Treatment and Generalization of Functional Category Production in Agrammatic Aphasia

Introduction

Recent research focused on treatment of agrammatism suggests that training more complex linguistic structures generalizes to less complex, but related, structures. For example, several studies have shown that training more complex sentences with 'wh' movement such as object clefts (e.g. *It was the artist who the thief chased*) results in generalization to less complex 'wh' movement structures such as object-extracted wh-questions (*Who did the thief chase?*), but not to 'NP' movement structures (e.g., passive voice). This complexity effect has recently been formalized as the Complexity Account of Treatment Efficacy (CATE; Thompson et al., 2003) as follows:

> "Training complex structures results in generalization to less complex structures when untreated structures encompass processes relevant to (i.e., are in a subset relation to) treated ones." (p. 602).

Notably, CATE has been tested only with noncanonical sentence structures, which are particularly difficult for agrammatic speakers. However, such patients often demonstrate impairments in producing morpho-syntactic elements found in canonical sentences (Benedet et al., 1998), impairments for which few treatments have been developed or experimentally tested. We, therefore, extend our treatment work to the study of functional morphology. Specifically we examined patterns of acquisition and generalization of the following elements in canonical sentences:

1. Complementizers: They know <u>that</u> the boy is tickling the girl.
2. Past tense inflections: The boy tickl<u>ed</u> the girl.
3. Third person present agreement inflection: The boy tickle<u>s</u> the girl.

Based on CATE, we predicted no generalization from training complementizers (1) to tense (2) or agreement (3) or from training (2) or (3) to (1). While all three are considered members of the same category, complementizers and tense/agreement are not in a subset relation to one another. Based on the location of functional categories in the syntactic tree, complementizers are elements within the Complementizer Phrase (CP); whereas, both tense and agreement are elements within the inflection phrase (IP). However, we predicted generalization from tense (2) to agreement and vice versa, since the two structures are related by their status within IP. However, we note that the location of tense and agreement is controversial. On some accounts, IP is "split" with separate nodes for tense and agreement and the tense node above agreement (Pollock 1989). However, others split IP into nodes with tense below agreement (Chomsky 1992; Ouhalla 1990). Still others (Bobaljik & Thrainsson 1998) suggest that IP is unsplit and tense and agreement are under I (see Figure 1). Thus, the complexity account predicts a relationship between tense and agreement morphology, but makes no specific predictions regarding the direction of generalization.

Notably, however, the Tree Pruning Hypothesis (TPH; Friedmann & Grodzinsky, 1997) predicts a different learning pattern reflecting the hierarchial structure of the syntactic tree, i.e. training elements associated with higher nodes in the tree should generalize to those associated with lower nodes, regardless of their status within CP or IP. (See Figure 2.) The TPH would thus predict that training items within CP (i.e.,

complementizers) would result in generalization to elements associated with IP (e.g., tense). In addition, training elements associated with the Tense Phrase (TP; tense inflections) would improve production of those in the Agreement Phrase (AgrP; agreement).

The present study was designed to examine the generalization effects of functional category treatment and to evaluate these patterns with regard to CATE and the TPH.

Method

Participants

Nine individuals diagnosed with agrammatic aphasia participated in this study[1]. All were premorbidly right-handed, monolingual native English speakers, had documented evidence of left hemisphere stroke, and were at least three months post onset. Participants were between 36-68 years old, and had between 12-20 years of education. The diagnosis of agrammatism was based on standardized testing, performance on the Northwestern Assessment of Verbs and Sentences (NAVS), and spontaneous speech production patterns.

Stimuli

Twenty transitive verbs, controlled for frequency, number of syllables, phonetic complexity, and pictureability were selected and placed in semantically reversible sentence frames of each type with animate agents and themes, for a total of 60 items. Artist drawn pictures were developed for each.

[1] Post-treatment testing for three participants is currently underway.

Design

A single subject multiple baseline design across behaviors and participants was used. The length of the baseline phase was systematically varied across participants and ranged from 2-6 sessions. Baseline probes were also administered prior to each treatment session to assess performance on the target form *and* to assess generalization to the two untreated forms. Four participants were trained initially on production of complementizer sentences, and then on verb inflection sentences (either present or past tense forms). The remaining five participants were trained first to produce verb inflection sentences (either present or past tense forms), and then complementizer sentences.

Prior to and following treatment the Western Aphasia Battery (WAB; Kertesz, 1982) and the Verb Inflection Test (VIT; Bastiaanse & Thompson, unpublished) were administered. In addition, neuroimaging (fMRI) tasks were developed to examine pre-post treatment neural patterns associated with production of the morpho-syntactic structures targeted for intervention.

Treatment

During each treatment session participants were asked to produce 15 target sentences (complementizer, past tense inflected or agreement inflected sentences). Training included the following steps: (a) thematic role training with line drawings, (b) placement of written sentence constituent cards in their surface structure position, (c) reading target sentence, (d) reassembly of scrambled written sentence constituent cards, and (d) re-reading sentences.

Data Analysis

Responses to baseline and treatment probes were graphically displayed for each participant across phases of the study with celeration lines computed for each phase using a split middle technique (Kazdin, 1984). To index effect size an *f*-statistic was computed for each category and interpreted using guidelines suggested by Cohen (1988). Changes in performance on the WAB and VIT data were computed using a t-test (for dependent means). FMRI data were analyzed using SPM-2.

Results

Response to Treatment. All participants showed improved performance on trained forms following relatively stable baselines. However, participants trained on complementizers showed no generalization to tense or agreement; nor did those trained on tense or agreement show change in production of complementizers. Within IP structures, three generalization patterns were noted: (a) tense generalized to agreement; (b) agreement generalized to tense, and (c) no generalization was observed from tense to agreement or from agreement to tense (see Figure 3).

Pre-Post Treatment Measures. Pre-post data from the WAB and VIT are shown in Table 1. As can be seen improved performance was noted from pre- to post treatment on all measures. Pre-post treatment fMRI data for three (of nine) participants[2] were collected and analyzed, with results showing a general reduction in activation in post-treatment as compared to pre-treatment scans, however the locus of significant activation differed across participants. (See Figure 4 for the results from one participant in the verb inflection production task.)

Discussion

The data from this study provide support for theories of syntax that argue for distinctions between CP and IP structures (Chomsky 1986; Cinque 1999). They also provide support for Bobalijk & Thrainsson's (1998) Unsplit IP hypothesis, which asserts that both agreement and tense occupy the same node, under I. With regard to theories of language breakdown and recovery, the lack of generalization from CP to IP structures, and vice versa, support CATE; however, they are not in line with predictions based on the TPH. The noted generalization patterns within IP structures suggest a functional relationship between these elements, however, a complexity hierarchy was not revealed by our findings. The theoretical and clinical implications of these findings will be discussed.

References

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Bobaljik, D.B. & Thráinsson, H. (1998). Two heads aren't always better than one. *Syntax, 1* (1): 37-71.

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[2] FMRI testing was not undertaken for six of the participants for medical (n=3) or time/travel issues.

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Table 1. Pre-post scores derived from administration of the Western Aphasia Battery (WAB) and Verb Inflection Test (VIT).

	Pre-treatment*	Post-treatment*
WAB AQ	77.4	80.6
VIT		
Agreement	20	33.1
Tense	27.6	53.3
Aspect	86.3	84.5
Infinitive	80	82.2
TOTAL	53.475	63.275

*Data for six participants only. Post-testing for the remaining three participants is currently underway. Statistical analyses will be done once post-testing is complete.

Figure 1. Syntactic tree showing nodes for complementizers and tense/agreement. Complementizers occupy the head of CP (COMP); tense/agreement occupy the head of IP (INFL).

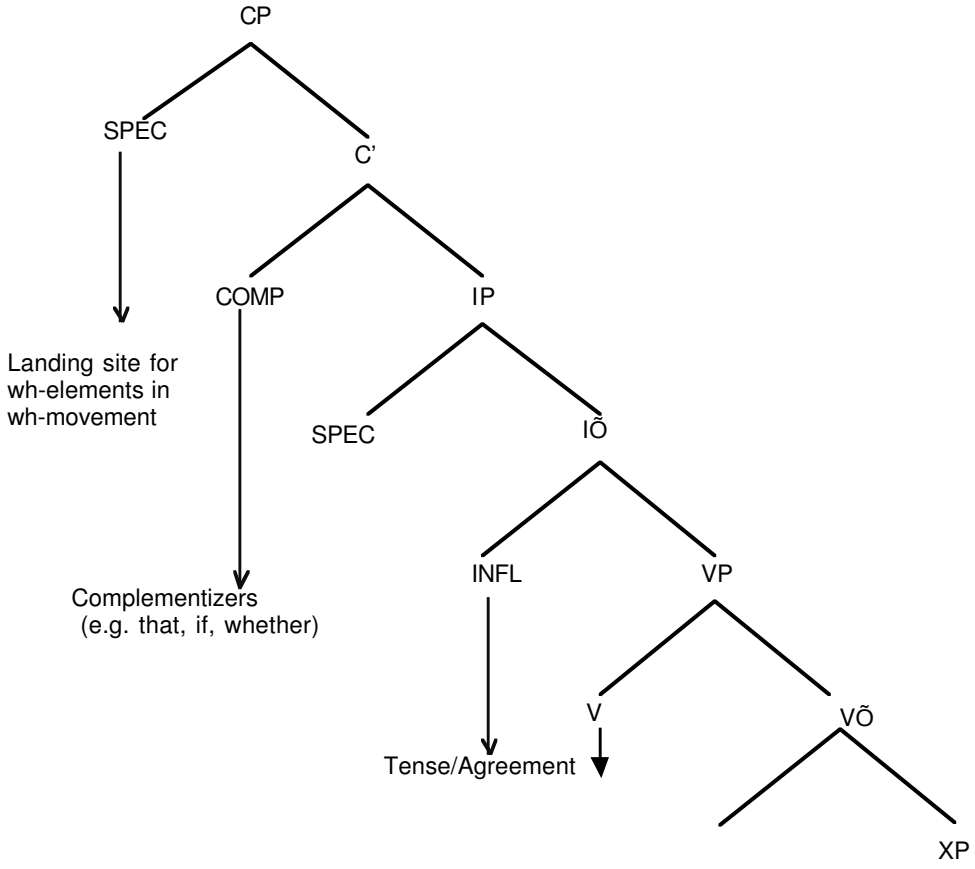

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Figure 2. Hierarchial functional category production deficit patterns hypothesized by the Tree Pruning Hypothesis (Friedmann & Grodzinsky, 1997, 2001, 2002).

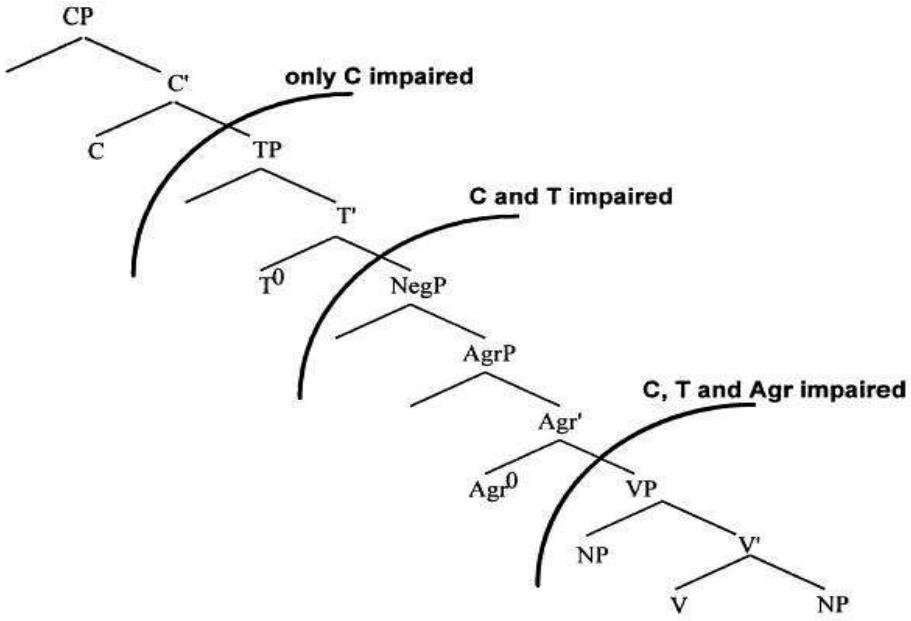
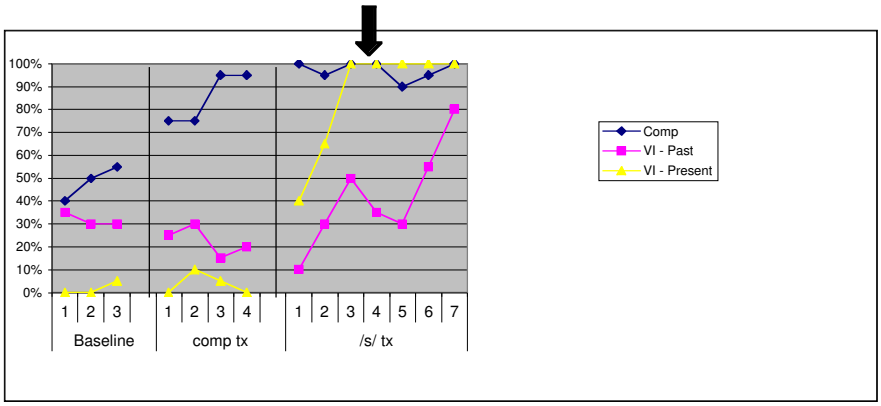
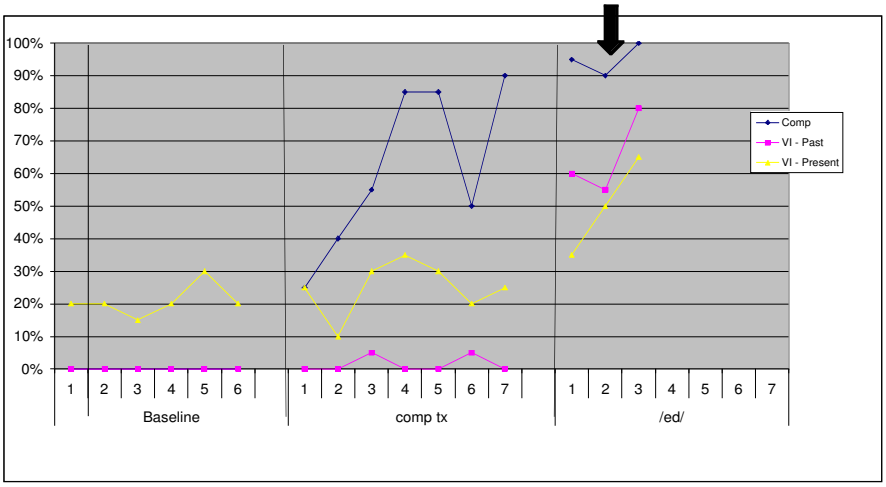


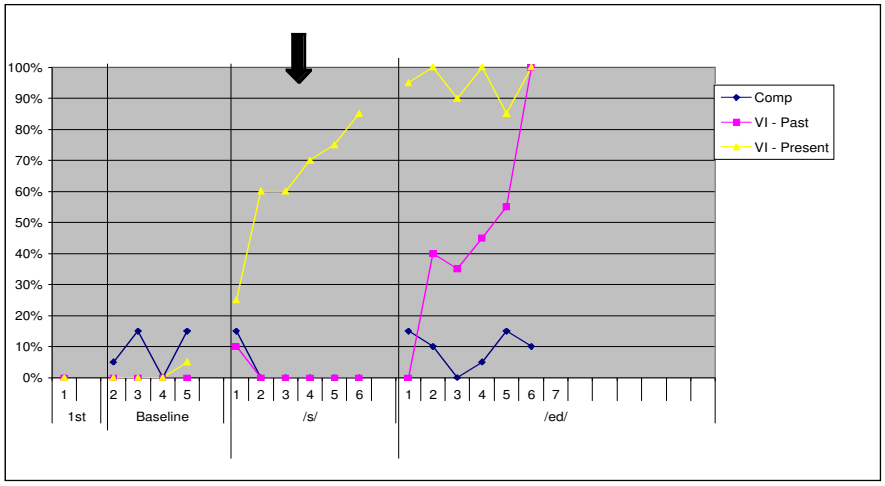
Figure 3. Treatment data from four participants showing three patterns of generalization between tense and agreement. A: agreement (present) generalized to tense; B: tense generalized to agreement; C: no generalization from tense to agreement or agreement to tense.



Pattern A



Pattern B



Pattern C

Figure 4. Activation patterns seen for agreement and tense as compared to verb stem production from pre-treatment to post-treatment scans for one participant.