A comparison of two theoretically driven treatments for verb inflection deficits in aphasia

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ABSTRACT

Errors in the production of verb inflections, especially tense inflections, are pervasive in agrammatic Broca’s aphasia (“The boy eat”). The neurolinguistic underpinnings of these errors are debated. One group of theories attributes verb inflection errors to disruptions in encoding the verb’s morphophonological form, resulting from either a general phonological deficit or a morphological affixation impairment. A second group of theories attribute verb inflection errors to disruptions that arise during sentence formulation, either for syntactic reasons or due to impairments in making fine semantic distinctions between inflectional variants of a verb (+PAST → ated; +FUTURE → will eat, walk). These morphophonological and morphosemantic accounts were evaluated by comparing the efficacy of two treatment protocols that exclusively targeted either morphophonological operations or morphosemantic distinctions. Using a single participant design, it was found that aphasic individuals who received morphosemantic treatment showed significant improvement in accurate production of trained and untrained verb inflections in sentence contexts. In contrast, individuals who received morphophonological treatment failed to show improvements in accuracy of sentence production, although the number and diversity of inflected verbs increased. The differential outcomes suggest that morphosemantic impairments contribute to verb inflection deficits in agrammatic aphasia to a greater extent than morphophonological impairments, at least in this group of participants.

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1. Introduction

Patterns of impairment in neuropsychological populations have provided invaluable theoretical insights into normal cognitive function. In this direction, the grammatically ill-formed speech often produced by individuals with Broca’s aphasia has been studied for possible insights into the neural and cognitive computation of grammar. A prominent feature of agrammatic speech is incorrect verb form usage, which significantly disrupts sentence well-formedness. Typical examples of verb form errors are Cinderella go to ball (for Cinderella went to the ball) or Parlamo ([we talk] for parlare [to talk]) (Miceli, Capasso, & Caramazza, 2004). The most frequent error pattern is that of verb form substitution, where the substituted verb form varies from the target only by one or two features (Menn & Obler, 1990). The exact mechanisms underlying verb inflection impairments are little understood, partly because current theoretical understanding of normal processes involved in verb inflection generation is limited. During the past decade, errors of verb morphology in agrammatic Broca’s aphasia have generated considerable interest due to their potential contribution to two theoretical debates, described in the following sections.

1.1. Word form encoding

One contentious issue is whether the representation of regular (talk-talked, cook-cooked) and irregular (sing-sang, drive-drove) verbs in the mental lexicon warrants two separate computational systems (dual mechanism accounts: Clahsen, 1999; Marslen-Wilson & Tyler, 1997; Pinker & Prince, 1991; Pinker & Ullman, 2002) or a single system (connectionist accounts: Bybee, 1995; Joanisse & Seidenberg, 1999; McClelland & Patterson, 2002; Penke & Westermann, 2006; Plunkett & Juola, 1999; Rueckl & Raveh, 1999; Rumelhart & McClelland, 1986). Dual mechanism models propose that the left posterior inferior frontal gyrus (or so called “Broca’s area”) is involved in rule-based computations of regular morphology (talk+ed → talked), and hence Broca’s aphasia is characterized by greater deficits in the production of regular inflections when compared to irregulars (Tyler et al., 2002; Ullman et al., 1997, 2005). However, other studies have failed to replicate the differential performance of regular and irregular
verbs (Bird, Lambon Ralph, Seidenberg, McClelland, & Patterson, 2003; Faroqi-Shah & Thompson, 2007; Inglis, 2005; Lacona & Caramazza, 2004; Miozzo, 2003; Penke & Westermann, 2006; Penke, Janssen, & Krause, 1999; Tsapkini, Iarena, & Kelhaya, 2002; for a meta-analysis see Faroqi-Shah, 2007). At the other end of the debate, single system models differentiate between regular and irregular verbs on a phonological–semantic continuum with a greater reliance on phonological processing for regular verbs and greater involvement of semantic mechanisms for irregular verbs. It is proposed that aphasic patients with phonological deficits will have greater difficulty with regular verbs (Bird et al., 2003; Braber, Patterson, Ellis, & Ralph, 2005; Lambon Ralph, Braber, McClelland, and Patterson (2005); Joanisse & Seidenberg, 1999). However, one problem for the phonological account is that not all patients with phonological deficits (Broca’s aphasia or otherwise) produce morphological errors (Miceli et al., 2004).

Despite these theoretical differences between single and dual mechanism accounts, the noteworthy commonality is that both groups attribute verb inflection impairments in agrammatic Broca’s aphasia to post-lexical (either morphological or phonological) difficulties associated with word form encoding. Little reference is made to the semantic and syntactic functions of verb inflections and their role in sentence formulation. The inherent and unspoken assumption seems to be that semantic-conceptual and syntactic operations that presumably precede and feed into morphophonological encoding are relatively spared. This poses common problems for both theories such as accounting for the grammatical class effect, that is, a dissociation between verb inflections and homophonous noun inflections (He cooks vs. The cooks) (Goodglass, Christiansen, & Gallagher, 1993; Lacona & Caramazza, 2004). Another problem is that individuals with Broca’s aphasia are capable of producing a relatively large number of inflected verbs, although these are not always appropriate to the context. For example, Faroqi-Shah and Thompson (2004) found that nearly 70% of verbs produced in a picture description task were affixed, although the accuracy of these verb inflections was only 30% (see also Druks, 2006). Substitution errors on word repetition tasks such as fighting for fought are also not easily accounted for because the word produced (fighting) is both morphologically and phonologically more complex than the target word (Badeckar, 1997).

1.2. Sentence formulation

The second theoretical debate that revolves around verb inflection errors in agrammatic aphasia is the mental computation of functional categories during sentence formulation (Bobaljik & Thrainsson, 1998; Chomsky, 2000; Pollock, 1989). Depending on the languages, verb inflections perform various syntactic functions, such as subject verb agreement, gender marking, negation, mood marking, tense marking, and case marking. In agrammatic aphasia, it has been cross-linguistically observed that certain inflectional functions, such as tense marking (He sleeps–He slept), are more consistently impaired than other inflectional functions, such as agreement (He sleeps–They sleep) (Arabatzis & Edwards, 2002; Friedmann & Grodzinsky, 1997 [Tree pruning hypothesis]; Goodglass et al., 1993; Kegl, 1995; Nanousi, Masterson, Druks, & Atkinson, 2006; Lee, 2003; Wenzlaff & Clahsen, 2005 [Tense underspecification hypothesis]). Some accounts propose that these patterns are predicted by the syntactic hierarchy of functional categories (Friedmann & Grodzinsky, 1997), while others propose that semantic relevance plays such that semantically relevant inflections (e.g., tense and aspect) are impaired while those that are purely syntactic (e.g., agreement) are spared in agrammatic aphasia (Faroqi-Shah & Thompson, 2007; Goodglass et al., 1993; Nanousi et al., 2006; Wenzlaff & Clahsen, 2005). Support for morphosemantic accounts comes from findings that agnostic aphasic individuals are impaired in tasks that require fine distinctions to be made between the semantic implications of inflectional affixes both in grammaticality judgment (Yesterday she walks to work) (Arabatzis & Edwards, 2002; Dickey, Milman, & Thompson, 2005; Friederici, Wessels, Emmorey, & Bellugi, 1992; Tyler, Behrens, Cobb, & Marsel-Wilson, 1990) and sentence production (Druks, 2006; Faroqi-Shah & Thompson, 2004; Nanousi et al., 2006). In contrast, access to morphosyntactic well-formedness constraints, both in grammaticality judgment (I will walked to work) (Friedmann & Grodzinsky, 1997; Grodzinsky & Finkel, 1998; Linebarger, Schwartz, & Saffran, 1983) and in sentence completion tasks (He will ____ to work) (Faroqi-Shah & Thompson, 2007) is relatively preserved. These accounts make little reference to post-lexical morphophonological operations and the possibility that verb inflection errors could be caused by impaired post-lexical morphophonological processes.

To summarize, verb inflection deficits in aphasia have been enmeshed in two debates: one post-lexical (morphophonological) and one sentential (morphosyntactic–morphosemantic), with little reciprocal reference between these two. A less addressed issue is whether the actual source of verb inflection deficits in agrammatism is a limitation of morphophonological operations or morphosyntactic operations, and if at all these two can be delineated (for an exception see Druks, 2006). Current empirical evidence is limited and has been inconclusive on this issue. One way to validate the morphophonological and sentential accounts of verb inflection deficits is to examine the effect of interventions that are specifically designed to remediate each of these “impaired” processes. The assumption is that a treatment that directly addresses the underlying impairment is more likely to produce significant treatment and generalization gains when compared to a treatment that does not target the underlying source of verb inflection errors.

1.3. Previous treatments of verb inflection deficits

There has been relatively little research on treatment of verb inflection deficits in agrammatic aphasia. Previous treatment studies and their findings are summarized in Table 1 (Balasubramanian & Coady, 1999; Mitchum & Berndt, 1994; Thompson, 2006a,b; Thompson et al., 2006; Weinrich, Shelton, Cox, & McCall, 1997; Weinrich, Boser, & McCall; 1999). All studies used a combination of oral production (morphophonology) and sentence structures (morphosyntax and morphosemantics) practice and hence it is unclear whether post-treatment improvements resulted from training oral production or sentence formulation.

In the present study, we compared two treatment protocols, one that specifically targeted morphophonological encoding of single words and another that addressed morphosemantic encoding in a sentence context. Although phonological and morphological accounts are theoretically distinct, it is clinically tricky to treat only one of these aspects of verb inflection encoding without the confounding effect of the other because oral production automatically engages morphological and phonological operations. Hence we do not make a distinction between morphology and phonology in our morphophonological treatment. The primary focus of the

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1. Not all authors distinguish between morphosyntax and morphosemantics, preferring to use the term morphosyntax for all higher level non-morphophonological operations (Badeckar, 1997; Druks, 2006; Friedmann & Grodzinsky, 1997). However, recent findings warrant a distinction between these two aspects. In this paper, morphosyntax refers to well-formedness constraints, and morphosemantics refers to conceptual-semantic aspects such as temporal reference (tense and aspect) and mood.
<table>
<thead>
<tr>
<th>Study and References</th>
<th>Treatment stimuli</th>
<th>Generalization stimuli</th>
<th>Procedure</th>
<th>Treatment intensity</th>
<th>Participants</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weinrich et al. (1994)</td>
<td>Ten 2-h session</td>
<td>13 sessions DH</td>
<td>Sentence structure and narrative speech</td>
<td>6 verbs with irregular past</td>
<td>15 sessions (total = 20h)</td>
<td>Subject #1 Improvement in trained items.</td>
</tr>
<tr>
<td>Boser and Weinrich (1998) and Weinrich et al. (1999)</td>
<td>Computer-aided C-VIC training followed by elicitation of verbal (ML or EA) or nonverbal (LP) responses. Cueing hierarchy used for incorrect sentences. Future tense only</td>
<td>14 sessions, twice weekly</td>
<td>Multiple back-sentence completion items for correct sentence, multiple baseline approach</td>
<td>Irregular past (15 sessions)</td>
<td>14 sessions</td>
<td>Subject #1 Improvement in trained items.</td>
</tr>
<tr>
<td>Boser, Weinrich, and Miller (2000)</td>
<td>Computer-aided C-VIC training followed by elicitation of verbal (ML or EA) or nonverbal (LP) responses. Cueing hierarchy used for incorrect sentences. Future tense only</td>
<td>6 verbs with regular past</td>
<td>Multiple back-sentence completion items for correct sentence, multiple baseline approach</td>
<td>Regular past (12 sessions)</td>
<td>6 verbs with regular past</td>
<td>Subject #1 Improvement in trained items.</td>
</tr>
<tr>
<td>Thompson &amp; Wexler (2001)</td>
<td>Computer-aided C-VIC training based on elicitation of written (DH) sentences. Multiple baseline approach. Cues used for incorrect responses. Multiple baseline approach</td>
<td>1h sessions, twice weekly (59 sessions)</td>
<td>Thematic role training, sentence anagram, and reading</td>
<td>Multiple baseline approach</td>
<td>50 items in Presenter’s Form 1 for nouns and verbs.</td>
<td>Subject #1 Improvement in trained items.</td>
</tr>
</tbody>
</table>

2 SK, MG, TP, and PP are referred to as AP1, AP2, AP6, and AP3 respectively in other work published by this author (Faroqi-Shah, Sampson, & Dickey, 2007).
Fig. 1. MRI scans of patients showing the axial view with left hemisphere lesions in the territory of the middle cerebral artery: (a) MG, (b) TP, and (c) SK. The quality of the image scans varies because these were obtained from patient medical records (except for MG for whom we had access to an electronic MRI file).

Table 2
Demographic details of participants

<table>
<thead>
<tr>
<th></th>
<th>MG</th>
<th>TP</th>
<th>SK</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)/gender</td>
<td>68/F</td>
<td>66/F</td>
<td>59/M</td>
<td>65/M</td>
</tr>
<tr>
<td>Pre-handedness</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Education years/highest degree</td>
<td>18/M.S.</td>
<td>16/B.A.</td>
<td>20+/Ph.D.</td>
<td>18/M.S.</td>
</tr>
<tr>
<td>Pre-morbid occupation</td>
<td>Elementary school counselor</td>
<td>Office clerk</td>
<td>Self-owned business</td>
<td>Mechanical engineer</td>
</tr>
<tr>
<td>Etiology</td>
<td>CVA of left middle cerebral artery</td>
<td>CVA of left middle cerebral artery</td>
<td>CVA of left internal carotid artery</td>
<td>CVA of left hemisphere</td>
</tr>
<tr>
<td>Medical history at onset of aphasia</td>
<td>Stroke following atrial fibrillation; h/o high blood pressure</td>
<td>Hospitalized for acute gastrointestinal bleeding; coagulant treatment was followed by atrial fibrillation and stroke 4 days later. Currently has a pacemaker</td>
<td>Acute onset of blurred vision, aphasia, hemiparesis and transient amnesia while on a business trip to China. Pre-morbidly healthy</td>
<td>CVA following colon surgery resulting in aphasia, right hemiparesis and double vision; h/o high blood pressure and retinal detachment</td>
</tr>
<tr>
<td>CT/MRI scan</td>
<td>MRI. Left fronto-parietal lesion, extending into the posterior superior temporal lobe</td>
<td>CT. Large low-density area involving the left frontal-parietal region. No evidence of intracranial hemorrhage</td>
<td>MRI. Flow void in the left internal carotid artery, white matter hyperintensities in the distribution of the middle cerebral artery and corpus callosum. Suspected emboli distribution from carotid to brain</td>
<td>No images available, radiologist’s report indicated a low-density lesion of the left frontal and inferior parietal regions</td>
</tr>
<tr>
<td>Other details</td>
<td>Passed hearingb and visionc screen</td>
<td>Passed hearing and vision screen</td>
<td>Bilateral moderate hearing loss, used hearing aids, passed vision screen</td>
<td>Passed hearing screen, retinal detachment in right eye, passed vision screen in left eye</td>
</tr>
<tr>
<td>Years post-onset</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

a All participants were pre-tested for comprehension of temporal adverbs by asking them to point to yesterday, today, tomorrow, next month, etc. on a calendar.

b Hearing screening was performed at 500, 1000 and 2000 Hz at 40 dBHL, ANSI 1969.

c Vision screening was passing at least 20/40 on a Snellen chart (with our without glasses).
2.4.1. Overall design

Upon meeting inclusionary criteria for the study, participants were randomly assigned to initially receive either morphosemantic (SK and PP) or morphophonological (MG and TP) treatment. Treatment type and verb type were counterbalanced and PP), while the other participant was trained on regular verbs (TP and SK). Internal validity is often a concern in single participant designs and this was achieved in two ways. First, a relatively large number of baseline assessments were used to document the absence of spontaneous recovery, that is, participants served as their own controls. Secondly, two participants were assigned to each treatment and showed similar outcomes to that treatment. Hence there was replication of treatment effects. This study was originally planned with a cross-over treatment manipulation such that each participant would have received the other treatment type in a second treatment phase. However, this could not be carried out in its entirety because of ceiling level of performance following morphosemantic treatment (for SK and PP; see Section 3). The cross-over treatments design was implemented for one participant with a 2-month washout period between treatments (TP).4

Data points were obtained for three phases: baseline, treatment, and follow-up. All participants received eight baseline assessments for the production of verb morphology in order to improve the validity of effect size calculations (Schultz, Crawford, & Sinner, 1999). Over the eight baselines, each of the 80 verb stimuli were probed thrice, once in each tense. The baseline phase was followed by the treatment phase, during which treatment was administered for 4–5 days/week in 1–2 h sessions. Production of tense was assessed at the beginning of every treatment session. Treatment was continued until a criterion of 90% accuracy on treatment probes for four consecutive sessions, or a maximum of 20 sessions was reached, or failure to improve by more than 10% after 12 therapy sessions, whichever came first. During post-treatment testing, a standardized aphasia test (WAB) and all the narrative measures were re-administered. Follow-up testing was conducted 2 weeks and 2 months after the cessation of treatment. As mentioned earlier, TP went through two 4 In all assessments of verb morphology/tense that used picture description, the relevant content words (nouns, verb) were provided by the experimenter in order to avoid a confound created by lexical retrieval difficulties.

*b Druks and Masterson (2000).

*b Faroqi-Shah (unpublished).

*b Stimuli taken from Bird et al. (2003).

*b Statistically significant change (McNemar’s, p < 0.05).

*b Western Aphasia Battery (Kertesz, 1982); AQ, Aphasia Quotient.

*b Faroqi-Shah (unpublished). Narratives obtained from 10 age-matched normals with the same stimuli and procedure as for individuals with aphasia.

*b Criterion for improvement was an increase exceeding 2 SD of an age-matched normal control group (n = 10).
2.4.2. Treatment

Every treatment session began with the administration of 20 treatment probes in order to measure treatment gains (see Section 2.4.3). This was followed by either morphophonological (patients MG and TP) or morphosemantic (patients SK, FP, and TP) treatment. Every attempt was made to match the overall format of the two treatment protocols.

Morphophonological treatment, which focused on the processing and production of verb inflections with an emphasis on oral production, involved the following treatment steps: (i) Confrontation naming for each treatment verb. The three verb sequences of a verb were placed in front of the participant while the participant attempted to name the action. (ii) Auditory discrimination (same–different judgment) of a word pair, such as washed–washes. (iii) Lexical decision of morphologically complex real words and pseudowords, such as washed, dug, and washly. (iv) Morphology generation, where participants were given the verb stem and asked to generate as many inflectional variants of the verb that they could think of. For example, sink, will sink, sinks is sinking, sank, and so on. (v) Oral and written transformation, where participants were first verbally presented with a model and asked to transform the treatment verb in the same manner. For example, “Call can be changed to called. Please change wash in the same manner”. Participants were first prompted to give a verbal response. This was followed by written transformation. (vi) Repetition, where participants repeated each inflectional variant of the treatment verb. This included repetition of function verbs associated with verb inflections, such as will wash and is washing. A second repetition was elicited for incorrect responses. The above six steps were repeated with each of the treatment verbs. Feedback regarding accuracy and the correct response with explanation was provided for all of the treatment steps. None of the above treatment steps involved the use of verb inflections in sentence contexts.

Morphosemantic treatment focused in associating temporal context with each verb form. It included the following steps: (i) Confrontation naming for each treatment verb. The procedure was identical to that used in morphophonological treatment. (ii) Anomaly judgment of auditorily presented sentences. Incorrect sentences contained mismatches between the temporal adverb and verb tense, such as Yesterday the boy will wash his hands. (iii) Auditory comprehension involved matching an auditorily presented sentence with the correct picture from a set of three. For this step, the three pictures representing each tense were placed in a random sequence. (iv) Sentence completion involved writing the correct verb form for a sentence that corresponds to a picture. For example, The boy __________ his hands. (v) Sentence construction involved selecting and arranging word cards (anagrams) to form a sentence that corresponds to a given picture. The above five steps were repeated with each of the treatment verbs. Feedback regarding accuracy and the correct response with explanation was provided for all of the treatment steps. None of these steps involved oral production and participants were discouraged from orally producing the sentences. In order to train tense only, we avoided introducing asperical markers such as progressive or perfective. Hence simple future, present and past tense was trained.

2.4.3. Assessment

Assessment of verb morphology was probed every session by asking participants to verbally describe 20 randomly selected pictures of the treatment verbs (Section 2.4.2). The treatment probes combined an element from each of the two treatments: oral production from morphophonological treatment, and sentence usage from morphosemantic treatment. Generalization was assessed in two aspects (Thompson, 2006a). Response generalization, which refers to performance on untrained stimuli, was assessed every fourth session using the 40 untrained verbs: 20 regular and 20 irregular (listed in Appendix B). Treatment and generalization probes were scored for the verb and its associated grammatical morphology, while ignoring all other syntactic errors. This ensured that scoring was uninfluenced by exposure to sentence contexts (morphosemantic treatment).

Three measures were obtained from the probe responses: the accuracy of tense, proportion of affixed verbs, and the type-token ratio of tense (see Appendix A for calculations). Stimulus generalization, which measures changes in untrained conditions, was assessed using narrative stimuli and a standardized aphasia test (WAB), once during baseline testing and once at the end of the treatment.

2.5. Reliability

Inter-rater reliability was obtained for 30% of randomly selected dependent measure samples (scoring of treatment and generalization probes, and narrative analysis) by raters who were blind to the treatment conditions. Reliability was obtained for 20% of the samples of independent variable (administration of the treatment steps) by observing videotaped sessions. Point-to-point reliability for all the dependent and independent variables exceeded 95%.

2.6. Data analysis

Percent accuracy scores of the treatment and generalization probes for the three experimental phases of the study (baseline, treatment, and follow-up) were graphically displayed for each participant and two measures of change in level were computed: (1) McNemar’s change test was used to compare the last baseline probe with the 12th treatment session. Statistical comparison was done with the 12th treatment session because each participant received a different number of treatment sessions depending on which of the three prior termination criteria were met first (Section 2.4.1). Since all four participants had received at least 12 treatment sessions, conducting statistical analysis on the performance of the 12th session avoided inflating treatment effects due to differences in the number of treatment sessions. (2) Effect size, which is a measure of change in performance between baseline and treatment phases, was computed for each participant using the following algorithm for estimating single subject effect sizes (also called Standard Mean Difference (SMD), Busk & Serlin, 1992) (A = baseline phase; B = treatment phase)\(^6\):

\[
\text{SMD}_{\text{all}} = \frac{\text{mean accuracy of treatment probes}_A - \text{mean accuracy of treatment probes}_B}{\text{group standard deviation}_A}\]

The criterion for improvement of narrative measures was a change in score that exceeded two standard deviations of the normative sample for those measures (Rochon, Laird, Bose, & Scaife, 2005).

\(^5\) Differences of opinion exist between the number of baseline and treatment probes used to compute effect size. Some authors compute effect size using only the last three baseline and treatment scores (SMD). This method excludes earlier lower scoring sessions and thus gives an inflated effect size value which does not take the slope of the learning curve into account. We follow Olive and Benjamin’s (2005) recommendation to compute SMD, which is a more conservative measure.

\(^6\) Although effect size is a good measure of overall change in level, it needs to be noted that its value is highly dependent on performance variability during the baseline phase. Hence group standard deviation was calculated across all participants and baseline sessions (Standard Deviation\(_A\)).
3. Results

The findings are reported according to the type of treatment. In each section, the outcomes for each participant are individually described in the following sequence: data on accuracy of tense for treatment probes, data on type-token ratio of tense and proportion of affixed verbs for treatment probes, and finally, generalization measures. Treatment probe accuracies (all tenses combined) for individual participants are shown in Figs. 3 and 4. Tables 3 and 4 provide post-treatment data for the stimulus generalization measures, namely standardized test scores and narrative speech. Table 5 provides data on response generalization measures. Samples of pre- and post-treatment probes for each participant are given in Appendix C.

3.1. Morphophonological treatment

3.1.1. MG

MG, who was trained on irregular verbs, received a total of 20.5 h of morphophonological treatment spread over 12 sessions. On the basis of a priori criteria, morphophonological treatment was discontinued after 12 sessions since the accuracy of treatment probes did not improve by more than 10% during this period (McNemar’s change test, \( p > 0.05 \)) (Fig. 3). Based on Cohen’s (1988) criteria for effect size, there was a negligible treatment effect (SMD\(_{all} = 0.06\)). Although there was limited improvement in the accuracy of MG’s production of tensed verbs in the treatment probes, there were marked increases in proportion of affixed verbs and type-token ratio of tense in these responses. The proportion of affixed verbs increased from a pre-treatment level of 0.47–0.88 in the final treatment probe (McNemar’s change test, \( p < 0.01 \)). The type-token ratio of tense changed from 0.2 pre-treatment to 0.4 post-treatment and this approached significance (McNemar’s change test, \( p = 0.06 \)). Notably, these two measures do not reflect accuracy of production, but overall diversity of production. This is illustrated in the post-treatment samples in Appendix C (2 and 4), which show that MG made repeated self-corrections by altering verb morphology in each attempt. Although MG produced a variety of irregular past tense verbs in the morphology generation step of treatment (Section 2.4.2), she rarely used irregular past tense in her responses to the treatment and generalization probes.

Generalization probes revealed no improvements in the tense accuracy (see Table 5), type-token ratio or proportion affixed verbs. Table 3 shows that the proportion of affixed verbs significantly increased in the post-treatment narratives (change > 2SD). There was also a significant increase in the proportion of verbs produced in the narratives (pre-treatment: 3 verbs; post-treatment: 11 verbs) (>2SD change). The other narrative measures remained unchanged. There was also a significant increase in the Aphasia Quotient of the WAB, in large part due to an increase in the spontaneous speech fluency score.

3.1.2. TP

TP, who was trained on regular verbs, received a total of 19.7 h of morphophonological treatment spread over 12 sessions. In most respects, TP’s response to morphophonological treatment was similar to that of MG. Treatment was discontinued after 12 sessions since the accuracy of treatment probes did not improve by more than 10% during this period (McNemar’s change test, \( p > 0.05 \)) (Fig. 3). Treatment probe (McNemar’s change test, \( p < 0.01 \)). There was no significant change in the proportion of affixed verbs, primarily because TP overused the ing form of verbs in her pre-treatment utterances (pre- and post-treatment: 0.8). Utterances (6), (8), and (10) in Appendix C reveal TP’s attempts at producing morphologically varied verbs after treatment. An interesting aspect of TP’s post-treatment utterances was an increased number of over-regularizations for irregular verbs, such as \( \text{dranked} \) in (10). Other examples were \( \text{wore} \), \( \text{swummed} \) (swam), \( \text{stealed} \) (stole), and \( \text{waked} \) (woke). TP rarely produced irregular past tense verbs.

There was no significant change in the accuracy of tense production in her narrative samples. In fact, there was a decrease in tense accuracy in her narrative speech (see Table 3), perhaps because TP’s post-treatment sample contained a larger variety of (incorrectly used) verb inflections. In contrast, the pre-treatment sample contained mostly Ving verbs used in a present progressive context, giving her a relatively high pre-treatment tense accuracy score. TP also produced a significantly larger proportion of verbs in her post-treatment narratives (>25D. change). There was a significant increase in single word repetition scores for both regular and irregular verbs (McNemar’s change test, \( p < 0.05 \)) (see Table 3). The Aphasia Quotient of the WAB increased significantly (McNemar’s change test, \( p < 0.05 \)). This increase was primarily the result of an improvement in comprehension scores (see Table 3). Since comprehension was not directly targeted dur-
ing morphophonological treatment, the source of this increase is unclear.

3.2. Morphosemantic treatment

3.2.1. PP

PP received a total of 24 h of morphosemantic treatment with irregular verbs for 18 sessions. During the treatment sessions, PP often complained of fatigue and sleepiness and at least a third of the sessions had to be ended early due to this. This may be a possible reason for the slower initial learning curve and more sessions to reach criterion (Fig. 4). The effect size was large (SMDall = 5.3). Shewart chart criterion was met, and there was a significant change in level for treatment probes (McNemar’s change test, p < 0.001). During the course of therapy, PP’s error pattern for irregular past tense generalization probes changed from no responses and incorrect tense to over-regularizations of untrained irregular past tense. Some examples are She feeld the horse, He buyed, He teared the book, and He weped. This pattern of over-regularizations is surprising because PP was trained on irregular verbs. Narrative measures showed post-treatment improvements in mean length of utterance, proportion of sentences, proportion of verbs, proportion affixed verbs, type-token ratio of tense, and accuracy of tense (>2S.D. change). Other post-treatment measures to increase significantly were the Aphasia Quotient of the WAB and the regular and irregular verb repetition scores (McNemar’s change test, p < 0.001). There was also a significant improvement in generalization probes for regular past tense, irregular past tense and other tenses (McNemar’s change test, p < 0.000). During the course of therapy, PP’s error pattern for irregular past tense generalization probes changed from no responses and incorrect tense to over-regularizations of untrained irregular past tense. Some examples are She feeld the horse, He buyed, He teared the book, and He weped. This pattern of over-regularizations is surprising because PP was trained on irregular verbs. Narrative measures showed post-treatment improvements in mean length of utterance, proportion of sentences, proportion of verbs, proportion affixed verbs, type-token ratio of tense, and accuracy of tense (>2S.D. change). Other post-treatment measures to increase significantly were the Aphasia Quotient of the WAB and the regular and irregular verb repetition scores (McNemar’s change test, p < 0.005).

3.2.2. SK

SK received a total of 20.5 h of morphosemantic treatment for regular verbs spread over 12 sessions. Shewart chart trend criterion was met, there was a significant change in level for treatment probes (McNemar’s change test, p < 0.000), and the effect size was large (SMDall = 5.2) (Cohen, 1988). As can be seen from Table 5, treatment effects generalized to improved tense production accuracy for untrained regular and irregular verbs (McNemar’s change test, p < 0.001) and were maintained in the follow-up tests. All the errors on irregular past tense verbs involved over-regularizations such as steeled (stole), weared (wore), and kepeed (kept) (see also Appendix C). Narrative measures showed post-treatment improvements in proportion of grammatical sentences, proportion of verbs, proportion affixed verbs, type-token ratio of tense, and accuracy of tense (>2S.D. change). There were slight increases in the fluency and repetition subtests of the WAB (Table 3), although this did not significantly increase the Aphasia Quotient (McNemar’s change test, ns).

3.2.3. TP

TP received 14 h of morphosemantic treatment for regular verbs over 8 sessions. As mentioned earlier, all comparisons of treatment effects were made with the performance on the post-treatment and follow-up testing consequent to morphophonological treatment (F1 and F2) since this was taken as her baseline performance for morphosemantic treatment. TP responded to the treatment with increased accuracy of tense production that was maintained above 90% over four consecutive sessions (Fig. 4). There were no changes in the type-token ratio of tense and proportion of affixed verbs (McNemar’s change test ns). It should be pointed out that she had achieved maximum possible scores for these latter two measures following morphophonological treatment and hence there was no room for increase in scores. Table 5 shows that the accuracy of generalization probes increased for present, future, and regular past tenses, but not for irregular past tense. In narrative speech, there was a significant change in three measures, the proportion of grammatical sentences, the proportion of affixed verbs, and the accuracy of tense. There were no changes in the WAB scores.

4. Discussion

This is the first study to directly compare two theoretical perspectives on morphological deficits inagrammatic aphasia by implementing focused intervention protocols. A treatment designed specifically to address oral production of morphologically complex verbs (morphophonological treatment) was compared with a treatment which emphasized making connections between verb morphology and its temporal reference (morphosemantic treatment). Participants receiving both treatments improved in the variety of verb morphology produced (type-token ratio of tense) by at least 0.3 and also showed improvements in the Aphasia Quotient by at least 4.8 points (Table 3). However, the two treatments produced differential effects in most other measures. Morphosemantic treatment resulted in improved accuracy of verb tense in elicited and narrative sentence contexts. In addition, generalization to untrained verbs was observed. This effect was consistent across all three participants who received treatment. In contrast, both the participants who received morphophonological treatment failed to improve in accuracy of tense production in sentence contexts. Treatment gains in this latter group were limited to an increase in the variety of verb morphemes produced, although these morphemes were often incorrectly used.

4.1. Other factors influencing intervention outcome

When differential effects of treatment are observed, it is important to consider possible confounding patient variables, such as differences in overall severity of aphasia, spontaneous recovery due to time post-onset, and lesion site and size. As described earlier, the
participants in the two groups were approximately comparable in terms of overall severity as revealed by the Aphasia Quotient and in production measures of sentence structure and morphology. Spontaneous neurological recovery is most likely to occur during the first year after stroke (Thulborn, Carpenter, & Just, 1999) and none of the participants were within this time frame. In addition, the repeated baseline probes failed to show spontaneous improvement in any participant. Although we do not have objective volumetric measures of the size of lesion, the images in Fig. 1 and radiologist’s reports failed to draw attention to any dramatic differences across participants.

Another issue is whether any kind of semantic treatment is always superior to phonological treatment. Although early studies seemed to suggest a superiority of semantic facilitation both in naming tasks and treatment effects (Howard, Patterson, Franklin, Orchard-Lisle, & Morton, 1985a,b; Nickels & Howard, 1995), more recent randomized clinical trials have found no difference in the efficacy of semantic and phonological tasks for (monomorphemic) word retrieval (Doesborgh et al., 2004; see also Hinkin, Rest, Herbert, Howard, & Osborne, 2002). Hence the findings of this study cannot be boiled down to general semantic versus phonological facilitation. The final issue is whether the superiority of morphosyntactic treatment resulted from the syntactic environment provided by treatment sentences. Although sentences were used in order to provide temporal reference, syntactic structure was not explicitly trained or corrected during morphosyntactic treatment. In fact, pre-treatment narrative samples and baseline probes reveal that all four participants produced a basic noun–verb–noun sentence prior to initiation of therapy. Further, all scoring was independent of sentence context. Hence it is unlikely that syntactic facilitation alone can account for the significant outcome of morphosyntactic treatment. In fact, Dickey, Milman, and Thompson (2007) found that the effects of treatment for syntactic structure did not automatically generalize to verb morphology and concluded that there is no direct relation between syntactic and morphological recovery (see also Thompson et al., 2006).

4.2. Comparison with previous interventions

This study crucially diverged from previous studies by training only one process, either morphophonology or morphosemantics. Another crucial difference was that training included only one verb type, either regular or irregular.

4.2.1. Morphophonology and morphosemantics

The differential outcome of morphophonological versus morphosyntactic treatment is not an inconsequential finding because both treatments could have automatically accessed the untrained process. That is, there was no way to prevent temporal reference from being automatically retrieved during some morphophonological treatment steps (such as morphology generation and oral transformation), and from a minimal level of pre-articulatory morphophonological encoding to automatically occur during some morphosemantic steps (such as sentence completion and anagram). A similar difficulty in separating phonological and semantic aspects of picture naming during therapy tasks has been discussed in the literature (Howard, 2002; Nickels, 2002). Given that morphophonological treatment was ineffective in the most crucial respect of tense accuracy, at least for the participants of this study, that oral production practice was neither necessary nor sufficient to improve the verb inflection deficit. The outcomes indicate that improvement is likely to occur if the tense conveyed by specific verb forms is trained. Almost all previously reported treatment studies included this latter aspect, either in oral, written or iconic form (Balasubramanian & Coady, 1999; Mitchum & Berndt, 1994; Thompson et al., 2006; Weinrich et al., 1997, 1999). To the extent that generalization across studies can be made, the treatment gains observed in previous studies presumably resulted more from associations made between various verb morphemes and their corresponding tense, and less from practice with oral production. If comparable treatment gains can be achieved by therapy that does not require oral production training, then there are important clinical implications in terms of optimizing time spent in clinical service delivery with fewer treatment steps. Further research is needed to confirm this conclusion. One caveat to this claim about the superiority of morphosyntactic treatment for verb inflection deficits in agrammatic aphasia is that our participants had mild to moderate non-fluent aphasia with no severe phonological difficulties. It is possible that at least some agrammatic aphasic individuals have additional phonological impairments (Kean, 1977; Kohn & Melvold, 2000), and may benefit from a combination of morphophonological and morphosyntactic treatment to improve production of verb inflections. Similarly, in a semantic-based treatment study for severe word retrieval impairments, Drew and Thompson (1999) reported that two out of four participants did not show improvement in naming until phonological information was incorporated into the treatment protocol.

4.2.2. Regular and irregular verbs

While generalization to future and present tense of untrained verbs was nearly perfect, the patterns of generalization for regular and irregular past tense are dependent on verb type. All three participants improved in the production accuracy of untrained regular past tense, regardless of whether regular or irregular verbs were trained. Irregular past tense generalization was observed for one participant who was trained in irregular verbs (PP) and one participant who was trained on regulars (SK) (see Table 5). A noteworthy aspect of the within-verb type generalization observed with irregulars for PP is that all trained irregular verbs involved vowel change (sang, rang, drank, broke, wore, tore, etc., see Appendix A) whereas irregulars tested for generalization involved a consonant addition along with vowel change (kept, slept, sold, fled, taught, etc.). The finding for SK and PP indicates that morphosyntactic treatment facilitated production of past tense verbs that had no overt morphophonological similarity with the trained past tense verbs. However, the generalizability of this finding is limited by TP, who failed to generalize to irregular past tense. TP’s lack of generalization to irregulars is consistent with previous studies that trained both regular and irregular verbs found limited generalization to untrained irregulars (Mitchum & Berndt, 1994; Weinrich et al., 1997, 1999).

Interestingly, all three participants (SK, PP, and TP) produced over-regularizations after the initiation of therapy, although these were not observed in any of their pre-treatment samples. In the case of SK and PP, over-regularizations disappeared as they approached criterion and were not observed in any post-treatment testing. Over-regularizations have also been reported in previous treatment studies (Mitchum & Berndt, 1994; Weinrich et al., 1997). Since SK and TP received regular verb treatment, the use of over-regularizations for irregular past tense targets can be explained as an over-extension of the trained regular affixation rule. Ironically, PP produced over-regularizations even though he was trained on irregular verbs and was not exposed to regular verb endings during treatment. This interesting behavior can be explained by assuming the blocking principle, which proposes that production of irregular past tense involves blocking the default regular past tense rule followed by retrieval of the irregular form (Aronoff, 1976; Marcus, Pinker, Ullman, Hollander, & Rosen, 1992). That is, production of
irregular verbs is assumed to automatically activate the default regular affixation rule. The blocking principle implies that treatment of irregulars should generalize better to untrained regulars than treatment of regulars would generalize to untrained irregulars. This is because treatment of regular past tense does not necessarily entail activation of irregular verb entries. A recently completed study with seven participants confirms the superiority of irregular verbs in producing generalization (Faroqi-Shah, 2008).

4.3. The nature of deficit in agrammatic aphasia

While evaluating the relative weight of morphophonological and morphosemantic explanations of verb inflection errors in agrammatic aphasia, the treatment outcomes of the present study support the latter explanation. Difficulties in processing semantic implications of verbal inflections are supported by other sources of evidence as well. For example, investigations of grammaticality judgments reveal that agrammatic aphasic individuals are worse at detecting errors of temporal reference (such as *Yesterday the boy walks*) than at detecting purely lexical or syntactic violations (such as *The boy is walker* or *The boy walking*) (Arbabazi & Edwards, 2002; Faroqi-Shah, Dickey, & Sampson, 2007; Friederici et al., 1992; Linebarger et al., 1983; Nanousi et al., 2006; Tyler et al., 1990). Similarly, most sentence completion studies reveal impaired performance with semantically relevant features rather than morphosyntactic constraints of verb inflections (Druks, 2006; Faroqi-Shah & Thompson, 2007; Goodglass et al., 1993; Nanousi et al., 2006; Wenzlaff & Clahsen, 2004) (but see Burchert, Swoboda-Moll, & De Bleser, 2005 for a mixed finding). Perhaps the earliest semantic interpretation of verb morphology deficits in agrammatic aphasia came from LaPointe’s (1985) proposal that verb groups are hierarchically organized in the mental lexicon on the basis of the complexity of semantic notions (attitude, voice, aspect, tense, and agreement) expressed by these verb forms as well as their derivational properties (see also LaPointe & Dell, 1989). According to this hierarchy, verb stems are the least marked and hence engage in a minimal processing load, followed by present third person singular tense (expressed by the affix V+*ig*), past tense (the affix V+*ed* in that order). LaPointe proposed that accessing more marked inflections placed greater processing demands on mental mechanisms than accessing less marked inflections and predicted that accuracy rates and substitution errors in agrammatic productions would conform to this hierarchy, although this prediction was not supported (Faroqi-Shah & Thompson, 2004; Janssen & Penke, 2002; see also Stavrakaki and Kouvava (2003) for another hierarchical prediction and Varlakosta et al. (2006) for contradictory data in Greek). In other words, although a morphosemantic deficit is supported by the present study and by earlier mentioned studies, existing data do not support hierarchical morphosemantic explanations.

Any theory of verb inflection deficits not only needs to account for morphosemantic non-hierarchical patterns of performance, but also needs to accommodate other findings that cannot be directly interpreted in terms of semantics. For example, production of verb inflections is found to be influenced by factors such as frequency of occurrence (Faroqi-Shah & Thompson, 2004; Ober, Harris, Meth, Centeno, & Mathews, 1999; Penke et al., 1999), phonological complexity (Braber et al., 2005; Obler et al., 1999), phonological environment (Janssen & Penke, 2002), overuse of non-finite forms such as progressives in English, and individual-specific overuse patterns (Faroqi-Shah & Thompson, 2004). In addition, morphological regularity has failed to show a consistent pattern of performance (Faroqi-Shah, 2007; Fix & Thompson, 2006) and there seems to be intra-individual variability across repeated testing (Faroqi-Shah, 2007). Perhaps these findings can be reconciled by assuming that during sentence formulation, the fine conceptual-semantic distinctions conveyed by inflectional affixes (+PAST, +PRESENT, +PROGRESSIVE) may fail to channel the selection of the appropriate verb form (e.g., +PAST → V + ED), although syntactic mechanisms may be relatively unimpaired (Faroqi-Shah & Thompson, 2007 [Diacritical Encoding and Retrieval Hypothesis]). When the grammatical encoder fails to select and/or retrieve context-appropriate verb forms due to a morphosemantic deficit, there ensues a competition between verb forms. An interplay of factors such as frequency of occurrence, phonological complexity, and individual usage patterns influence the final choice of verb form. This may result in substitution errors, such as *He sleeping for He slept*. In other words, lexical and morphophonological factors are secondary to the morphosemantic impairment in agrammatic aphasia (see also Druks 2006) for a similar view, and also Badeckar (1997) for a similar account for single word reading errors such as *fighting for fought*. It must be noted that these secondary factors not only influence the production of verb inflections in agrammatism, but are known to influence a variety of other linguistic items in a variety of aphasic individuals (Bird & Franklin, 1999; Dell, 1990; Gagnon, Schwartz, Martin, Dell, & Safran, 1997; Garrett & Jones, 1987; Luzzatti et al., 2002).

To conclude, this study evaluated current theoretical perspectives on verb inflection impairments and found greater support for a morphosemantic account. Although impairments in encoding and retrieval of tense (and aspect) are most frequent, this account does not rule out the possibility that other morphosemantic features may be impaired in individual patients (e.g., case marking), or that there may be overlying phonological deficits as part of the syndrome of Broca’s aphasia. A final thought is that researchers who propose morphophonological and morphosemantic (and morphosyntactic) explanations may actually differ in their patient selection criteria because, in general, morphophonological proponents describe their patients as non-fluid or Broca’s aphasic, while authors proposing morphosemantic (morphosyntactic) accounts use the term agrammatic aphasia to describe their patients. Hence it is worthwhile to compare both theoretical perspectives in the same group of aphasic individuals.

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7 A variety of frequency measures have been examined: Centeno, Ober, Cairns, Garro, and Merrifield (1996) used affix frequency, Faroqi-Shah and Thompson (2004) used surface frequency, while Penke et al. (1999) used conjugation frequency.

8 Findings regarding the role of phonological complexity are inconsistent. For example, Lorch (1990) reported that it is not uncommon for phonologically and morphologically more complex verb forms to substitute phonologically simpler verb forms.
Appendix A. Procedure for tense-aspect coding of verb morphology

Tense-aspect was coded for each verb in the sentence, including copulas. There were two tiers of codes assigned to each verb: accuracy of tense and type of tense marking.

Tier 1: Each verb was coded for accuracy of tense with the following codes:
- [tense]: Accurate production of all tense morphology.
- [*tense]: Tense marking is clearly incorrect in relation to the context. In most cases, there is preceding adverbial or clausal indication of the intended tense. For example, Long long ago...Queen is bad.
- [-tense]: There is no indication of tense marking on the verb. This was mostly the use of either verb stems or the progressive aspect without associated auxiliary. For example, Running...Running...boy running.

Tier 2: The second level of coding specified the type of tense-aspect conveyed by the verb. This code was given to [tense] and [*tense] codes. In most cases, [-tense] verbs received no tense code, but received an aspect code if the progressive form was produced (as in the above example). If the [-tense] code was assigned to a verb stem was produced in isolation, then no code was given in the second tier. In fact, it was sometimes unclear if the verb was indeed a verb (as most verbs in English are also homophonous nouns). The following tense-aspect codes were used in the second tier:
- [nonfinite]: When it is clear that the verb is used in a non-finite context, especially in embedded clauses. For example, walk in He wanted to walk.
- [sload]: Simple present tense. For example, He walks.
- [spast]: Simple past tense. For example, He walked. The sky was cloudy and gray.
- [sfuture]: Simple future tense. For example, He will walk.
- [pppresent]: Progressive present tense. In this case, the tense was conveyed by the auxiliary and progressive aspect was indicated on the verb inflection. This was the most common code among pre-treatment narratives for aphasic participants. For example, He is walking.
- [pppast]: Progressive past. For example, He was walking.
- [prfuture]: Progressive future. For example, He will be flying to Colorado.
- [pppepresent]: Perfect present tense. The past perfect was used when auxiliary indicated event completion. For example, He has walked.
- [pppast]: Perfect past. For example, He had walked.
- [ppfutur]: Perfect future. For example, He will have walked by the time we eat.
- [ppprepast]: Perfect progressive past. For example, He had been walking for two hours.
- [ppprepresent]: Perfect progressive present. For example, He has been walking for two hours.
- [ppprefuture]: Perfect progressive future.
- [emph]: Emphatic past. For example, He did eat.
- [eapa]: Emphatic present. For example, He is walking...Hurricanes do occur. Conditional tense is coded when conditional modals such as might, could, and would are used. This tense is added in addition to one of the above codes (that is, a third tier). For example, He might have walked [tense][pppast][con].

The first 150 words of each participant’s narrative were used to calculate the following:

\[
\text{accuracy of tense} = \frac{\text{[tense]}}{\text{[tense] + [*tense] + [-tense]}} \quad \text{(this corresponds to the total number of verbs)}
\]

\[
\text{type-token ratio of tense} = \frac{\text{number of unique codes in tier 2}}{\text{total number of tier 2 codes}}
\]

Appendix B. Verb stimuli

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Generalization</th>
<th>Irregular verbs</th>
<th>Generalization</th>
</tr>
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<tbody>
<tr>
<td>rake</td>
<td>iron</td>
<td>sleep</td>
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<tr>
<td>peel</td>
<td>water</td>
<td>sing</td>
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<td>wear</td>
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<td>kick</td>
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<td>smoke</td>
<td>empty</td>
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<td>rob</td>
<td>vacuum</td>
<td>wake</td>
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<td>lead</td>
<td>teach</td>
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<tr>
<td>skate</td>
<td>scrub</td>
<td>bite</td>
<td>pay</td>
</tr>
</tbody>
</table>

Appendix C. Pre- and post-treatment probe samples for each participant

C.1. Morphophonological treatment

- **MG**
  - Responses for the untrained verb peel and the trained verb drink
  - (1)–(4).
  - **Target:** The lady will peel the potatoes
    (1) Pre-treatment: Tomorrow...to cook the potatoes...to cook.
    (2) Post-treatment: Tomorrow...the...she peeled. She is peeling.
  - **Target:** The boy drank the water
    (3) Pre-treatment: drink...the drink...afterwards...the drink is done.
    (4) Post-treatment: Yesterday...is drinking. I drink a lot of water. He will drink a drink.

- **TP**
  - **Target:** The lady will peel the potatoes
    (5) Pre-treatment: The girl peeling...about to.
    (6) Post-treatment: Tomorrow the girl is peeling the potatoes.
  - **Target:** The lady peeled the potatoes
    (7) Pre-treatment: peeling...peeling.
    (8) Post-treatment: Will peel the thing...peels the thing or whatever.
  - **Target:** The girl drinks the water
    (9) Pre-treatment: Nowadays...girl is drinking the water.
    (10) Post-treatment: The girl dranked.
C2. Morphosemantic treatment

- PP
  - Target: The lady will peel the potatoes

- (11) Pre-treatment: A bowl filling up with trees...and peeling.

- (12) Post-treatment: The lady will peel the potatoes.

- Target: The lady peels the potatoes

- (13) Pre-treatment: Nowadays peel and put it in the water.

- (14) Post-treatment: The lady peels the potatoes everyday.

- Target: The girl drank water

- (15) Pre-treatment: The little girl...drink the water.

- (16) Post-treatment: She broke...uh... drank all the water.

- SK
  - Target: The lady will peel the potatoes

- (17) Pre-treatment: Going to...to prepare to...the peel.

- (18) Post-treatment: The young lady will peel the apples or potatoes.

  - Target: The girl drank the water

- (19) Pre-treatment: He's drinking.

- (20) Post-treatment: The girl drank the water from the fountain.

- TP (the pre-treatment samples given here are taken from the first and second follow-up tests that were administered prior to the initiation of morphosemantic treatment)

- Target: The lady peeled the potatoes

- (21) Pre-treatment: Will peel the thing.

- (22) Post-treatment: This girl here peeled all the potatoes.

- Target: The girl drank the water

- (23) Pre-treatment: The girl is drinking it.

- (24) Post-treatment: The girl drank...drink...no drinked.

References


