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Contrasting Effects of Errorless Naming Treatment and Gestural Facilitation for Word Retrieval in Aphasia

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Abstract

Purpose—We compared the effects of two treatments for aphasic word retrieval impairments, errorless naming treatment (ENT) and gestural facilitation of naming (GES), within the same individuals, anticipating that the use of gesture would enhance the effect of treatment over errorless treatment alone. In addition to picture naming, we evaluated results for other outcome measures that were largely untested in earlier ENT studies.

Methods—In a single participant crossover treatment design, we examined the effects of ENT and GES in eight individuals with stroke-induced aphasia and word retrieval impairments (three semantic anomia, five phonologic anomia) in counterbalanced phases across participants. We evaluated effects of the two treatments for a daily picture naming/gesture production probe measure and in standardized aphasia tests and communication rating scales administered across phases of the experiment.

Results—Both treatments led to improvements in naming of trained words (small-to-large effect sizes) in individuals with semantic and phonologic anomia. Small generalized naming improvements were noted for three individuals with phonologic anomia. GES improved use of corresponding gestures for trained words (large effect sizes). Results were largely maintained at one month post treatment completion. Increases in scores on standardized aphasia testing also occurred for both ENT and GES training.

Discussion—Both ENT and GES led to improvements in naming measures, with no clear difference between treatments. Increased use of gestures following GES providing a potential compensatory means of communication for those who did not improve verbal skills. Both treatments are considered to be effective methods to promote recovery of word retrieval and verbal production skills in individuals with aphasia.

Keywords

aphasia; anomia; rehabilitation; errorless; speech therapy

One of the most common symptoms seen in individuals with aphasia is anomia or word retrieval difficulty (Goodglass & Wingfield, 1997). Cognitive neuropsychological models of lexical processing, such as the one depicted in Figure 1 (after Goldrick & Rapp, 2007; Laine & Martin, 2006), guide the interpretation of word retrieval impairments among individuals with aphasia. Lexical models typically recognize that the ability to retrieve words depends on the integrity of lexical-semantic mechanisms whereby concepts and meanings are represented, and lexical phonologic mechanisms which make available the repository of

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familiar spoken words in the individual's language. Likewise, gesture production includes parallel mechanisms for retrieval of familiar gestures and gesture execution (Rothi, Ochipa, & Heilman, 1997). Similar models of gesture processing depict an interaction between lexical and praxis processing mechanisms (Krauss et al., 2000; Rose & Douglas, 2001), thus an adaption in the model in Figure 1 represents a connection between lexical and gesture output mechanisms.

When the left hemisphere is damaged by stroke or other brain injuries, portions of the lexical and praxis systems can be disturbed, leading to different patterns of failure (Howard & Gatehouse, 2006). In general, lexical-semantic system impairment will lead to difficulty in both spoken naming and auditory comprehension of words, as well as recognition and production of gestures. Phonologic lexical system impairment leads to word retrieval difficulty, with retained comprehension of spoken words. Of course, neurologic disease does not respect these boundaries and individuals can experience deficits due to dysfunction of multiple lexical mechanisms.

Treatments for Anomia

Because anomia is so common in individuals with aphasia, clinical researchers have examined a variety of methods to treat this impairment (Nickels, 2001; Raymer, 2011; Raymer & Rothi, 2008). Some treatments are intended to restore word retrieval abilities by placing the patient in an enriched lexical environment to rehabilitate the normal semantic-phonologic processes engaged in word retrieval. Other treatments use compensatory methods that attempt to engage intact cognitive mechanisms, such as gesture, to support the impaired word retrieval mechanisms in a manner that differs from normal, possibly leading to reorganization in the word retrieval process over time (Nickels, 2001; Rothi, 1995). One approach to treatment that falls along the lines of a restorative treatment method is errorless naming treatment (Fillingham, Sage, & Lambon Ralph, 2005a,b,2006). In contrast, a compensatory approach to facilitate word retrieval is through the use of gestures.

Errorless Naming Treatment

Fillingham, Sage, and their colleagues (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003; Fillingham et al., 2005a, 2005b, 2006; Conroy, Sage, & Lambon Ralph, 2009) have examined errorless naming approaches to word retrieval treatment in individuals with aphasia. In this method, the participant views a target picture and is given the name of the picture along with multiple opportunities to rehearse the correct name of the picture supported by oral reading and repetition, while avoiding production of errors during training. Because the picture allows for activation of semantic mechanisms, and the name repetition draws upon phonologic skills, the approach can generally be considered a restorative semantic-phonologic treatment approach.

One perpective underlying this approach is the Hebbian learning principle that neurons that fire together wire together. That is, each time a response is produced, whether correct or error, the chance of that response occurring again in the future is potentially increased (Fillingham et al., 2006). In addition, Fillingham et al. noted the importance of intact memory and executive systems to be able to monitor performance and filter erroneous responses, to avoid future production of errors that may result from Hebbian wiring. In their review of the aphasia word retrieval treatment literature, Fillingham et al. (2003) found that studies employing error-reducing (somewhat errorless) methods were as effective as errorful treatments for improving word retrieval in individuals with aphasia. They noted that treatment effects were best in individuals with 'expressive' impairments and more limited in those with 'expressive-receptive' impairments, an observation akin to the phonologic-semantic distinction discussed earlier.

Subsequently Fillingham, Sage, and colleagues (2005a,b; 2006; Conroy et al., 2009) published a series of papers directly comparing effects of errorless and errorful methods for aphasic word retrieval. They found that effects of errorless training were comparable to effects of errorful methods for their patients as indicated by improvements in picture naming abilities for trained words. Generalized improvements for untrained words were more limited. Positive effects of ENT were reported for both nouns and verbs (Conroy et al., 2009). McKissock and Ward (2007) also found that errorless training was as effective as errorful practice in their patients with aphasia. Further, they found that feedback provided to patients about the accuracy of their responses during errorful training was critical to improved performance in a picture naming task, as errorful training without feedback led to no improvement in picture naming.

Although this series of studies uniformly reported that errorless techniques are as effective as errorful techniques in training word retrieval, the results largely diverge from the pattern seen in the memory rehabilitation literature where errorless training was superior to errorful training (Wilson, Baddeley, Evans, & Shiel, 1994; Wilson & Evans, 1996). That is, within aphasia, errorful and errorless techniques are largely of equivalent value. Notably absent from the errorless naming treatment studies, however, are outcomes examining the impact of treatment beyond picture naming, such as on standardized aphasia tests and on measures of communication activity/participation (WHO, 2001). Studies often note that individuals who participate in training often prefer the errorless techniques, which tend to be less frustrating and effortful. Yet, some preliminary data reported by Lacey, Glezer, Lott, and Friedman (2004) suggested that errorless training improvements were amplified when effort was introduced. Studies are needed that systematically examine outcomes of errorless training for measures that span the disability continuum from language functions (picture naming, standardized aphasia tests) to communication activity/participation (e.g., rating scales), and that incorporate elements of effortful production during errorless practice.

Gestural Facilitation of Naming

An alternative, compensatory method that researchers have applied to remediate word retrieval impairments is gestural facilitation of naming. Luria (1970) referred to such a process as “intersystemic gestural reorganization,” using intact gesture abilities to activate the impaired language system. Cognitive models of lexical and praxis processing as well as studies examining neural correlates of the two systems recognize the interactive nature of language and action (Bernardis & Gentilucci, 2006; Krauss et al., 2000; Rothi et al., 1997; Willems & Hagoort, 2007), suggesting that gesture may be useful to mediate activation of lexical retrieval. A number of small studies have demonstrated positive effects of gestural training with lexical gestures (pantomimes) in individuals with aphasia (Hoodin & Thompson, 1983; Kearns, Simmons, & Sisterhen, 1982; Pashek, 1997; Rao & Horner, 1978; Raymer & Thompson, 1991; Skelly, Schinsky, Smith, & Fust, 1974). Although the earlier studies concentrated on noun retrieval, more recent work has examined effects of gestural facilitation for nouns and verbs and found improvements in both classes of words (Raymer et al., 2006; Rodriguez, Raymer, & Rothi, 2006; Rose, Douglas, & Matyas, 2002; Rose & Douglas, 2008; Rose & Sussimulch, 2008). Generalized improvements for spoken naming of untrained words were typically more limited across studies, however. Verbal improvements were better in those with phonologic anomia than those with semantic anomia, an observation that has led Rose (2006) to suggest that gesture plays a role in facilitating word retrieval at a phonological access stage of processing. Whereas most participants improved production of trained gestures, several also demonstrated generalized increases in the use of gestures for untrained words (Raymer et al., 2006).

One factor that has not been teased out in the prior gesture studies, however, is the role that spoken rehearsal of the word plays in response to these gestural treatments. There is modest evidence to suggest that the gesture in addition to the verbal rehearsal enhances treatment effects, but that evidence is based on the treatment response of only a few participants with aphasia (Kearns et al., 1982; Rose, Douglas, & Matyas, 2002; Rose & Douglas, 2008). In fact, in the studies of Rose and colleagues, what they call gesture-only treatment includes a word repetition component if needed, thereby making their treatment more of a gesture-plus-verbal treatment, similar to the treatment used in studies of Raymer and colleagues (Raymer et al., 2006; Rodriguez et al., 2006). Given the effects of training seen in errorless naming treatment, however, it is not entirely clear that the gesture provides any advantage in the training beyond the spoken rehearsal (repetition) typically incorporated during the gestural treatment protocol.

Evidence garnered from functional neuroimaging studies demonstrates a close connection between gestures and words, particularly with respect to semantic processing engaged in left Broca's area (Gentilucci & Dalla Volta, 2008; Skipper, Goldin-Meadow, Nusbaum, & Small, 2007). Thus, there is reason to believe that gestural training may provide a benefit during word retrieval that does not occur in errorless naming training alone. Further, an advantage of gestural treatment is that gesture improvements can be observed even when verbal improvements are not seen in the most severely impaired patients (Rodriguez et al., 2006; Ferguson, Evans, & Raymer, 2011). Like the studies of errorless naming treatment, gestural treatment outcomes have been primarily limited to performance on picture naming tasks and standardized aphasia measures, and the communication impact of these treatments has been largely untested.

Errorless naming treatment and gestural facilitation of naming are effective approaches for improvement of word retrieval abilities in individuals with aphasia. Whether an errorless treatment approach can be amplified with the use of gestural facilitation, and what the outcomes are beyond the picture naming paradigm are largely untested. Further, the impact of the nature of the word retrieval impairment, semantic versus phonologic, is largely unexplored for errorless naming treatment in particular. The purpose of this study was to determine whether the effects of errorless naming treatment can be enhanced through the use of gestural facilitation in individuals with aphasia. We used a single participant crossover experimental design to examine these effects in eight individuals with aphasia and varied naming impairments.

Methods

The eight participants in this study all incurred a unilateral left hemisphere stroke that resulted in aphasia at least four months prior to enrollment. Demographic characteristics of the group are shown in Table 1. The four women and four men ranged in age from 40 to 79 years (mean 58.1 years) and were 5 to 30 months post stroke onset (mean 13.5 months). All participants were right-handed, speakers of English as the preferred language at home, and with at least a 6^{th} grade education (range 11–16 years of education, mean 13.5 years). Potential participants were excluded if they had a history of: developmental learning difficulties, other neurological illnesses known to affect cognition, chronic medical illness that would disrupt the ability to participate in an ongoing treatment (e.g., cancer, renal failure), alcohol or drug dependence, or severe uncorrected sensory defects (vision, hearing). While undergoing the experimental treatment, participants did not take part in other forms of individual speech-language therapy other than group therapy addressing general communication goals. All signed written informed consent to participate in the research which was approved by the university Institutional Review Board.

Language Evaluation

All potential participants completed a pre-treatment evaluation to determine whether the stroke-related language and communication impairments met criteria for participation in the treatment component of the experiment. The Western Aphasia Battery-Revised (WAB-R, Kertesz, 2007) was administered to characterize the general pattern of language impairments with subtests of verbal fluency, repetition, auditory comprehension, and word retrieval. A score of <93.8 indicated the presence of aphasia. Participants were excluded if they had auditory comprehension impairments too severe to complete the treatment protocol (score of <4.0 on the WAB-R Auditory Comprehension subtests), and if a severe motor speech disorder rendered speech unintelligible for single words (score of <2.0 on the WAB-R Repetition Subtest). The Boston Naming Test (BNT, Kaplan, Goodglass, & Weintraub, 2001) was administered to assess word retrieval abilities in a standardized confrontation picture naming format. A score of <40 of 60 was required to be included. Of 15 individuals originally tested, nine met criteria for inclusion in the study (four were too mild and two were too severe). One participant had to withdraw from the study due to health issues, leaving eight individuals who completed the trial.

As seen in Table 1, WAB Aphasia Quotients for the eight participants ranged from 49.3–66.7, with patterns of impairment across tasks indicating that four individuals had Broca's aphasia, two had transcortical motor aphasia, one had transcortical sensory aphasia, and one had Wernicke's aphasia. BNT scores ranged from 2–27, indicating that most participants had moderate-severe anomia, and one had very severe anomia (808).

Lexical Battery—To characterize the basis for the word retrieval impairment, participants completed an experimental lexical battery incorporating 60 nouns. The first two subtests were developed by Zingeser and Berndt (1990), and the other was developed in our lab: 1) Picture Naming: The participant viewed a line drawing of an object (noun) and named it (What is it?). 2) Sentence Completion: The clinician and participant read a printed sentence aloud and the participant filled in the final word (Man's best friend is a …. e.g., dog). Verbal responses in Tasks 1 and 2 were recorded by the clinician online as well as with audiotape for reliability purposes. Correct responses in these two word retrieval tasks were target words or synonyms produced in a normative study. Minor motor speech errors (distortions, substitutions of one phoneme) were disregarded in scoring. 3) Spoken Word-Picture Yes/No Verification: The clinician said a word and the participant decided whether the word was correct for the target picture. Each picture was presented once with its target word (yes) and once with a semantically related distractor word (no, e.g., picture-dog, "Is this a cat?"). To be scored as correct, the participant had to respond correctly for both the 'yes' and 'no' presentations. Verification tasks have been found to be more sensitive to comprehension impairment than alternative word/picture matching tasks (Breese & Hillis, 2004).

We calculated percent accuracy in each lexical task and considered participants impaired if they performed more than 2 standard deviations below the mean in normative data from healthy adults generated in an earlier study (Raymer, Rueger, & Noga, 2004). A semantic word retrieval failure was indicated by below normal performance (>2 SD below normal mean) in naming tasks as well as the verification task. A primarily phonological retrieval failure was represented by impaired performance (>2 SD below normal mean) in naming tasks, and within normal levels of performance (within 2 SD deviations of the mean) in the verification task. Results in Table 1 show that five individuals had primarily phonologic anomia (P806, P809, P810, P812, P814) and three had primarily semantic anomia (P804, P808, P815).

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Treatment Procedures

In the treatment phase of the study, we incorporated a multiple baseline crossover treatment design. All participants took part in a phase of errorless naming treatment and gestural facilitation training, with order of training randomly determined at entry to the study as stratified by the presence or absence of semantic impairment. Following a phase of baseline testing on several outcome measures (further described later), all participants received two consecutive phases of word retrieval treatment for two sets of 24 pictured nouns to allow for within participant comparison of the treatment effects. During treatment phases, each session was initiated with a daily probe picture naming/gesture production task to assess acquisition effects for a trained picture naming set and generalization of improvement to an untrained picture naming set. Participants were seen for 2–3 one-hour sessions per week for up to 20 sessions of treatment per phase. The treatment phase was terminated if participants reached >90% correct in two consecutive daily probes or at the end of 20 sessions. At completion of each treatment phase, further post-testing took place. Finally, follow-up testing took place at one month post-treatment completion. Due to health issues, two participants had adjustments to their experiment schedules. Participant 815 discontinued training phase 2 after 14 training sessions, and both P815 and P804 were not seen for follow-up.

Treatment Methods—Both treatment methods were devised to implement elements of errorless training, avoiding errors as much as possible in initial treatment steps (Wilson & Evans, 1996), but then increasing the need for effort and self-generation in final steps of the protocol (Tailby & Haslam, 2003). Both treatments used 24 trained pictured nouns for naming, half of which were part of the daily picture naming probe measure described below.

Errorless Naming Treatment encompassed the following steps in which one of 24 target pictures was present for all steps. The participant was reminded to respond only if confident of the correct word at all steps, and the occurrence of errors was tallied across training steps: 1) The clinician modeled the correct picture name and the participant repeated the name three times. 2) The participant was shown the written target word and read the word aloud three times. 3) The written word was removed and the participant was given five seconds to keep the name in mind. 4) Finally, the clinician prompted the participant to once again name the target picture (repeating it three times), but only if they could correctly remember the name. If they had forgotten the name, the clinician once again provided the name to repeat three times.

As a means to encourage spontaneous effortful use of target words that had initially been practiced in an errorless manner, a final barrier activity phase was implemented after all 24 picture names were rehearsed, a step that diverges from the procedures used in prior errorless naming treatment studies. The participant verbalized to the clinician what picture was present, without the clinician seeing the picture. No compensatory communication methods were allowed (e.g., gestures, drawing) and the participant was encouraged to produce a word only if sure of the target word. If unable to say the correct word, that picture was set aside and at the end of the series, the clinician once again modeled the word for repetition three times by the participant.

Gestural Facilitation Training included the following steps, intended to parallel errorless naming treatment as much as possible, but adding a gestural component in the training to determine the impact of the gestural facilitation over the ENT protocol. One of 24 target pictures remained present across steps: 1) The clinician modeled the correct name and associated gesture for the target picture. 2) The clinician modeled the gesture alone for the participant to imitate three times. The clinician manipulated the hand and arm as necessary to establish the correct hand configuration, orientation, and joint movement of the gesture.

3) The clinician modeled the picture name and the participant repeated the name three times. The clinician parsed the word into syllables as needed to assist the participant in correctly pronouncing the word. 4) The clinician modeled the picture name and gesture and the participant repeated the combination three times. 5) After a five second pause, the clinician prompted the participant to once again provide the name and gesture for the target picture (repeating it three times), but only if they could correctly remember the name. If they had forgotten, the clinician once again modeled the combination for the participant to repeat three times.

As in the ENT protocol, a final step in gestural training included a barrier activity implemented after all 24 picture names and gestures had been rehearsed. This new step in our protocol that we had not used in our earlier gesture treatment studies (Raymer et al., 2006; Rodriguez et al., 2006) was implemented to promote effortful spontaneous use of the gesture training strategy. The participant indicated to the clinician what picture was present through verbalization and/or gesture, only if confident that they remembered the correct response. If unable to say a word, that picture was set aside, and at the end of the series the clinician modeled the gesture and word for imitation by the participant once again.

Outcome Measures

Several measures were administered at intervals throughout the experiment, some in daily probes as part of the single participant experimental design, and others at pre- (A1) and post-treatment (A2, A3 and 1 month follow-up) intervals. The outcome measures represented a range of tasks and rating scales to assess outcomes for language functions at the word retrieval level as well as communication activities/participation in keeping with the WHO (2001) Model of Functioning, Disability and Health.

Daily probe—A confrontation picture naming task was used as a direct measure of word retrieval abilities probed daily to monitor response to treatment in this single participant research design. From a set of 220 black and white line drawings of objects (nouns) for which healthy individuals conceive of corresponding pantomimes (e.g., comb, jacket, kitten), we selected 60 pictures that the participant failed to name accurately in at least two baseline administrations of the full 220 picture set. For two participants with the mildest word retrieval impairment, we had to include some words that were named incorrectly only once during baseline probes. The selected pictures were divided into 24 used for errorless naming treatment (ENT), 24 used for gestural training (GES), and 12 retained as an untrained control set. We matched the three picture sets on the basis of baseline accuracy of naming, word frequency, and syllable length.

The full 60 item picture naming daily probe task was administered in three to six baseline sessions, with baseline length randomly determined for each participant at entry to the experiment. One concern in implementing an errorless naming training protocol is that daily naming probes, which are inherently *errorful*, may in fact counteract *errorless* training effects. Thus, during the treatment phases of the experiment, only half of the probe items in each set (30 pictures total) were administered in the daily probes, and the remaining 30 items were tested only in pre- and post-treatment phases. The full 60 item set was administered at the completion of each phase of treatment and again at one month follow up. Clinicians scored the responses online for accuracy of naming and recognizable gesture production, and videotaped the responses to allow for reliability analyses by a second examiner blind to treatment conditions. Minor motor speech errors (distortions, substitutions of one phoneme) were disregarded in scoring. The percent correct naming and gesture production were calculated across sessions for the two trained sets (ENT set and GES set) and one untrained control set.

All naming and gesture responses were graphed to allow visual inspection of treatment response patterns. To analyze the daily probe picture naming/gesture production data, we calculated the standardized effect size statistic (d) using the procedures described by Busk and Serlin (1992) and advocated as the optimal method for analysis of single participant data in aphasia (Beeson & Robey, 2006): d = (mean A_2) – (mean A_1)/standard deviation A_1; where A_2 = the post-treatment points (A2 or A3 or 1 month follow up), and A_1 = the baseline (A1). An effect size >2.5 was considered a small treatment effect (Busk & Serlin, 1992), and an effect size >5.8 was considered a large effect (Beeson & Robey, 2006). In the event of no variability in the baseline phase, the standard deviation of the baseline+initial treatment probes was used.

Standardized Testing and Communication Scales—At baseline, treatment phase completion, and one-month follow-up, participants also completed standardized aphasia tests, including the WAB-R (Kertesz, 2007) and the BNT (Kaplan et al., 2001). Changes in test performance from pre-treatment to post-treatment were considered meaningful if the increase exceeded the standard error of measurement (5 points for both tests). Finally, two rating scales were administered to garner judgments of communication change at each phase of the experiment as provided by a family member or a caregiver familiar with the individual with aphasia. Such proxy raters may tend to overestimate the severity of communication difficulty (Hilari, Owen, & Farrelly, 2007), however, their overall ratings tend to be closely aligned with those of patients with aphasia. We administered: 1) the Communicative Effectiveness Index (Lomas et al., 1989), a 16 item questionnaire in which caregivers rate how well the person is able to communicate in different situations as compared to before the stroke, a measure that was sensitive to change in our earlier studies; and 2) the Functional Outcomes Questionnaire for Aphasia (FOQ-A; Glueckopf et al., 2002), a questionnaire developed to assess how well individuals are able to perform a variety of communication tasks.

Reliability Analyses

All sessions were videotaped to allow for assessment of reliability of dependent and independent measures for at least 25% of sessions across participants. A trained examiner completed scoring online, and a second trained examiner scored at least 25% of all responses to assess inter-examiner agreement in coding for accuracy of naming and gesture productions for all participants except one (P815 was not completed). In the event of disagreement, the second score was incorporated. Reliability of agreement exceeded 90% across participants (mean 96.5%; range 91.2–98.6% agreement).

To determine reliability of the independent variable, that is, the fidelity of administration of treatment protocols, we examined for the presence of each training step for at least 25% of training sessions across six of the eight participants. Treatments were administered as planned, with more than 90% of all treatment steps present in the protocol (gesture training: mean 99.0%, range 95.1–100%; errorless naming training: mean 97.3%, range 91.7–100%). Overall, reliability analyses showed strong agreement in scoring of probe tasks and administration of treatment protocols.

Results

Daily probe measures: Naming

The primary outcome task measured through all phases of the experiment was picture naming for a set of 60 nouns, 24 trained with errorless naming treatment (ENT), 24 trained with gestural facilitation training (GES), and 12 that served as untrained controls. Performance was tracked across 3–6 baseline sessions prior to initiation of two treatment phases, randomly counterbalanced across participants. Four individuals completed ENT followed by GES training (phonologic anomia: P806, P809, P812; semantic anomia: P804), and four completed GES followed by ENT training (phonologic anomia: P810, P814; semantic anomia: P808, P815). Results for the daily naming task are reported in Figures 2–9. Effect sizes are provided in Table 2.

ENT training results—Visual inspection of upper panels of Figures 2–9 along with consideration of effect sizes in Table 2 show that improvements were evident following ENT for naming of trained nouns in 6 of 8 participants, four with phonologic anomia and two with semantic anomia. Effect sizes were in the large range (>5.8) for two with phonologic anomia (P806, P812) and one with semantic anomia (P808). Naming changes for untrained sets during ENT were limited, however, as only two individuals with phonologic anomia (P806, P809) showed small improvements for the untrained GES and control sets. As expected, no changes were evident for gesture production during ENT (lower panels of Figures 2–9). A small positive effect size for control set gestures was noted for P808 during ENT which took place in the second phase of training, thereby likely representing a delayed effect of gesture training that had taken place in phase 1.

To determine the extent to which participants avoided error production during ENT phases of the experiment, we charted the occurrence of errors during the steps of ENT training. Figure 10 shows that, although participants were told not to respond unless they were confident that they would produce a correct response, all individuals produced errors through training sessions. The individuals with phonologic anomia tended to reduce the number of errors that occurred over time, whereas the three with semantic anomia tended to maintain a stable production of errors ever time. Despite the occurrence of errors during training, daily probes showed positive effects of ENT for naming abilities.

Gesture training results—Visual inspection of upper panels of Figures 2–9 along with effect sizes in Table 2 show that improvements were evident following GES for naming of trained nouns in 3 of 8 participants, two with phonologic anomia (P810, P812) and one with semantic anomia (P808). Effect sizes were large in all three. Changes in naming for untrained sets during GES again were limited. Only two individuals with phonologic anomia showed naming improvements for the untrained ENT (P810) and control (P806) sets.

Changes in the use of gestures following GES training can be seen in the lower panels of Figures 2–9. Six of 8 participants demonstrated clear increases in their use of gestures for trained words. The four with phonologic anomia had very large effect sizes as they went from low gesture use in baseline to high levels of accuracy following GES training. Two individuals with semantic anomia had smaller improvements in gesture use. Increased gesture use for untrained nouns, with corresponding small effect sizes, was evident in two individuals with phonologic anomia (P806, P808).

Two individuals demonstrated virtually no gesture attempts across the experiment. One of these, P814, had high levels of naming improvements, thereby precluding the need to produce gestures. The other, P815, was a woman with fluent aphasia who had no changes for verbal or gesture responses throughout the experiment.

One Month Follow-up—Follow-up data were collected for the primary outcome measure for six of eight participants; two individuals with little training effect on the daily probe measure (P804, P815) were not able to be seen for follow-up. Effect sizes were calculated, comparing performance at one month to the original baseline levels of performance to determine longer term outcomes of the experiment. Improvements in naming were maintained on the ENT trained set for 4 of 6 individuals (three small effects and one large effect), and on the GES trained set for 5 of 6 individuals (three small effects and two large effects). In addition, 3 of 6 had small improvements on the control naming set as well (all small effects). Improvements in gesture use were maintained at one month for 3 of 6 individuals for the GES trained set. One individual (P812) maintained small gesture improvements for the untrained ENT and control sets as well.

Comparison of ENT and GES results—Six of 8 participants improved in naming for ENT training (mean effect for trained set = 3.90±3.68), while three of 8 improved naming for GES training (mean effect for trained set = 4.14±6.16). Six of 8 participants improved in gesture production following GES training (mean effect for trained set = 13.94±13.48), while only one improved gesture use during ENT training (mean effect for trained set = −.91±1.5). Although the sample size is small, paired samples t-tests were calculated comparing the effect sizes for naming and gesture production in ENT and GES training. The only significant difference occurred for gesture use in the trained words (t=2.87, df=5, p=.035), as gesture use of course improved significantly more following GES than ENT. The difference did not last at follow up, however (t=1.74, df=4, p=.16). There was no significant difference in naming results for ENT versus GES for trained words (t=.13, df=7, p=.90) nor for untrained words (t=.06, df=7, p=.96). Nor was there a difference between the two treatments in naming results at follow-up (mean effect size for trained ENT naming = 3.55; mean effect size for trained GES naming = 5.99, t=1.95, df=5, p=.11).

Standardized Tests and Rating Scales

Table 3 shows results of standardized testing with the WAB-R and BNT, as well as scores on two rating scales of communication activities. Improvements greater than the standard error of measurement are highlighted in bold. Five individuals improved on the WAB-R compared to the previous level of performance, four following ENT training (P806, P810, P814, P804) and three following GES training (P806, P814, P815). Likewise, five individuals improved their scores on the BNT, two following ENT training (P806, P814) and five following GES training (P806, P812, P814, P804, P808). Overall, 4 of 5 individuals with phonologic anomia showed some improvement on standardized testing while 3 of 3 with semantic anomia also showed some improvement.

Table 3 also reports results for two rating scales of communication activities, the Communicative Effectiveness Index (CETI) and the Functional Outcome Questionnaire (FOQ). A familiar family member or caregiver was asked to complete these scales, thereby scores are missing for four of the participants whose caregivers did not respond in a timely manner. For the other four individuals, no clear patterns of improvement emerged comparing baseline to the two post-treatment phases. For P810, although some increase was evident on the FOQ after each training phase, no corresponding improvement was evident on the CETI. For P814, increases on both the FOQ and CETI were seen after phase 2 ENT training. Absence of scores in baseline makes it difficult to interpret these findings completely. Finally, P808 showed some increases on both the CETI and FOQ following phase 1 GES training; those gains were lost during phase 2.

Discussion

Comparison of Treatments

This single participant crossover design allowed us to examine patterns of response to two naming treatment protocols, errorless naming training (ENT) and gestural facilitation training (GES). Both treatments have been showed to improve naming behaviors in prior studies (Fillingham et al., 2005a, 2005b, 2006; Raymer et al., 2006; Rose et al., 2002), yet effects had never been directly compared in the same participants to determine whether one

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treatment was stronger than the other. Further, in earlier studies of gestural facilitation training, it was not clear whether the effects occurred simply due to the verbal component of training or if the gestural component was a necessary element in training. If the gesture component was an active element of training, the expectation was that the effects of GES treatment might surpass those of ENT, as the use of the gesture might enhance the training effect beyond the treatment steps that required rehearsal of the spoken word several times, steps that were somewhat parallel in both treatments. Results did not clearly support that contention.

Contrary to expectations, there appeared to be some advantage of ENT over GES in the acquisition phases of the study, as 6 of 8 participants had positive treatment response to ENT, whereas only 3 of the 8 had positive effects for GES. Keeping in mind the small sample size for this analysis, this difference was not significant when examining the effect sizes, because the effect sizes in those three individuals who improved following GES were considerably larger than those who improved in ENT. Turning to the follow-up phase of the experiment, 4 of 6 individuals maintained strong effects for the ENT trained set, and 5 of 6 maintained strong effects for the GES trained set. The fact that more participants showed a training effect for GES at follow-up than at acquisition is somewhat misleading. Three of these individuals maintained the GES treatment effect. The other two likely maintained what was an effect of generalization that had taken place during their first ENT training phase, with less effect of the GES training in phase 2. Nevertheless, these changes were maintained at one month post treatment completion.

One potential factor in these findings was the order of treatment administration. Of the six who improved following ENT, four took part in ENT during the first treatment phase. Two of those individuals showed some generalized improvements for the untrained GES set during ENT (P806, P809), thereby reducing some of the potential treatment effect in the second GES phase. Yet, three who improved following GES received GES in the second treatment phase. Therefore, order of treatment may have impacted the findings somewhat, but they are largely counterbalanced across participants and do not account for all findings.

Another consideration when comparing the two naming treatments is the extent to which there was generalization to naming of untrained words. Again, no clear difference emerged. Two individuals showed small positive generalization effects in both treatment phases, P806 and P809 during ENT and P806 and P810 during GES. At follow-up, the small positive long term outcomes for the untrained control set in four of six participants speaks to an interaction effect of the two treatments and cannot help distinguish whether one treatment was better than the other.

Finally, the results of the standardized aphasia tests and communication rating scales are an issue when comparing the impact of the two naming treatments. Again, however, no clear difference was evident. Improvements were seen on both the WAB and BNT following both treatments for at least a portion of the participants. Less strong effects were evident overall on the communication scales, and those improvements that were noted were again mixed, with some individuals improving following ENT and some improving following GES.

Clearly, there is one domain in which the GES treatment surpasses ENT in outcomes. That is in the area of gesture production. Six of eight participants in this study initiated the baseline sessions using very few gestures, despite considerable difficulty thinking of words. Very strong increases in the use of gesture followed GES training, particularly for the trained items. Three of six individuals maintained their gesture use at follow up. The extent to which gesture use facilitated communication is not clear, however, as the items in the communication rating scales tended to focus on activities in which verbal production took place and much less so on nonverbal means of communication, such as the use of gestures.

Comparison to Previous Studies

Both ENT and GES treatment approaches have been reported to increase word retrieval abilities in individuals with aphasia. The current study differs from prior studies in several important ways to expand the evidence base about the two treatments.

Looking first at ENT, prior studies have reported only picture naming outcomes for their participants with aphasia (Fillingham et al., 2005, 2006). In contrast, the current study examined several secondary outcomes measures. We also made some adjustment to the treatment protocol in using a barrier activity as a final step in training in an attempt to promote spontaneous effortful use of target words in a communication exchange like those that may take place beyond the training setting. Prior studies of ENT training have not characterized the source of lexical impairment with respect to the semantic or phonologic basis for word retrieval failure, as we did in the current study.

Our research has shown that the ENT protocol that we implemented led to improvements beyond the immediate effects for naming of trained words to other standardized aphasia tests. The increased scores on the Boston Naming Test for two individuals is consistent with improvements in picture naming in the daily probes. Improvements for four individuals on the Western Aphasia Battery, a general battery of language tasks, represented increases for repetition and naming subtests, and again are consistent with the emphasis on repetition skills that is part of the ENT protocol. The effects of ENT for communication rating scales were more variable, however, so the general impact of the treatment in daily communication activities was less clear. What still needs to be examined in greater detail is the impact of ENT for connected speech outcomes, such as conversation and narratives. We plan to investigate changes in connected speech measures in a future analysis of language samples collected as part of the current investigation.

Examining the GES outcomes of this study, we likewise had made an adjustment to the treatment protocol in comparison to our earlier studies (Raymer et al., 2006; Rodriguez et al., 2006) in an effort to facilitate greater generalized use of gestures and spoken naming. First, we included a barrier activity, as we used in ENT. Also, we extended the length of our treatment phases to 20 sessions, which is longer than the 12 session phases used in our prior studies of GES treatment. In this study we saw greater impact of GES for standardized aphasia test outcomes than in our earlier work, perhaps as an outgrowth of the extended treatment phases used in this study. However, there was a trend toward less generalized use of gesture to untrained words in this study than we have seen in our earlier work (Raymer et al., 2006), despite the inclusion of a barrier activity at the end of daily training. In our prior work, it was often observed that those individuals who did not improve in verbal naming instead showed large increases in gesture use, potentially as a compensatory means of communication. This was noted to some extent as three of five individuals who did not improve in naming showed increased gesture use (806, 809, 808). Thereby, gestures might provide a means of compensatory communication in such individuals. One potential factor which we will be exploring in future analyses is the influence of limb apraxia in limiting generalized gesture improvements in this group. Our earlier gesture treatment studies, however, have suggested that even those with severe limb apraxia are amenable to changes in gesture use with training (Raymer et al., 2006). As in ENT, we also plan further examination of GES effects for connected speech outcomes for both word retrieval analyses and gesture production. Rose and her colleagues (Rose et al., 2002; Rose & Douglas, 2008; Rose & Sussmilch, 2008) have contrasted the effects of gesture and verbal treatments in several studies. They reported that all treatments led to similar positive outcomes for picture naming, with no clear advantage to a treatment that combined lexical-semantic and gestural facilitation stages in training. The findings of the current study are quite similar in that both ENT and GES has positive effects for naming abilities, with some generalized improvements in standardized language testing. This suggests that the positive effects for naming abilities that have been reported following gestural facilitation training in past studies may in fact be a function of the verbal repetition stages of the training protocol, perhaps moreso than the gesture components of the protocol. Apart from the gesture element of the training, the ENT and GES protocols employed in our study were quite parallel. During both treatments, the picture remained present to allow semantic activation for the target lexical item. Both treatments allowed multiple opportunities for repetition and spontaneous production of target words, thereby activating lexical phonological stages of word retrieval. Thereby the similar training effects are not unexpected.

Treatment Effects for Semantic and Phonologic Anomia

The impact of the source of word retrieval failure has not been explored in earlier ENT studies. Studies of other word retrieval treatment paradigms, including gesture facilitation studies, often reportedgreater success for individuals with phonologic anomia, with more limited impact evident in those with semantic anomia (Nickels, 2001; Raymer, 2011; Raymer et al., 2006; Rose & Douglas, 2001; Rose & Sussmilch, 2008). The findings of the current study showed that individuals with both phonologic (4 of 5) and semantic (2 of 3) word retrieval failure benefited from ENT and GES treatments. ENT training had positive effects for trained words in four of five individuals with phonologic anomia and two of three semantic anomia participants. GES training improved verbal naming in two with phonologic anomia and one with semantic anomia. In contrast to earlier studies, one individual with semantic anomia (P808) responded positively as represented by large effect sizes in trained picture naming for both treatments which lasted through follow-up testing and expanded to performance on the Boston Naming Test. It is notable that P808 was younger, presented with a nonfluent pattern of transcortical motor aphasia, and was much further post stroke onset (30 months) as compared to P804 and P815, the other two participants with semantic anomia, who were considerably older, had fluent forms of aphasia, and were only 6–8 months post onset, factors that may have influenced treatment results. Likewise in our earlier work (Raymer et al., 2006), those with semantic anomia associated with fluent aphasia had limited naming outcomes associated with GES training. Despite minimal changes on the primary naming task, semantically-impaired participants P804 and P815 in this study improved on standardized aphasia testing, particularly following the first treatment phase, which was ENT for P804 and GES for P815. It was noted, however, that the only participants who showed generalized naming improvements were those with phonologic anomia (P806 and P809 during ENT, and P806 and P810 during GES). Our results suggest that those individuals with moderate phonologic or semantic anomia accompanying a nonfluent form of aphasia seem to be those who are most amenable to the naming treatments, whether ENT or GES. This again speaks to the importance of the repetition stages of the treatments that provided opportunities for retrieval and execution of phonological word forms in both training protocols.

An advantage of single participant experimental designs is that data can be analyzed for those individuals who do not seem to respond to treatment, as was the case for P814, an individual with phonologic anomia. Despite no change on the daily probe measure, P814 showed strong changes on the two standardized aphasia tests and the rating scales. Interestingly, he was the participant with the mildest form of aphasia at onset of the study, although his mild aphasia was accompanied by considerable apraxia of speech. The important observation is that a daily probe picture naming measure may not always tap into all of the changes that take place as part of a word retrieval treatment protocol. It is possible that ongoing aphasia treatment may lead to improvements in essential cognitive processes other than language, such as attention and working memory, that then impact on standardized language measures and overall communication abilities. This possibility needs to be explored in future studies.

Summary and Conclusions

The eight individuals who participated in this crossover treatment experiment showed considerable improvements on several language measures, particularly in a daily probe naming and gesture production task. These changes likely are not simply an effect of spontaneous recovery, as all participants were greater than 5 months post stroke onset. In contrast to predictions that GES might enhance the verbal outcomes of training as compared to a parallel ENT paradigm, little difference was noted in naming and verbal production outcomes between the treatments. The only clear difference between ENT and GES was in the strong gesture improvements seen following GES training, providing a potential means of compensatory communication in some individuals who did not improve verbal production. These observations are in keeping with a large word retrieval treatment literature in which many different treatment methods, both restorative and compensatory, have reported success in improving naming abilities for participants with aphasia (Raymer, 2011). Placing persons in an enriched communication environment, whether it is through the use of errorless naming, gestural facilitation, semantic-phonologic activities, or orthographic cues, enhances activation of the lexical system and increases the likelihood of future word retrieval success. The challenge for future studies is to find methods to assure that those positive changes are lasting, perhaps through the use of computers. Now that the positive effects of both ENT and GES for most individuals with aphasia have been documented in single participant designs, future studies need to apply these treatments in larger scale prospective randomized trials.

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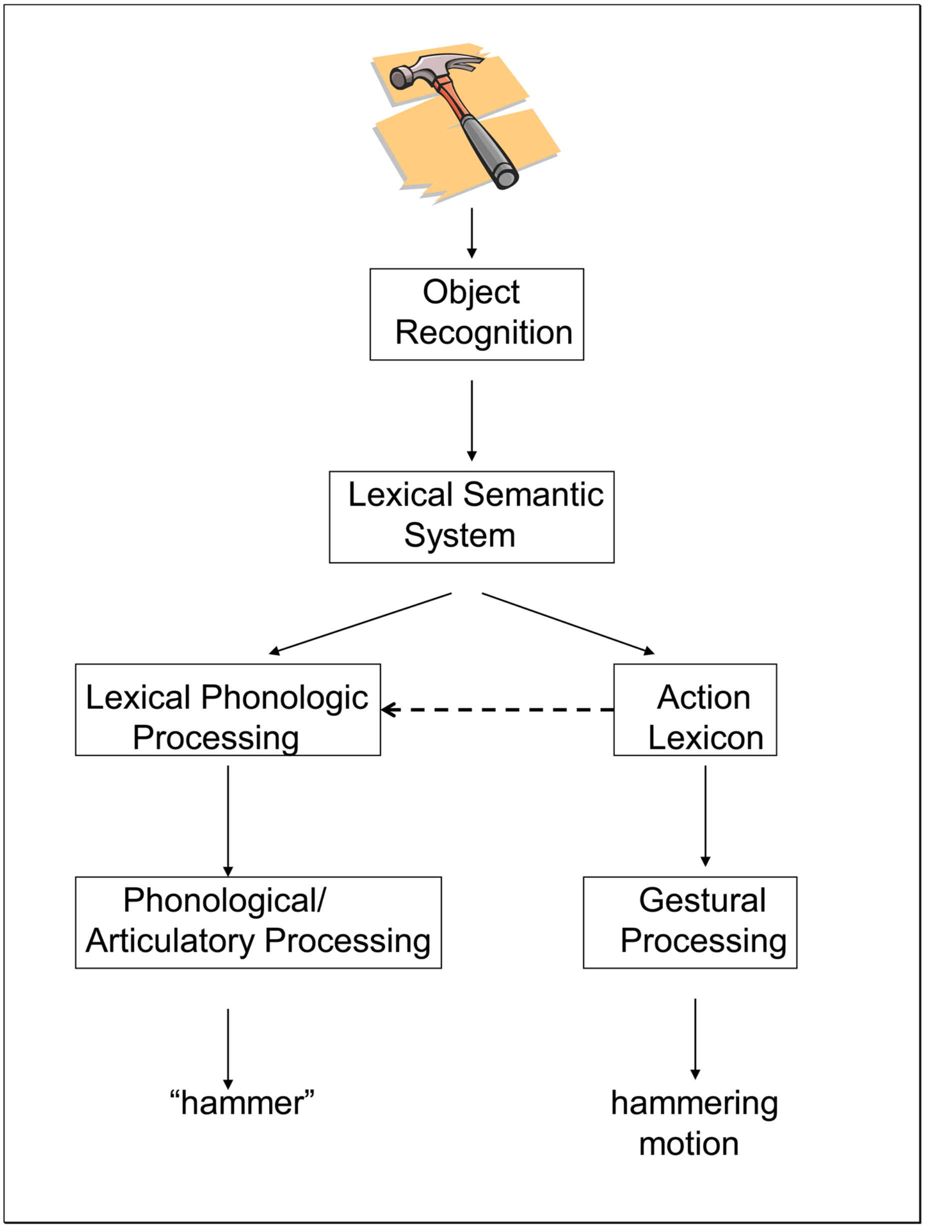

Figure 1.
Model of lexical processing.

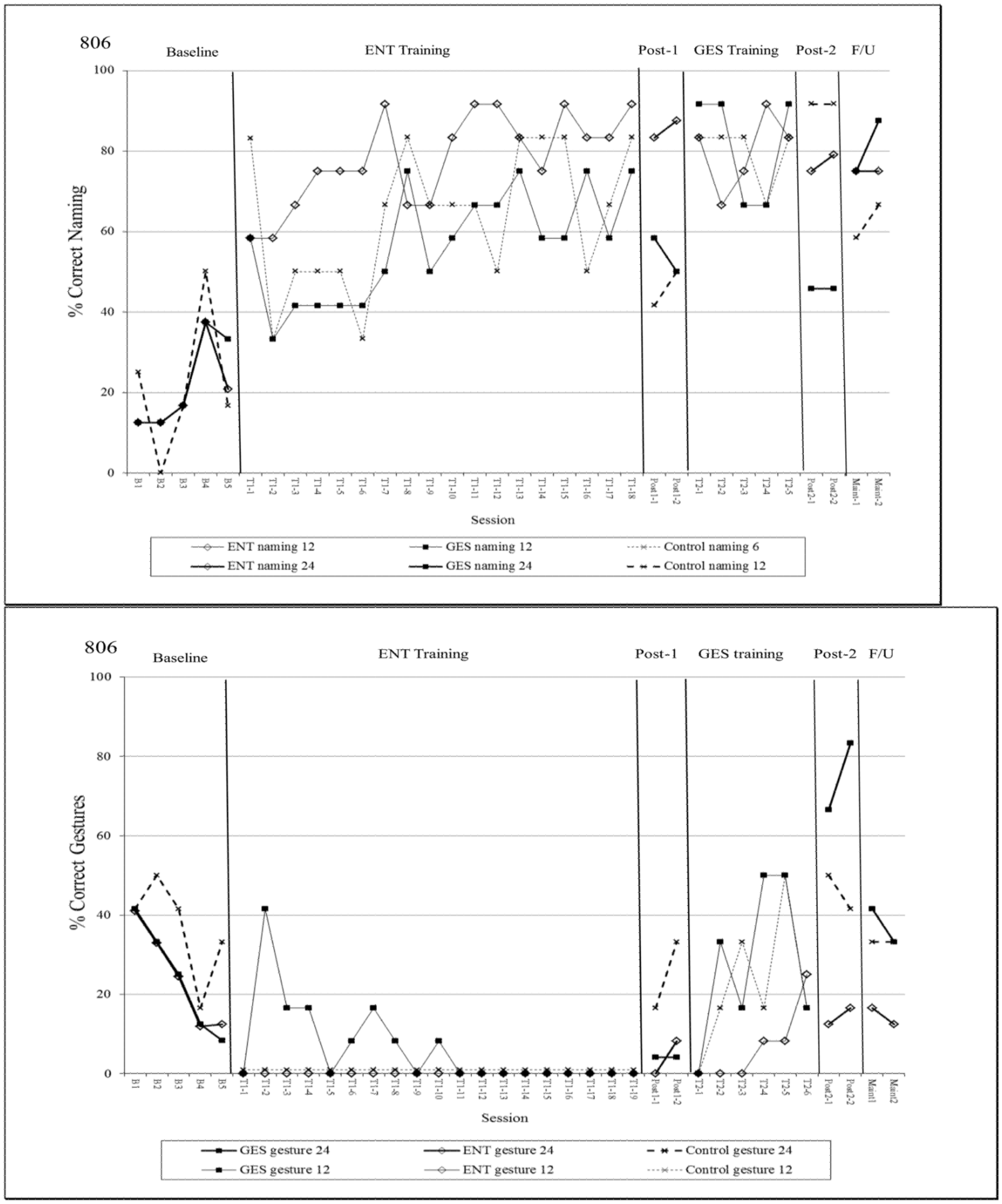

Figure 2.

Participant 806 (phonologic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

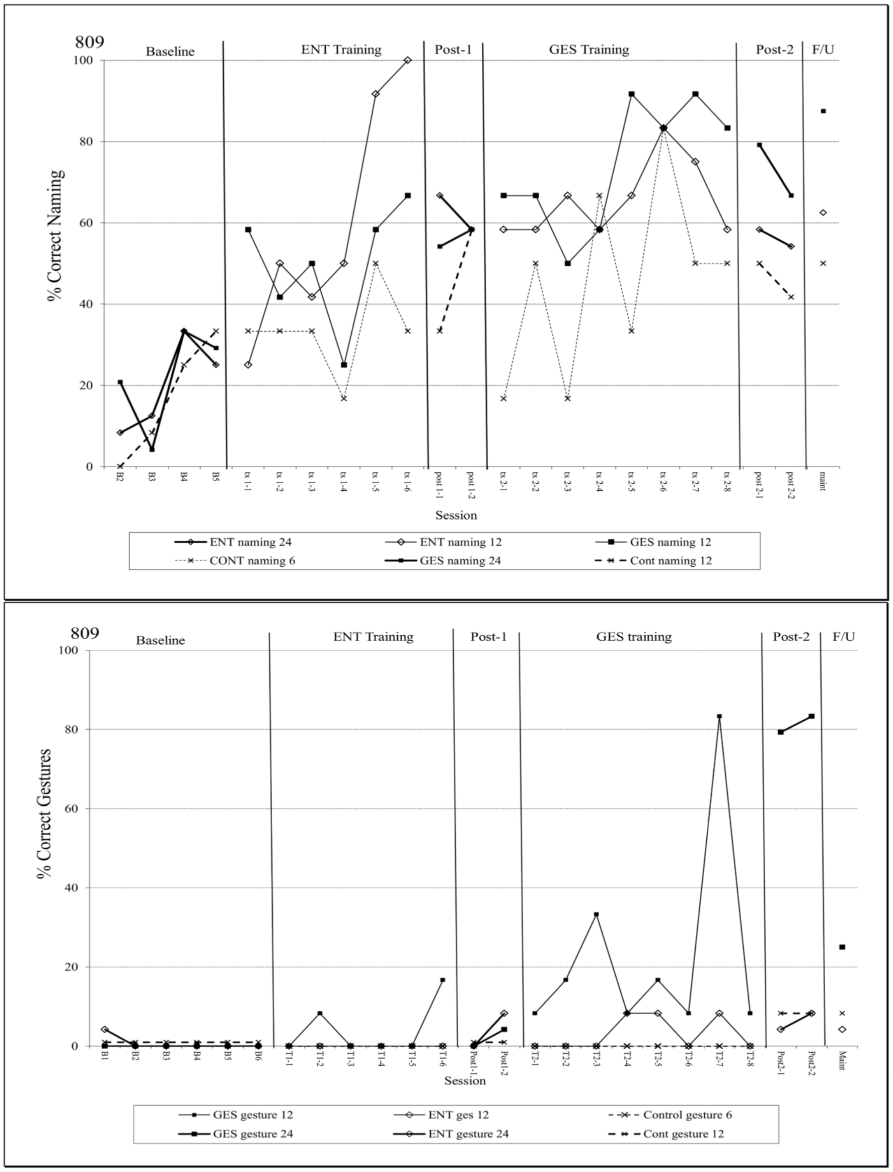

Figure 3.

Participant 809 (phonologic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

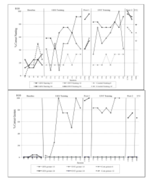

Figure 4.
Participant 810 (phonologic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

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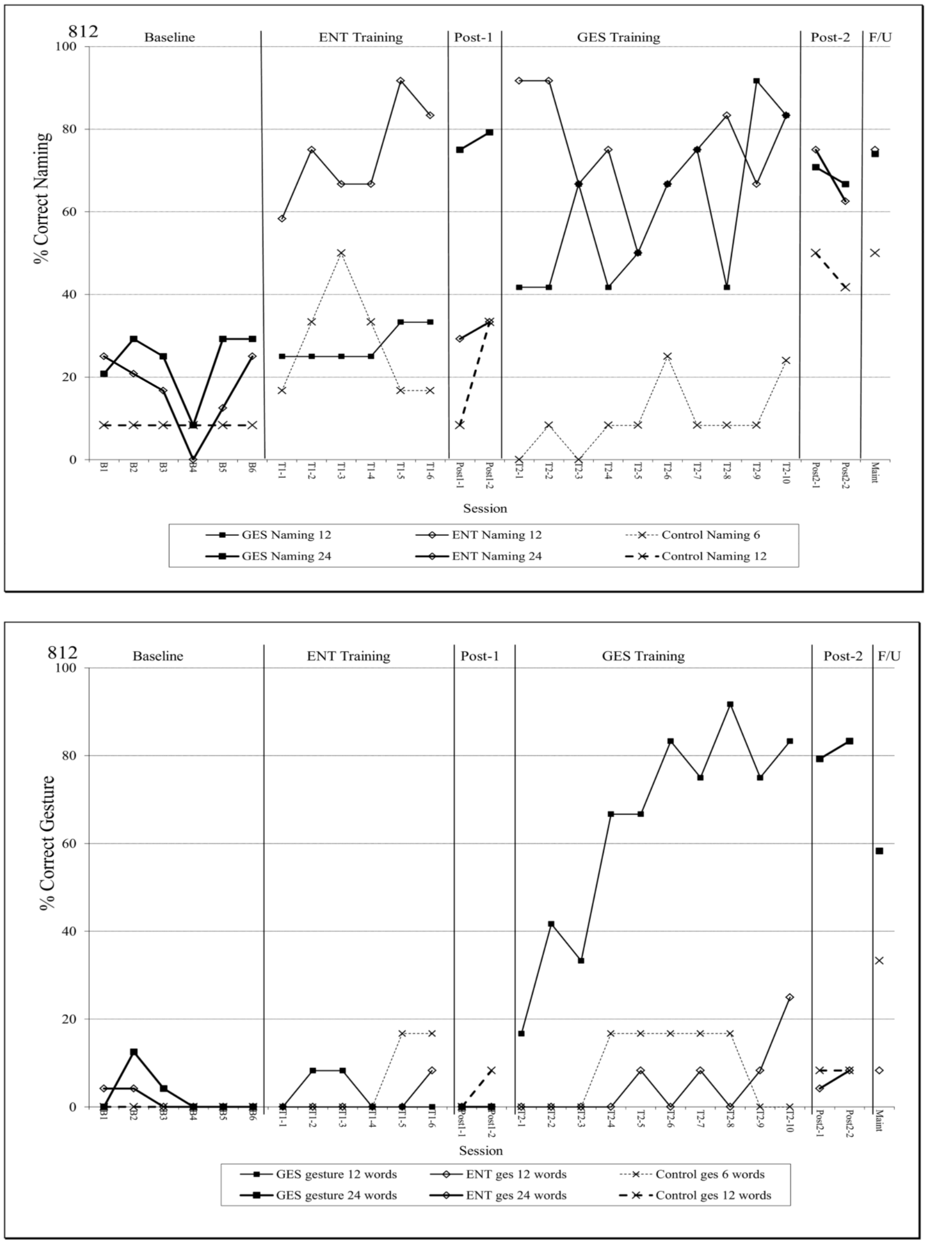

Figure 5.

Participant 812 (phonologic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

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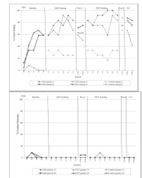

Figure 6.
Participant 814 (phonologic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

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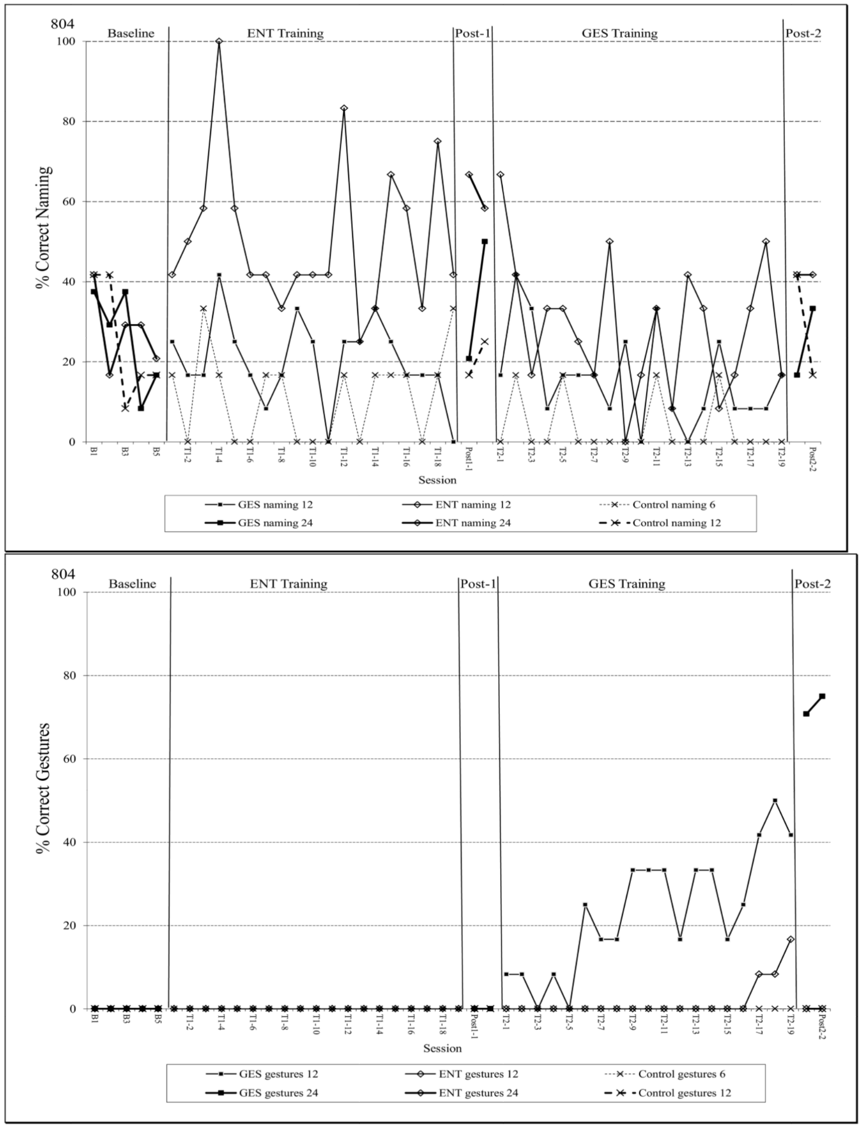

Figure 7.
Participant 804 (semantic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

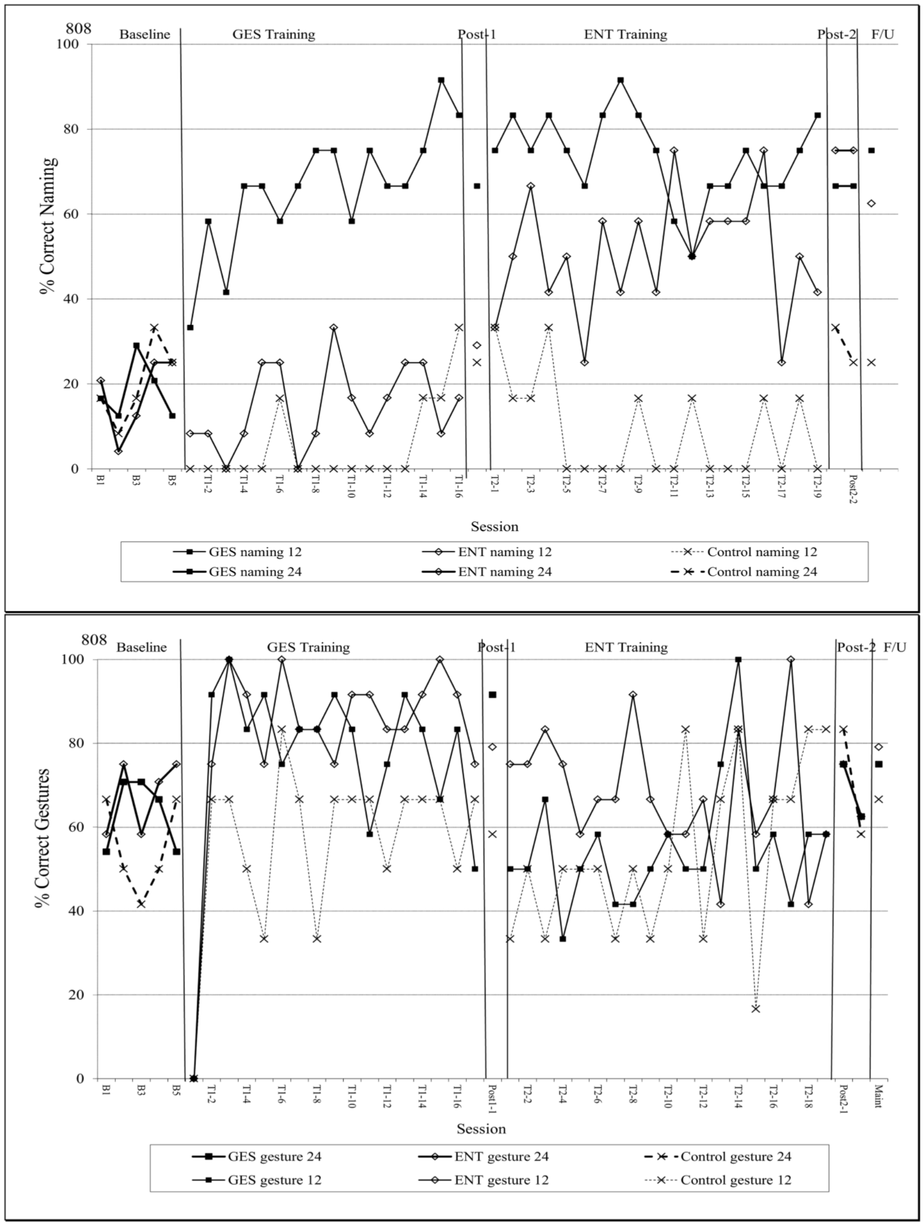

Figure 8.
Participant 808 (semantic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

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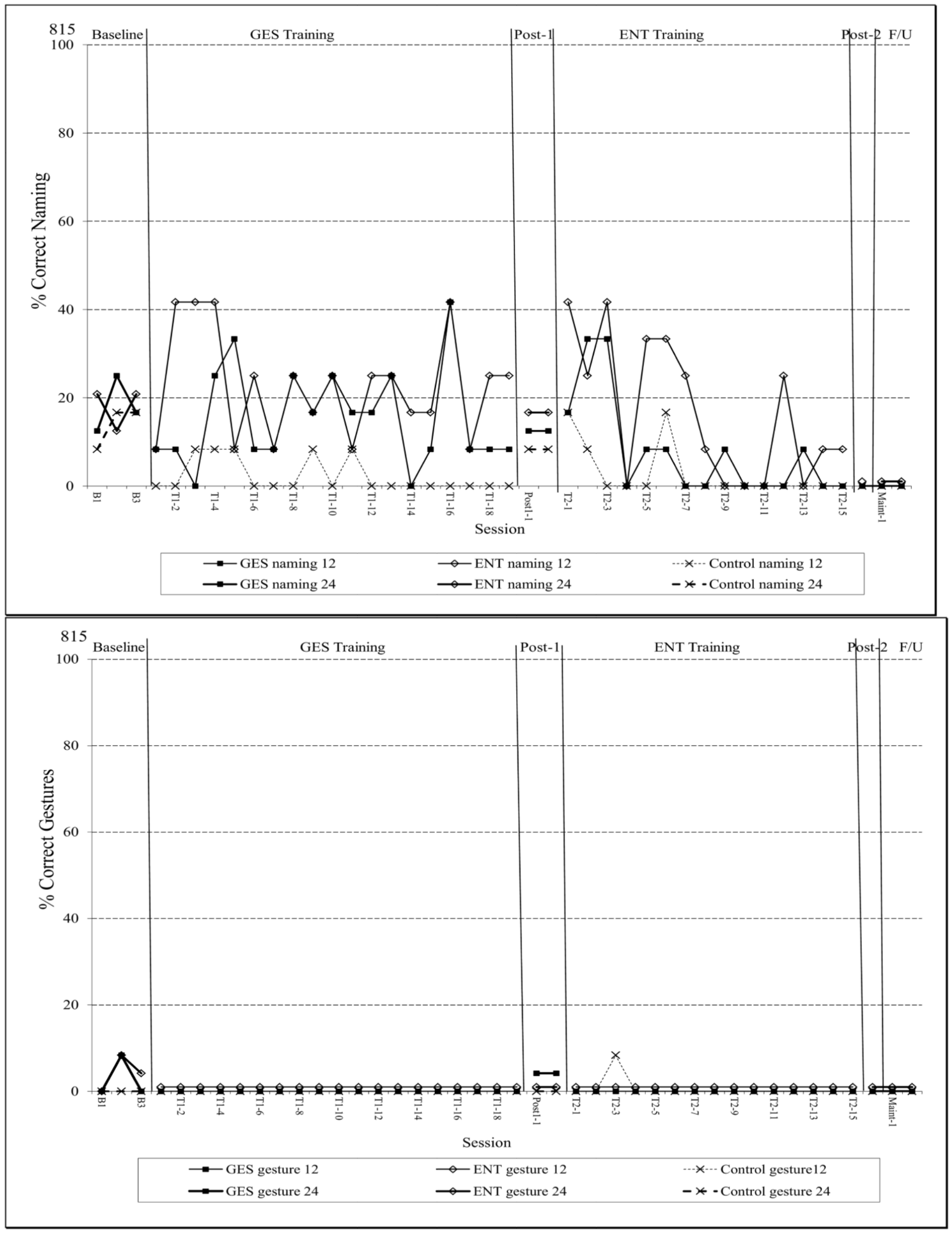

Figure 9.

Participant 815 (semantic anomia) naming (upper graph) and gesture production (lower graph) across phases of training.

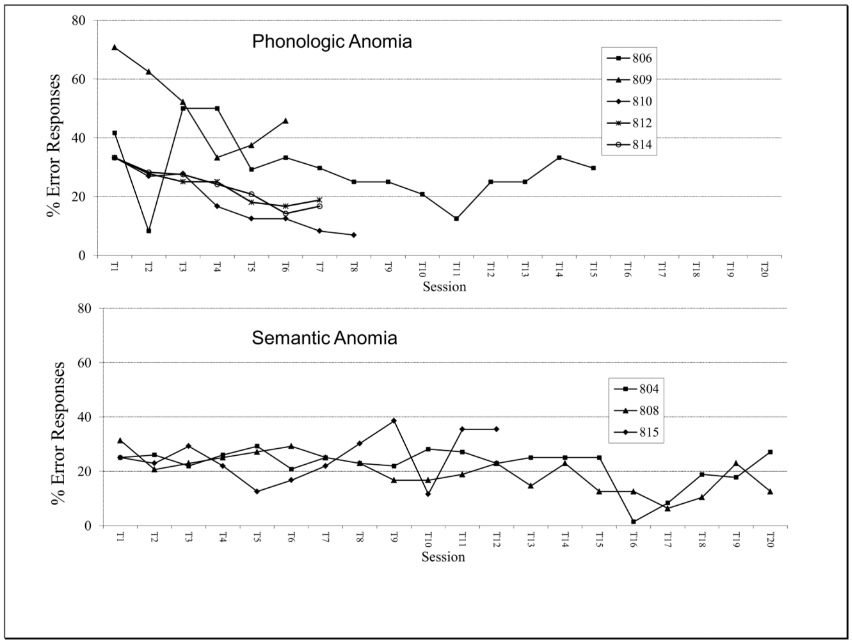

Figure 10.
Error production across sessions of ENT training.

Table 1

Demographic characteristics and preliminary aphasia testing for five individuals with phonologic anomia and three with semantic anomia

Participant	806	809	810	812	814	804	808	815
Age (yrs.)	47	40	56	54	63	78	48	79
Education (yrs.)	15	12	11	12	16	16	14	12
Gender	F	M	M	M	M	F	F	F
Time post CVA (mos.)	29	7	5	6	17	6	30	8
WAB-R Fluency	4	4	4	2	4	6	5	6
Auditory Comp.	7.6	7.65	9.45	8.75	8.65	6.25	5.3	6.5
Repetition	2.3	3.3	3.8	4.4	8.7	9.2	7.0	6.4
Naming	5.5	4.7	5.4	5.1	6	2.1	4.7	4.9
Aphasia Quotient*	52.8	49.3	55.3	56.5	66.7	61.1	54.0	59.6
BNT (n=60)*	18	10	27	18	23	11	2	8
Noun Battery % (n=60)								
Picture Naming	56.7	38.3	41.6	53.3	73.3	26.6	21.7	20.0
Sentence Completion	51.7	31.6	66.6	36.6	80	40.0	43.3	50.0
Wd/Pic Yes/No Verif.	95	93.3	98.3	91.6	93.3	51.6	41.7	71.7
Naming Impairment	Ph	Ph	Ph	Ph	Ph	Sem	Sem	Sem
Aphasia Type	Bro	Bro	Bro	Bro	TMA	TSA	TMA	Wern

Note:

*normal cut-off score on the WAB-R=93.8/100 and BNT=50/60; Ph=phonologic anomia; Sem= semantic anomia; Bro=Broca's aphasia; TMA = transcortical motor aphasia; TSA = transcortical sensory aphasia; Wern=Wernicke's aphasia

Table 2

Treatment effect sizes (d) across phases of the experiment (numbers in bold represent meaningful effect sizes; >2.5 small effect, >5.8 large effect)

	Phonologic Anomia					Semantic Anomia		
	806	**809**	**810**	**812**	**814**	**804**	**808**	**815**
ENT Phase:	1	1	2	1	2	1	2	2[#]
ENT Set Naming (tx)	**6.51**	**3.77**	**5.19**	**6.66**	.98	**3.65**	**7.86**	−3.46
GES Set Naming (untx)	**4.10**	**2.92**	0.35	.33	.11	0.74	−0.87	−1.96
Control Set Naming	2.24	2.34	1.77	1.5	.36	−0.27	0.65	−1.73
ENT Set Gestures	−.95	1.02	*	−.91	−1.12	0	−3.5	*
GES Set Gestures	−.73	1.32	−9.19	.69	−1.12	0	−2.95	*
Control Set Gestures	.10	*	*	*	*	0	**2.60**	*
GES Phase:	2	2	1	2	1	2	1	1
ENT Set Naming (untx)	−2.83	−1.03	**2.91**	−2.83	.62	−8.51	0.83	−.29
GES Set Naming (tx)	−1.41	1.64	**13.34**	**12.73**	1.73	−1.31	**7.23**	−.87
Control Set Naming	**7.78**	0	1.55	1.42	.02	−2.82	−0.35	−1.15
ENT Set Gestures (untx)	**3.18**	**3.18**	*	**11.82**	.45	0	1.85	*
GES Set Gestures (tx)	**17.70**	**33.07**	**43.96**	**25.35**	.67	**4.0**	**2.83**	*
Control Set Gestures	**3.52**	*	*	.71[#]	*	0	0.53	*
Follow-Up								
ENT Set Naming	1.25	**3.77**	**3.60**	**6.41**	1.27	NA	**4.98**	NA
GES Set Naming	**5.30**	**5.05**	**10.73**	**4.39**	2.38	NA	**8.13**	NA
Control Set Naming	**2.92**	**2.53**	2.46	**4.62**	.02	NA	0.53	NA
ENT Set Gestures	−0.81	1.02	*	**2.73**	−.67	NA	1.37	NA
GES Set Gestures	0.96	**15.87**	**29.18**	**11.02**	−.45	NA	1.3	NA
Control Set Gestures	−.26	1.79	*	**11.43**	*	NA	1.40	NA

*Not calculable because no variability and no gain;

#Shortened treatment phase; NA=Not available

Table 3

Results of standardized measures and rating scales across phases of the experiment

	Phonologic Anomia					Semantic Anomia		
	806	**809**	**810**	**812**	**814**	**804**	**808**	**815**
WAB-R AQ (max 100)								
Pre	52.8	49.3	55.3	56.5	66.7	61.1	54.0	59.6
Post 1	**60.7**	37.5	57.4	56.9	**73.7**	**66.8**	55.6	**66.7**
Post 2	**68.8**	53.6	**71.7**	57.1	**82.2**	68.5	58.8	46.5*
BNT (max 60)								
Pre	18	10	27	18	23	11	2	8
Post 1	**22**	11	12	10	**28**	13	**11**	9
Post 2	**32**	7	24	**23**	**37**	**18**	7	3
CETI								
Pre	95.3	--	75	37	--	56.29	55	67.6
Post-1	87	--	60	42.3	43.8	--	88	--
Post-2	92.5	--	70.6	39.6	**73.3**	51.63	62	39.3
FOQ								
Pre	4.09	--	2.31	2.65	--	3.12	3.44	2.23
Post-1	4.75	--	2.96	3.15	3.62	--	4.65	--
Post-2	4.56	--	3.71	3.25	3.87	3.65	3.9	2.53