no, uh-huh, nope, etc.)
    - acknowledge hearing and/or understanding (e.g., okay, allright, oh, aha, yes, etc.)
    - comment or express emotions (e.g., wow, oh man, doggoneit, hmmm, shit, etc.)
    - request information (e.g., pardon?, what?, etc.)

→ **Turns can overlap. Examples include:**

1. While the therapist is providing feedback or instructions, the participant may be occasionally acknowledging that they understand the instructions, with an occasional “yes” or “okay.” These interjections would count as a turn.

2. When a participant in the dyad produces a target word, and then uses that target word in a sentence, the other participant may also produce/practice the word. This would count as a turn.
    - P1: car I see red car
    - P2: yes car car
3. Special case:
    - When a participant ceases to persist in a turn (indicated by looking up at the clinician, asking "huh?," giving a questioning glance, etc.), and the clinician provides a cue or prompt, then what follows would be a separate turn.
        - P1: That is a road … no? (Looks up at clinician)
        - C: Close, you drive it on the road, it is a tr-
        - P1: truck truck truck. Do you have a truck?
    - However, if the clinician is providing cues/prompts while the participant persists with the turn/holds the floor (e.g., circumlocuting, performing articulatory gestures, gesturing to self-cue, etc.), then even though the clinician is providing information, it is still considered a single turn.
        - P1: road …no…road…no…tr…road…tr…truck truck. Have a truck?
        - C: tr- tr-
        - C: Who are you asking?
        - P1: Dustin.
        - C: Great, now put that all together for me in a sentence.
        - P1: Gr…no…gr…no, Dustin, you have a truck?
        - C: d-

→ **To be considered a turn, an utterance (or string of utterances) does not have to be intelligible.**

→ **Turns should be classified as major versus minimal (minor) turns. All turns are major except for:**

1. 1-2 word utterances used:
   - acknowledge hearing and/or understanding (e.g., okay, allright, oh, aha, yes, etc.)
   - comment or express emotions (e.g., wow, oh man, doggoneit, hmmm, shit, etc.)
   - quickly yield his or her turn

→ **Major turns should be marked if they do not pertain to treatment stimuli. All unmarked major turns will be counted as "re: tx stim." Major turns do not pertain to treatment stimuli if:**

1. they occur during non-treatment conversation (e.g., events of the day, topics other than the picture stimuli)
2. they occur during requests for bathroom breaks, snacks, etc.
3. they occur during general discussions about the activities

Adapted from Comrie et al., 2001; Kennedy et al., 1995; Perkins et al., 1995

APPENDIX X

PRE- AND POST- TREATMENT RESPONSES FOR P1

Target	Pre-treatment	Post-treatment
chair	pear pear	tear
coat	/plo/ clothes /ploz/	/lækɪt/, /pot/
dress	/tɪs/ desk	/pɛs/
knife	/bis bis/	/paɪs/
picture	/blædɪsə/	/pɪkɪt/
pocket	[UI] /klek/	pocket
road	[UI]	node
shirt	pluck pleck	pocket, tut
submarine	[UI]	tub, bus, /sɛb/
book	[UI] that is [UI] bottle	Bible
radio	bees bees	/pleɪdibo/
brain	that's a coat [UI] /bed/	blain, plane
ear	[UI]	beers
feet	that's a boat a /pɔt/ [UI] [UI]	peets, seats
fly	/bæləput/ [UI] //bæləkot/	bee, beetle
horse	/pɔt/	/pɔrs/
leg	key keys keys	knees
mouth	that's ice ice	kisses