Introduction

Intensive aphasia treatment has been employed with equivocal results likely due to variability in the severity of participants as well as in the parameters that comprise intensity (e.g., session duration). Constraint Induced Language Therapy (CILT; Pulvermüller et al., 2001) is an intensive aphasia therapy that has been replicated successfully and also tends to use similar dosage parameters across replication studies (e.g., Barthel, et al, 2008; Maher, 2006). Meinzer and colleagues (2008; 2007) found that it was their most severely affected participants who tended to benefit most from treatment of CILT, positing that those who had withdrawn from verbal communication the most were those most likely to benefit from the forced use inherent to CILT. It is also possible that since CILT and associated treatment materials was designed for more impaired participants; those more mildly affected may have been insufficiently challenged during the treatment period. If so, it follows that that neural change would be less likely.

The present study employed a multiple probe technique (McReynolds & Kearns, 1983) in which CILT was delivered at a dosage of three hours per day for twenty days. A hierarchy of complex stimuli was created to pose adequate challenge for two individuals with mild aphasia. Discourse analysis and naming response time were used to quantify changes in language efficiency. In addition, fMRI scanning was performed at four time points throughout the treatment process in order to compare potential language changes to changes in neural activation patterns. These results are expected to add to the limited fMRI data currently available for intensive aphasia treatment.

Methods

Participants

The two participants were recruited from a university-based aphasia group. They were both right handed males, more than five years post left CVA. Both participants were classified as having mild aphasia with scores on the Western Aphasia Battery Aphasia Quotient (WAB AQ; Kertesz, 1982) exceeding 86. While taking part in the study, individuals did not participate in any other form of language rehabilitation.

Intervention

CILT was administered according to the protocol described by Maher and colleagues (2006) and modified by the authors to include additional treatment levels requiring production of increasing lexical complexity. Three-hour sessions were conducted five days a week, for four weeks for a total of 60 hours of treatment. The few studies that report follow-up data after CILT, tend to report additional increases in language production four weeks post the “standard” two week treatment dosage (e.g.,Maher et al., 2006; Mozeiko et al., 2011; Szaflarski et al., 2008). In order to a) capitalize on the probable continued neural change occurring post treatment and b) provide a time-off from a very rigorous treatment schedule, a five week break was incorporated after the first 30 hours of treatment. Participants were required to produce and respond to verbal

communication with the verbal modality only. Participants were instructed on linguistic targets prior to each session and the clinician provided cueing as necessary.

Assessments

Standardized tests, treatment and generalization probes and fMRI scans were administered at four time points: pre-treatment, mid-treatment, post-treatment and at an eight week follow-up.

Standardized assessments included the WAB AQ, the Boston Naming Test (BNT; Kaplan et al., 1983) and the Computerized Revised Token Test (CRTT; McNeil et al., 2008).

Probes of treatment and generalization were administered after every six hours of treatment. These assessed performance on the trained materials, equivalent untrained materials and maintenance of mastered levels. To assess generalization of treatment to connected speech, picture descriptions were elicited. Discourse probes were analyzed for Correct Information Units (CIUs, Nicholas & Brookshire, 1993) and then the proportion of CIUs to total words and CIUs/minute were calculated to measure efficiency of verbal production.

FMRI scans were conducted in order to compare corresponding language changes over time. Temporal sparse sampling was used to allow monitoring of overt responses in the scanner. Responses consisted of the naming of previously established "hard" and "easy" trained and untrained stimuli.

Results

Standardized test measures

Despite high pre-treatment scores on the WAB AQ, participants increased their scores by 8 and 4 points respectively and one participant increased his BNT performance by 10%. No change was seen on the CRTT (see Table 1).

Probes of Treatment and Generalization

Both participants demonstrated mastery (90% accuracy) at treatment levels 4 and 5 by the end of the first two weeks of treatment and of 6-7 after the second treatment session (see Figures 1 and 2). One participant also mastered level 8.

Probes of generalization to discourse showed moderate increases in slope (see Figures 3 and 4). Small effect sizes were calculated from the first treatment session and moderate-large effects for the second treatment session using procedures as outlined by Beeson and Robey (2006).

Neuroimaging

Robust differences were seen in the hard vs. easy condition for both participants (see Figs. 5 and 6) and the pre-treatment vs. post-treatment condition. Less change was observable in the trained vs. untrained condition. In order to qualitatively compare activation across scans for each participant, an anatomical region of interest was used. There was greater activation change in the right hemisphere inferior frontal gyrus than in the left for both participants (see Figs. 7-10). Maximum activation for both participants was observed after the second treatment session.

Discussion

Behavioral results

- Participants with mild aphasia appear to benefit from a double dose of CILT; however standardized measures are not sensitive enough to capture the magnitude of these changes.
- Near equivalent gains on probes of untreated materials may be an indicator that neural change has taken place.
- Greater gains on discourse probes were observed in the second treatment session during which more complex stimuli were trained.

fMRI results

- Increased activation following the second treatment session indicates that neuroplastic change continues to occur in mild, chronic aphasia.
- The greater increase in right homologue activation compared to left perilesional activation confirm the few studies reporting positive language gains that correspond with increased RH following CILT (e.g., Richter, Miltner, & Straube, 2008).
- Individual differences in lesion location and extent might reflect the difference in spared tissue.

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Table 1. Results of standardized language assessment and change in scores, pre-treatment, mid-treatment, immediately post and eight weeks post tx.

	Western Aphasia Battery- AQ				Computerized Revised Token Test				Boston Naming Test		
ID	**Pre-tx**	**Post-tx 1**	**Post-tx 2**	**Follow-up**	**Pre-tx**	**Post-tx 1**	**Post-tx 2**	**Follow-up**	**Pre-tx**	**Post-tx 2**	**Follow-up**
MB1	87.6	93.8	95.8	93.9	71.1%	83.2%	82.5%	79.5%	77%	87%	90%
MM2	95	97.6	99.6	97.8	92.8%	91.1%	93.6%	91.%%	92%	93%	97%

Figure 1. MM2 Percent Accuracy on Treatment Levels 4-8

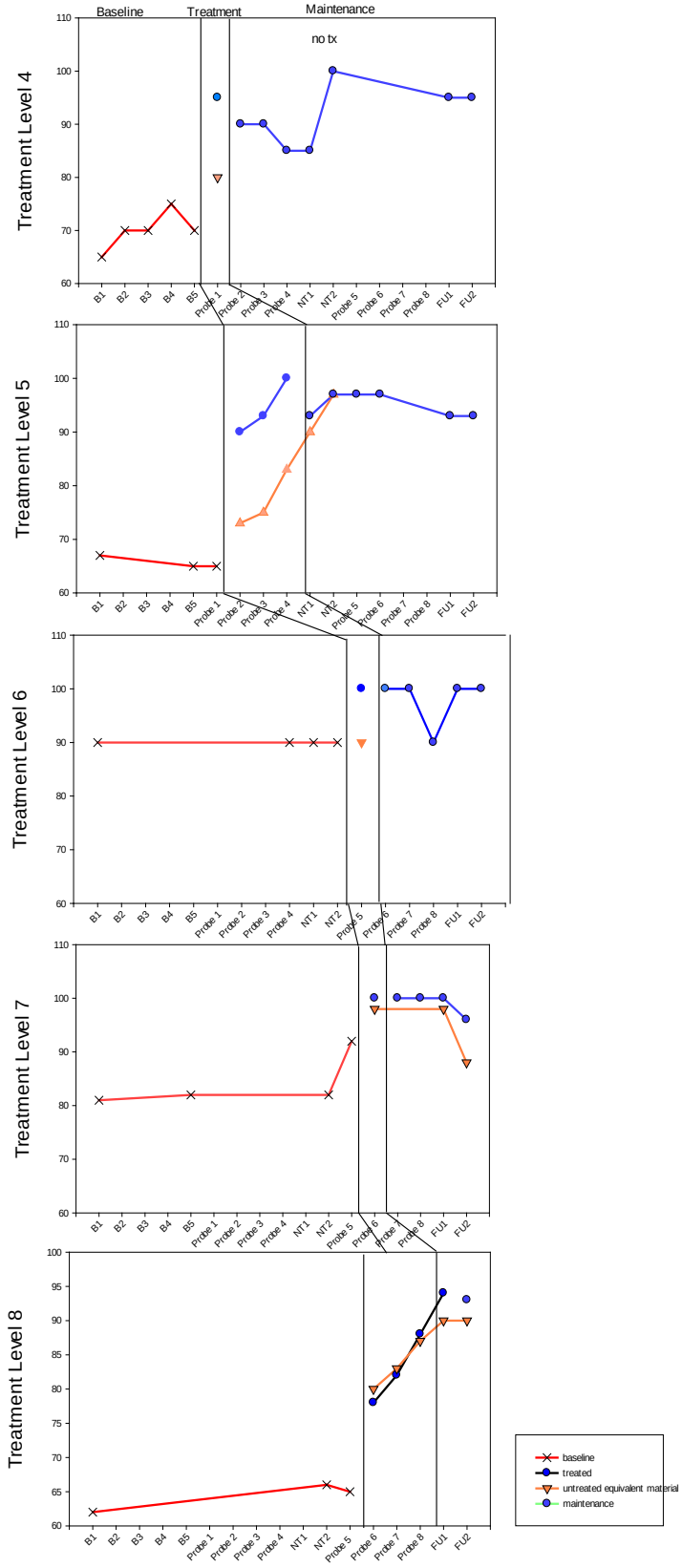
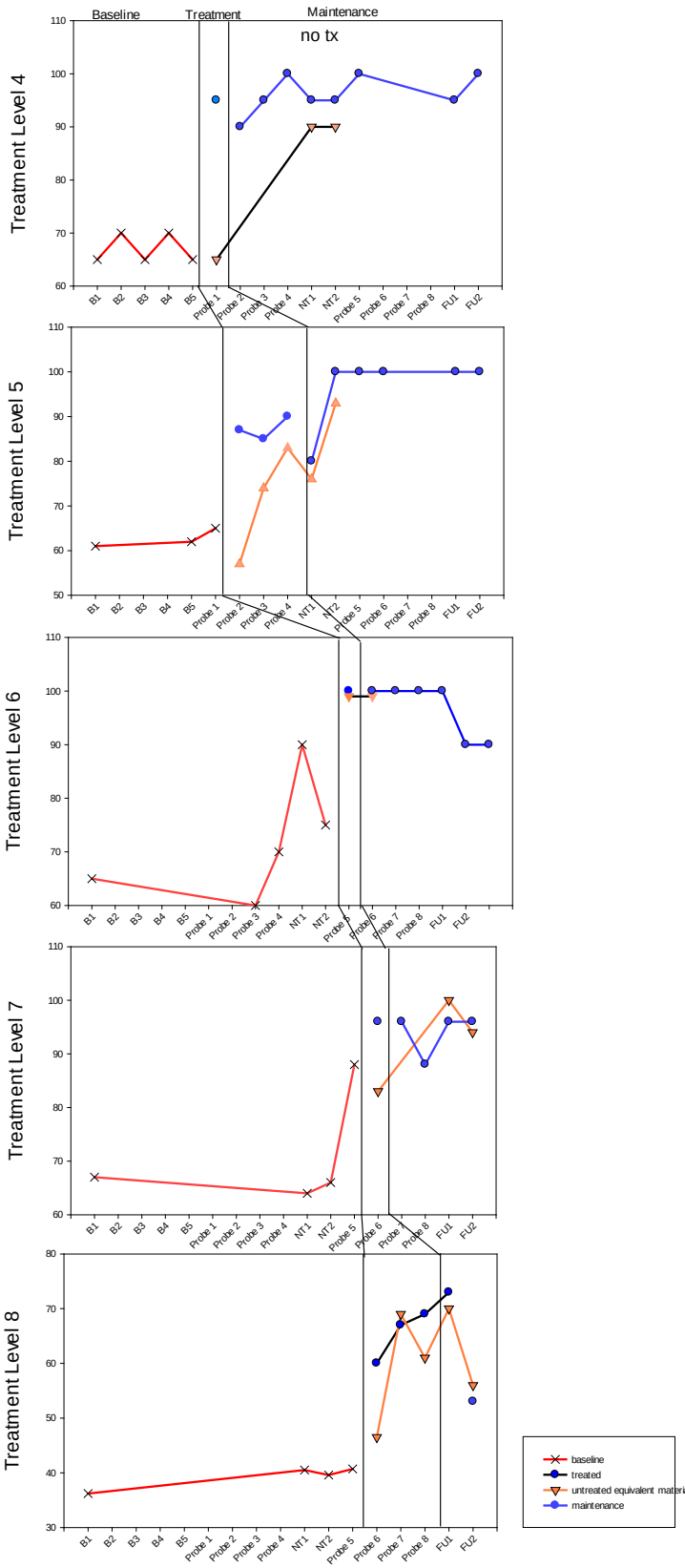


Figure 2. MB1 Percent Accuracy on Treatment Levels 4-8



Figs 1-2. B1-5-baseline probes, Probes 1-8-treatment probes; NT1-immediate post first treatment session; NT2- immediate pre second treatment session; FU1-immediate post second treatment session; FU2- eight weeks post treatment.

Figure 3. MM2- Narrative Discourse Probes

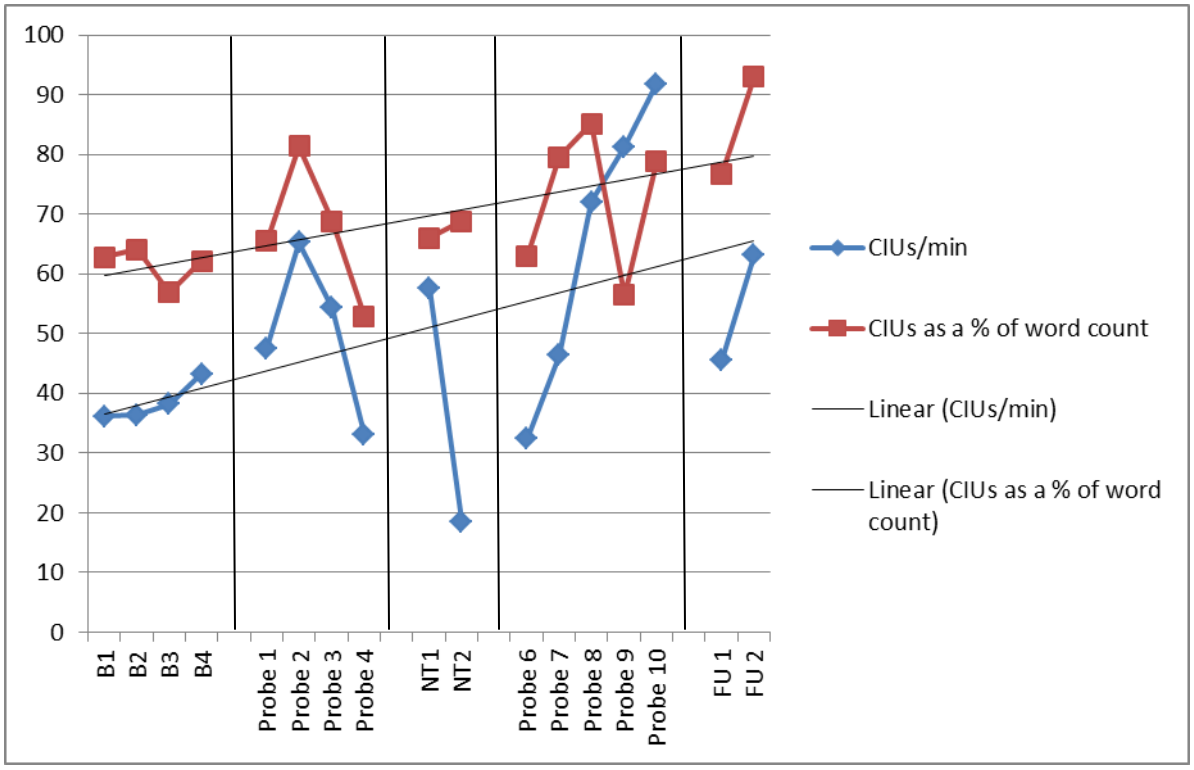
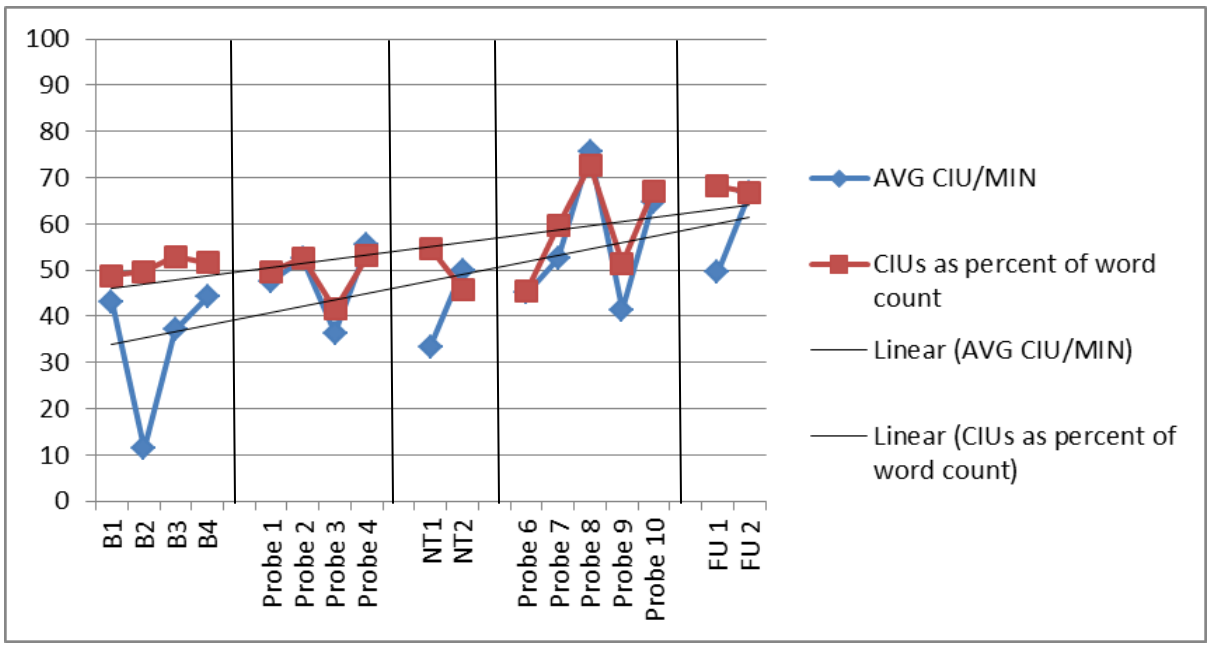


Figure 4. MB1- Narrative Discourse Probes



Figs 3-4. B1-4-baseline probes, Probes 1-8-treatment probes; NT1-immediate post first treatment session; NT2- immediate pre second treatment session; FU1-immediate post second treatment session; FU2- eight weeks post treatment.

Figure 5. MB1-hard-easy contrast for all scans.

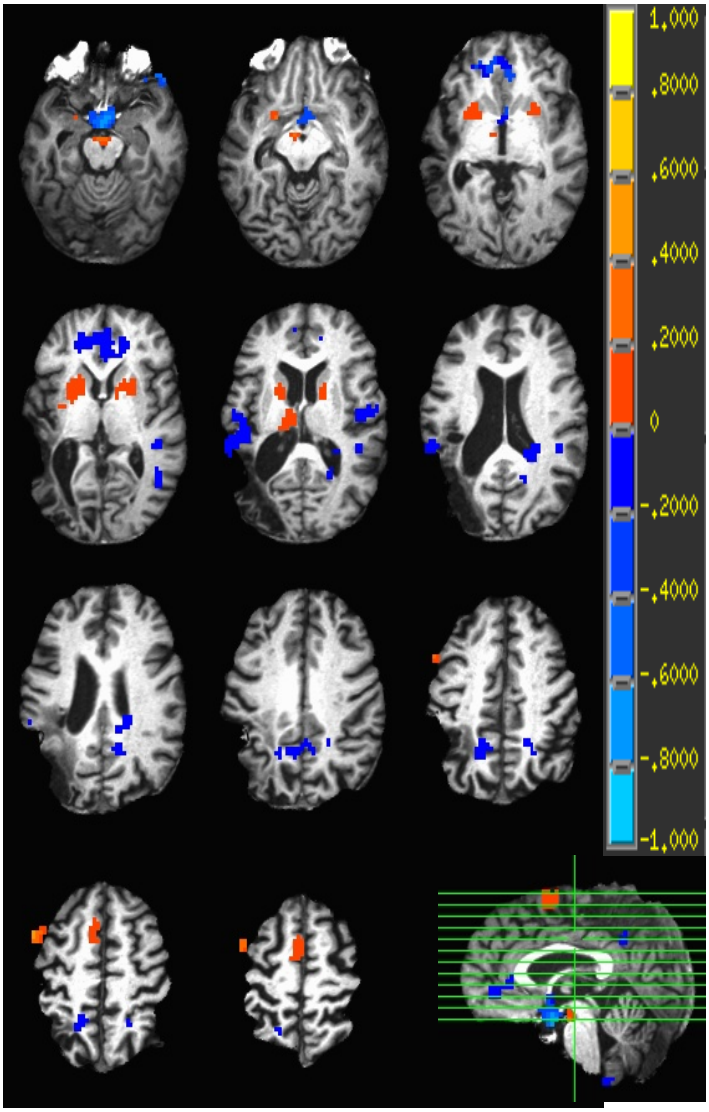


Figure 6. MM2-hard-easy contrast for all scans.

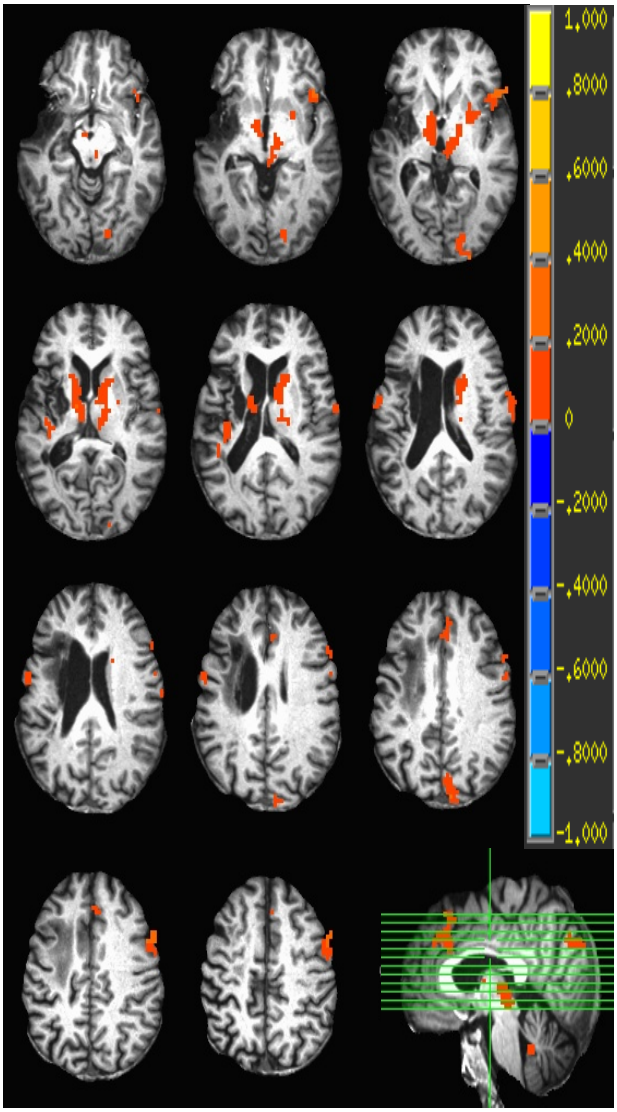


Figure 7. MB1-RIFG activation

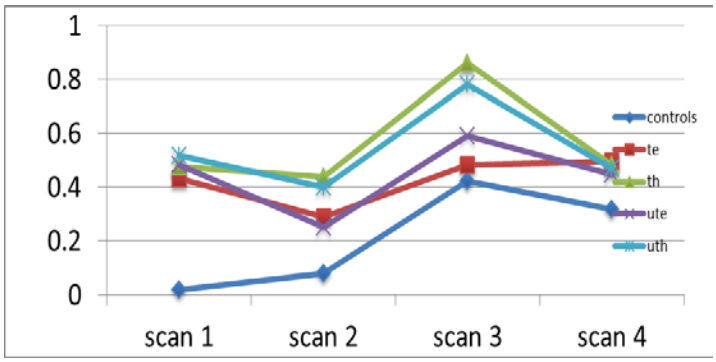


Figure 8. MB1-LIFG activation

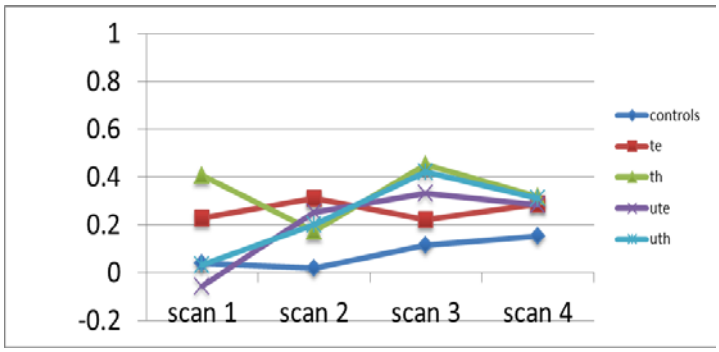


Figure 9. MM2-RIFG activation

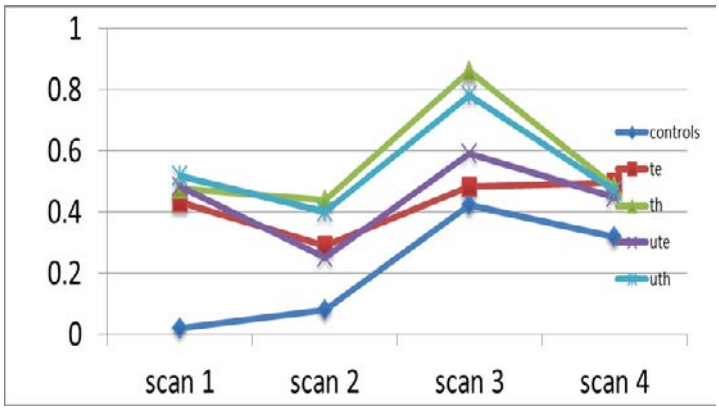


Figure 10. MM2-LIFG activation