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Effects of Syntactic Complexity, Semantic Reversibility and Explicitness on Discourse Comprehension in Persons with Aphasia and in Healthy Controls

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Abstract

Purpose—Prior studies of discourse comprehension have concluded that the deficits of persons with aphasia (PWA) in syntactically based comprehension of sentences in isolation are not predictive of deficits in comprehending sentences in discourse (Brookshire & Nicholas, 1984; Caplan & Evans, 1990). However, these studies used semantically constrained sentences in discourse, which do not require syntactic analysis to be understood. We developed a discourse task to assess the effect of syntactic complexity, among other factors, upon discourse comprehension.

Method—38 PWA and 30 healthy control subjects were presented with passages that contained 2 – 3 semantically reversible sentences that were either syntactically simple or syntactically complex. The passages were presented auditorily and comprehension was assessed with the auditory and written presentation of four multiple-choice questions immediately following each passage.

Results—Passages with syntactically simple sentences were better understood than passages with syntactically complex sentences. Moreover, semantically constrained sentences were more likely to be accurately interpreted than semantically reversible sentences. Comprehension accuracy on our battery correlated positively with comprehension accuracy on an existing battery.

Conclusions—The results show that the presence of semantically reversible syntactically complex sentences in a passage affects comprehension of the passage in both PWA and neurologically healthy individuals.

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Introduction

Persons with aphasia (PWA) often have difficulty assigning thematic roles to noun phrases in sentences when two conditions are met: 1) the sentence is “semantically reversible;” that is, either NP could reasonably play either thematic role around the verb; and 2) the sentence has a non-canonical word order (e.g. Caramazza & Zurif, 1976; Ansell & Flowers, 1982; Caplan & Futter, 1986; Grodzinsky, 1989). In English, the thematic role of <agent> is canonically assigned to the preverbal subject position while the role of <patient> is canonically assigned to the postverbal object position. Thus, PWA often have trouble understanding sentences such as (1b) but not (1a).

1)

a. The man hugged the boy.

b. The man was hugged by the boy.

PWA with poor performance on these semantically reversible sentences with non-canonical word order are considered to have deficits in syntactically based comprehension. The reasons for such deficits are topics of research (see Grodzinsky, 2000; Caplan et al, 2007, for discussion of some accounts).

To the best of our knowledge, no research has been conducted on the effect of these sentences on comprehension of a discourse in PWA. One of the few studies of the effect of syntactic structure on discourse comprehension was conducted by Caplan and Evans (1990). They created pairs of narratives with identical propositions, in which word order of the sentences was varied. In one narrative, the sentences were presented exclusively with canonical word ordering, while the sentences in the paired narrative were presented with exclusively non-canonical word order. They found that even among PWA with documented syntactic deficits, discourse comprehension was unaffected by the presence of sentences with non-canonical word order. However, Caplan and Evans’ (1990) goal was to determine whether syntactic processing was obligatory even when sentences were semantically constrained. Therefore almost all of the sentences in their narratives were semantically constrained, not semantically reversible. The study, therefore, deliberately did not present the sentence types that are difficult for PWA and on which performance is taken as an indication of a deficit affecting syntactically based comprehension. In contrast, the present study examines the effect of semantically reversible sentences with non-canonical word order on discourse comprehension in PWA.

This study also examines other factors that are known to affect discourse comprehension in PWA. Brookshire, Nicholas and colleagues (1984; 1993; 1995; 2008) found that PWA answer questions about main ideas more accurately than questions about details and answer questions about propositions that are explicitly stated more accurately than propositions that are implied. Their batteries, the Discourse Comprehension Test (DCT) (Brookshire & Nicholas, 1993) and the Discourse Comprehension Test – Revised (DCT-R) (Brookshire & Nicholas, 2008), have become the standard for measuring patient discourse comprehension (e.g. Nicholas & Brookshire, 1995; McNeil et al., 1997; 2004). Similar to Caplan and Evans (1990), all of the sentences in the passages in these tests are semantically constrained, so these tests do not examine comprehension of discourses that contain sentences that PWA with syntactically based comprehension deficits would be expected to *not* understand. Therefore, these tests do not examine comprehension of discourses that contain sentences for which PWA with syntactically based comprehension deficits would be expected to exhibit poor comprehension. However, the findings that the level of detail and explicitness with which propositions are presented affect the understanding of a discourse in PWA provides measures of comprehension that can be incorporated into any new test of discourse comprehension. The tests developed by Brookshire, Nicholas and colleagues also provides materials against which performance of PWA on a new test of discourse comprehension can be compared. We capitalized on these results to validate the test of discourse that we developed.

The present study addresses the question of whether there is an effect of syntactic complexity upon comprehension of discourses that contain semantically reversible sentences with non-canonical word order. In order to address this question, we have devised a Test of Syntactic Effects on Discourse Comprehension (TSEDC). This paper will describe the development of the test and the effects of manipulating syntactic complexity and semantic reversibility upon discourse comprehension. The TSEDC has also incorporated Brookshire and Nicholas' (2008) probe of explicitly and implicitly stated propositions, and we tested a subset of the PWA who received the TSEDC on the DCT-R in order to provide evidence for the construct validity of the TSEDC.

Methods

Materials

Nine pairs of passages were created ranging in length from 9–16 sentences (69–149 words). The two versions were identical aside from 2–3 semantically reversible sentences, which differed in word order in the two versions. In the "syntactically simple" version of a passage, these reversible sentences were presented in a canonical word order; in the "syntactically complex" version of a passage, these reversible sentences were presented in a non-canonical word order. The remaining sentences were syntactically simple actives and were semantically constrained. We shall refer to passages containing reversible sentences in a canonical word order as "simple" passages and to passages containing reversible sentences in a non-canonical word order as "complex" passages. Samples of the two versions are presented in Appendix A, with reversible sentences in italics.

The reversible sentences were presented in one of four syntactic pairs: Active/Passive, Subject Relative/Object Relative (SR/OR), Subject Cleft/Object Cleft (SC/OC), and Transitive/Unaccusative. The first type of sentence in each of these pairs has canonical word order and the second type of sentence in each of these pairs has non-canonical word order. Examples of the four pairs described above are shown in (2–5).

2) Active: The man hugged the boy.

Passive: The boy was hugged by the man.

3) Subject Relative (SR): The man who hit the woman kissed the daughter.

Object Relative (OR): The woman who the man hit kissed the daughter.

4) Subject Cleft (SC): It was the man who hit the woman.

Object Cleft (OC): It was the woman who the man hit.

5) Transitive: The boy was shaking the girl.

Unaccusative: The boy was shaking.

Like active and transitive sentences, the embedded clauses of SR and SC sentences have canonical word order. Passives have non-canonical word order in the main clause, and OR and OC sentences have non-canonical word order in the embedded clause. Unaccusative sentences are similar to passives. Though they have no postverbal object, the preverbal subject is assigned the thematic role of <patient>. Studies have shown that PWA have more difficulty with the comprehension and production of all the sentence types with non-canonical word order than the sentence types with canonical word order (for passive, OR and OC, see references above; for unaccusative sentences, see Lee & Thompson, 2004, and

McAllister et al., 2009). Comparison of comprehension of the reversible *sentences* with noncanonical word order to comprehension of the reversible sentences with canonical word order allows for the determination of whether these features of sentences affect performance of PWA when these sentence types occur in a discourse, as has been shown for sentences in isolation. Comparison of comprehension of the *passages* with reversible sentences with non-canonical word order to comprehension of the passages with reversible sentences with canonical word order allows for the determination of whether the presence of these sentences affects the ability of PWA to comprehend a discourse overall.

Because the goal of developing the TSEDC was to test the effect of sentences that require syntactically based comprehension, the meanings of the reversible sentences had to be determinable only through the use of syntactically based comprehension mechanisms. We therefore had to also ensure that the meanings of these sentences could not be inferred from the passage context in which they occurred. Contextual cues were therefore controlled in the TSEDC so that the thematic roles in the reversible sentences were not deducible through contextual inference or discourse-linking (Pesetsky, 1987; 2000). The assignment of thematic roles in the semantically constrained sentences was supported by contextual cues. Also, while the semantically constrained sentences were occasionally embellished with temporal or thematic connectives (e.g. *suddenly* or *unfortunately*) to facilitate narrative pragmatics, reversible sentences lacked any such embellishment to further ensure that comprehension of the reversible sentences was not influenced by the discourse context.

The pairs of passages were equated for six referential and semantic indices in Coh-Metrix (Graesser et al., 2004), reported in Appendix B. These indices serve as measures of passage cohesion. For example, a passage containing (6b) would have greater cohesion than a passage containing (6a) due to the presence of a referential pronoun. If the thematic role of <patient> were in doubt, *her* would support the correct interpretation that the <patient> thematic role is assigned to *the girl*. In contrast, no such support is present in (6a).

6) **a.** The boy kicked the girl in the shin.

b. The boy kicked the girl in her shin.

Additionally, to ensure that the passages were natural and to reduce their demands on memory, all passages described a chronological sequence of events such that each sentence was either expository (generally found at the beginning of a passage) or was a thematic continuation from the sentences immediately prior. No more than four characters were introduced per passage.

Each passage was followed by four questions that referred to: 1) a constrained sentence conveying an explicitly stated proposition, 2) a constrained sentence conveying an implicitly stated proposition, 3) a reversible sentence conveying an explicitly stated proposition, and 4) a reversible sentence conveying an implicitly stated proposition. Each question was presented in a multiple-choice format with four possible responses to reduce the possibility of correctly guessing the answer, following Fossett et al. (2004). All multiple-choice responses consisted of characters or events mentioned in the immediately preceding passage.

To ensure that correct answers to the questions could be reliably achieved only through an understanding of the information presented in the passage, as opposed to a reliance on world knowledge or information presented in the other questions, the passage dependency of each question was measured (Tuinman, 1974). The passage dependency of the questions was assessed by presenting the questions to 19 healthy controls before and following the presentation of the associated passages (Fossett et al., 2004). A Passage Dependency Index (PDI) was calculated for each question using the formula 1 – [proportion of correct answers to questions before the passage ÷ proportion of correct answers to questions following the passage]. Low PDIs suggest an ability to accurately respond to questions without exposure to the passage. High PDIs suggest that above-chance response accuracy can be attributed to successful passage comprehension. All questions had PDIs greater than 60%.

Participants

Thirty-eight PWA aged 25–83 years (mean age = 61 years) and 30 control subjects aged 27–82 years (mean age = 62.2 years) participated in the study. PWA were recruited from area hospitals and the Boston University Aphasia Resource Center. All PWA were diagnosed with aphasia by a licensed speech-language pathologist. The basis for the diagnosis varied as a function of the institution where a PWA was seen for clinical purposes, and included diagnostics such as the Boston Naming Test and the Boston Diagnostic Aphasia Examination. PWA had a broad range of traditional clinical diagnoses such as Broca’s aphasia or Wernicke’s aphasia, but they were not always classified, or classifiable, into these groups. The group tested is thus a sample of PWA who are interested in participating in research studies.

To examine the effect of syntactically based comprehension deficits on comprehension of passages with the sentence types described above, 18 PWA were tested for syntactically based comprehension of sentences in isolation using established methods (sentence-picture matching or sentence enactment tasks: Caplan et al., 2007). In sentence-picture matching, PWA were asked to select which of two pictures accurately depicted an auditorily presented, semantically reversible sentence. Foil pictures depicted the reversed thematic roles of the sentence. In object manipulation, PWA were asked to enact the meaning of the same set of sentences using paper dolls. A variety of sentence types were tested, including sentences with both canonical and non-canonical word order (for details of this battery see Kiran et al., In press). Results are shown in Table 1.

The remaining 20 PWA were tested on Set A of the DCT-R (Brookshire & Nicholas, 2008). Demographic and clinical data regarding these PWA are presented in Table 2. The DCT-R tests comprehension of main ideas and details within a text when stated either explicitly or implicitly. All sentences of the DCT-R are semantically constrained. DCT-R Set A passages are 195–210 words long. The DCT-R auditorily presents eight binary choice questions following each passage. Half of PWA in this group were presented the DCT-R followed by the TSEDC while the remaining half were presented the tests in the reverse order.

Procedure

All passages and questions in the TSEDC were digitally recorded by a male speaker in an anechoic chamber using SoundEdit Software and a Macintosh iBook computer. The passages were presented using E-prime software (Schneider, Eschmann & Zuccolotto, 2002) as a self-paced listening task, in which participants heard one sentence of the passage at a time and pressed a key to hear the next sentence. No text was shown on the computer screen during the passage. After the final sentence of each passage, a key press presented the first of four questions. Each question and the four associated multiple-choice responses were presented both auditorily and visually on a computer screen. Participants answered each question with a key press corresponding to the numerically assigned multiple-choice response (1–4). The response triggered the following question.

Following the presentation of a practice discourse to acclimate participants to the task, participants were presented with 4 simple passages and 5 complex passages, or vice-versa. Presentation of complex and simple passages was counterbalanced across participants so that each version of the passage was presented to approximately the same number of participants. Accuracy and response reaction times were recorded by the software for analysis. The accuracy of each question was coded as a binary variable (correct or incorrect). Listening times for each sentence were also collected. All testing was completed in one session.

Results

Analysis of Accuracy on the TSEDC

Table 3 presents the percentage of correct responses to the TSEDC questions by subject group and by factor. Group consists of the two levels PWA and Controls. Results of the two groups of PWA are also shown. The remaining three factors are Passage Complexity (Simple and Complex), referring to passages with canonical and non-canonical reversible sentences; Reversibility, consisting of the levels Reversible and Constrained, referring to the two types of sentences described above; and Explicitness, composed of the levels Explicit and Implicit. To determine the significance of these factors, accuracy data were analyzed using ordinary logit models (Jaeger, 2008) testing the effect of syntactic complexity and the effect of explicitness.

To test the hypothesis that semantically reversible sentences with a complex syntactic structure are less reliably understood by PWA than by controls, a Passage Complexity × Reversibility × Group ordinary logit model was computed. Because of the *apriori* expectation that reversible syntactically complex sentences would be more difficult than reversible syntactically simple sentences, while the constrained sentences in the simple and complex passages (which were identical) would not differ, separate Passage Complexity × Group ordinary logit model analyses for reversible and constrained sentences were computed. The results are summarized in Table 4.

The results of the Passage Complexity × Reversibility × Group model showed main effects of group, reversibility and passage complexity. Controls were more likely to answer questions correctly than PWA, questions pertaining to constrained sentences were more likely to be answered correctly than questions pertaining to reversible sentences, and questions pertaining to simple passages were more likely to be answered correctly than questions pertaining to complex passages. Additionally, there was a two-way interaction between reversibility and group, such that the effect of reversibility was less pronounced in controls than in PWA. The separate Passage Complexity × Group ordinary logit models for reversible and constrained sentences both showed main effects of group, and there was an effect of passage complexity only for reversible sentences (there were no interactions of Group and Passage Complexity) (Figure 1).

To test the hypothesis that explicitly stated information is more easily understood by PWA than implicitly stated information, whether or not it is presented in semantically reversible and syntactically complex sentences, a Reversibility × Explicitness × Group logistic regression was computed. The results are summarized in Table 5.

The results show a main effect of group, with controls more likely to answer questions correctly than PWA. Additionally, there was an interaction between reversibility and explicitness (Figure 2). Questions about constrained sentences conveying explicitly stated propositions were more likely to be answered correctly than questions about reversible sentences conveying explicitly stated propositions. Implicitly stated propositions exhibited equal comprehension accuracy when presented in reversible and constrained sentences.

Comprehension of sentences in isolation compared to sentences in the TSEDC

Analysis of the effect of complexity, reversibility and group were undertaken with the 30 normal participants and the 18 PWA who were tested for syntactically based comprehension of isolated sentences (Table 6). There were main effects of reversibility and group, but not of passage complexity. As when comparing all PWA to controls, there was an interaction between reversibility and group.

Comprehension of sentences in isolation was measured on sentences with canonical word order (actives) and non-canonical word order (the sum of number correct on passives, ORs, CRs, and unaccusatives) in the SPM and OM batteries. Correlations between these measures and different aspects of performance on the TSEDC are shown in Table 7. Correlations between a) overall performance on the batteries and overall performance on the TSEDC, b) overall performance on the batteries and overall performance on the complex and simple passages, and c) performance on canonical sentences in the batteries and overall performance on the complex and simple passages were all significant. Correlations between performance on canonical sentences in the SPM battery and reversible sentences in the simple passages and between performance on non-canonical sentences in both batteries and performance on the reversible sentences in the complex passages were significant.

Correlation of TSEDC and DCT-R responses

To examine the construct validity of the TSEDC, the TSEDC responses of the 20 PWA tested on the DCT-R were correlated with the responses to the DCT-R. Accuracy on TSEDC questions about each of four sentence types (Passage Complexity × Reversibility) was correlated with DCT-R accuracy. The explicit / implicit factor of the TSEDC was assumed to map onto the stated / implied factor of the DCT-R. Thus, accuracy on TSEDC questions about explicit propositions was correlated with accuracy on DCT-R stated questions, while accuracy on TSEDC questions about implicit propositions was correlated with accuracy on DCT-R implied questions. The main idea / detail factor of the DCT-R does not correspond to any TSEDC factors; therefore DCT-R accuracy was collapsed across main idea and detail questions.

Correlations with the DCT-R were significant for TSEDC questions about constrained sentences (in simple passages, $r = 0.46$, $R^2 = 0.21$, $p = 0.003$; in complex passages, $r = 0.63$, $R^2 = 0.40$, $p < 0.001$). Correlations with the DCT-R were non-significant for TSEDC questions about reversible sentences (in simple passages, $r = 0.15$, $R^2 = 0.02$, $p = 0.361$; in complex passages ($r = 0.18$, $R^2 = 0.03$, $p = 0.280$).

Discussion

The main effect of group indicates that controls perform better on the TSEDC than PWA. Given that comprehension of PWA is typically poorer than comprehension of healthy controls, this finding indicates that the TSEDC is a sensitive measure of general comprehension deficits typically seen in PWA.

The main effect of reversibility indicates that reversible sentences were less accurately understood than constrained sentences in these passages. Since constrained sentences were also contextually supported, this may reflect poorer comprehension of semantically reversible sentences or better understanding of contextually supported sentences; further work in which constrained sentences are not contextually supported or reversible sentences are contextually supported is needed to determine which of these explanations is correct (both mechanisms may be operative). The interaction between reversibility and group shows that semantically reversible sentences in these passages are less accurately understood by PWA than by healthy controls; again, this may reflect a greater beneficial effect of contextual support or a greater impairment in comprehension of reversible sentences in PWA than in controls.

The main effect of complexity indicates that discourses containing sentences presented exclusively with a simple syntactic structure are more accurately understood than discourses in which a subset of sentences are semantically reversible and have a complex syntactic structure -- the presence of as few as 2–3 semantically reversible syntactically complex sentences in a discourse adversely affects comprehension of the discourse. However, the effect of the manipulation of syntactic complexity in the reversible sentences is restricted to the comprehension of the reversible sentences; there is no “spill-over” effect on the comprehension of other sentences in the passage, as indicated in the second and third models of Table 4. The lack of an interaction between passage complexity and group indicates that this conclusion holds for both PWA and for healthy controls.

The lack of an interaction between passage complexity and reversibility in the first model of Table 4 is surprising. This interaction was expected to show that semantically reversible sentences with non-canonical word order are harder to understand than semantically reversible sentences with canonical word order, while the difficulty of semantically constrained and syntactically simple sentences does not differ as a function of the type of passage in which they are found. Such an effect of non-canonical word order has been robust in prior studies (see Grodzinsky, 2000 for review) and is alluded to in the second and third models of Table 4. To ensure that this lack of an interaction was not masked by inclusion of data from controls in the model, post-hoc analyses of patient data were run separately from controls by subgroup. There was no interaction between passage complexity and reversibility for PWA tested on sentences in isolation ($z = -1.69$; $p = 0.09$) nor for PWA tested on the DCT-R ($z = -0.66$; $p = 0.51$). The absence of this interaction requires further study.

The interaction between reversibility and explicitness showed that explicitly stated propositions were better understood when presented in constrained sentences than in reversible sentences, and that implicitly stated propositions were understood equally well when presented in reversible and constrained sentences. The effect of reversibility on questions about explicitly stated information indicates that the process of decoding the thematic roles in a reversible sentence is difficult. The absence of an effect of reversibility on questions about implicit information suggests that the difficulty of drawing inferences is a greater determinant of performance on questions than the difficulty associated with comprehending a sentence is.

The correlation of performance of PWA on sentences in isolation and on sentence types in the TSEDC shows that PWA performed similarly (relative to one another) on the same reversible sentence types (canonical, non-canonical) in the two contexts. In addition, performance on syntactically simple sentences was significantly correlated with overall performance on the TSEDC, as is expected given the canonical word order in most sentences in the TSEDC.

Significant correlations in accuracy between questions of the TSEDC and of the DCT-R would suggest that the sentences to which the questions refer either share common linguistic attributes or are processed within the discourse in a similar manner. Following this logic, the observation that the accuracy of TSEDC questions about constrained sentences correlates significantly with the accuracy of DCT-R questions indicates that the constrained sentences of the TSEDC share common linguistic attributes with all the sentences of the DCT-R. The reader will recall that all of the sentences in the DCT-R and the constrained sentences in the TSEDC are both semantically constrained and have meanings that are contextually supported by other sentences in the passage. These observations thus provide initial evidence for the construct validity of the TSEDC.

In contrast, the non-significant correlations between the accuracy of TSEDC questions about reversible sentences and the accuracy of DCT-R questions indicate that these two sets of sentences are not linguistically and/or psycholinguistically similar. Therefore, the unique feature of the TSEDC -- the presence of contextually unsupported semantically reversible sentences whose meanings must be determined through syntactic analysis – does in fact distinguish this test from other tests of discourse comprehension.

Conclusion

The TSEDC is a new test that investigates effects of reversibility, syntactic complexity and propositional explicitness upon sentence comprehension within discourse. Existing tests of discourse comprehension do not examine the combined effects of the first two of these three factors.

The results of this study demonstrate that the TSEDC is sensitive to previously documented differences in comprehension in both PWA and controls and in the effect of explicitly versus implicitly stated information in a discourse. The TSEDC also documents effects of the presence of semantically reversible and syntactically complex sentences on comprehension of discourses. Performance of PWA on the DCT-R correlates with their performance on the comparable, but not on the unique, parts of the TSEDC, providing initial evidence for the construct validity of the TSEDC. Future work will aim to establish the validity of the TSEDC more thoroughly with larger sample sizes and more advanced psychometric techniques such as factor analysis or structural equation modeling. The TSEDC may prove to be a useful tool for evaluating syntactically based comprehension deficits in discourse in persons with aphasia.

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Appendix A

Sample TSEDC Passages and Questions

Simple

Last night was Sam's first shift working as a train conductor.

His job was to ensure that the train arrive at the station safely and without incident.

Unfortunately, an incident occurred at a congested street crossing during rush hour.

There was an electricity blackout.

The train's engine and all the streetlights shut down.

The train blocked the traffic.

A car and a bicycle tried to force their way through.

Suddenly the electricity came back on.

The train started moving and caused a collision.

The car that had hit the train rolled over the bicycle.

Sam is no longer a train conductor.

Complex

Last night was Sam's first shift working as a train conductor.

His job was to ensure that the train arrive at the station safely and without incident.

Unfortunately, an incident occurred at a congested street crossing during rush hour.

There was an electricity blackout.

The train's engine and all the streetlights shut down.

The traffic was blocked by the train.

A car and a bicycle tried to force their way through.

Suddenly the electricity came back on.

The train started moving and caused a collision.

The train that the car had hit rolled over the bicycle.

Sam is no longer a train conductor.

Questions

Explicit: Constrained sentence

What time of day does this take place?

a. Morning; b. Afternoon; c. Evening; d. Night

Implicit: Constrained sentence

Why is Sam no longer a train conductor?

a. There was a collision; b. the train blocked the traffic; c. the traffic blocked the train; d. There was a blackout

Explicit: Reversible sentence

What happened during the collision?

a. the train hit the bicycle; b. the car hit the bicycle; c. the train rolled over the bicycle; d. the car rolled over the bicycle

Implicit: Reversible sentence

Why did a car and a bicycle try to force their way through?

a. There was a collision; b. the train blocked the traffic; c. the traffic blocked the train; d. There was a blackout.

Appendix

Appendix B

Coh-Metrix for all TSEDC Passages

Passage	Positive Additive connectives	Positive Temporal connectives	Adjacent argument overlap	Adjacent stem overlap	Argument overlap	Anaphor reference
Choking						
Simple	92.0	11.5	0.46	0.55	0.37	0.02
Complex	90.9	11.4	0.36	0.46	0.35	0.02
Sheriff						
Simple	43.5	8.70	0.40	0.30	0.46	0.13
Complex	42.7	8.56	0.40	0.30	0.46	0.13
Woods						
Simple	60.6	10.1	0.64	0.73	0.68	0.09
Complex	58.3	9.7	0.64	0.73	0.68	0.09
Park						
Simple	43.5	14.5	0.38	0.38	0.31	0.13
Complex	42.3	14.1	0.38	0.38	0.31	0.13
Party						
Simple	40.0	10.0	0.42	0.42	0.28	0.02
Complex	40.4	10.1	0.42	0.42	0.25	0.02
Train						
Simple	38.8	9.71	0.50	0.50	0.44	0.00
Complex	38.1	9.52	0.50	0.50	0.44	0.00
Racquet						
Simple	18.7	28.0	0.46	0.46	0.25	0.04
Complex	19.6	29.4	0.36	0.36	0.23	0.04
Dress						
Simple	38.1	19.0	0.50	0.50	0.43	0.12
Complex	42.1	21.1	0.46	0.46	0.35	0.13
Restaurant						
Simple	41.4	13.8	0.47	0.27	0.32	0.23
Complex	40.3	13.4	0.40	0.27	0.31	0.19

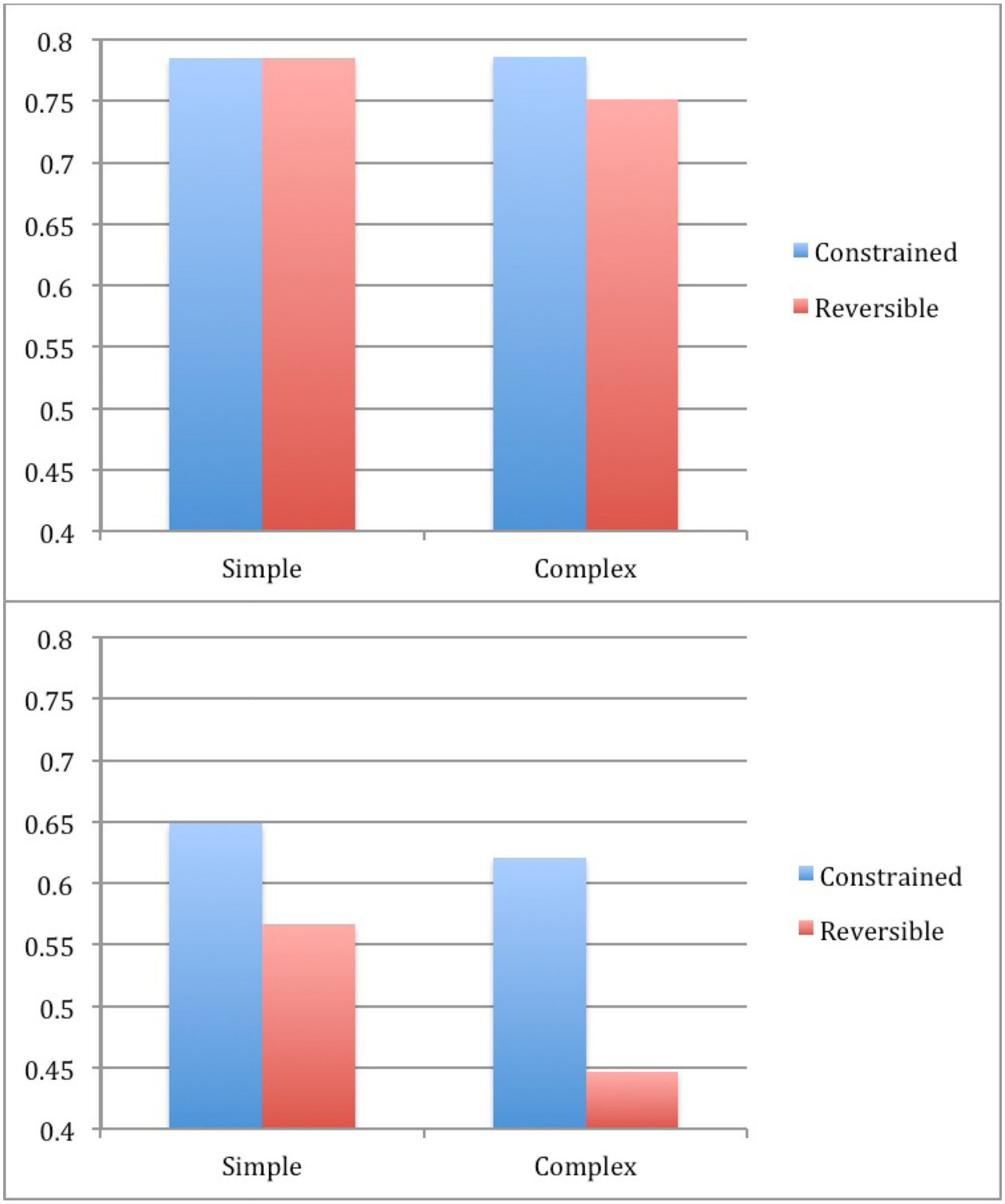

Figure 1.
Effect of Reversibility (Constrained, Reversible) as a function of Passage Complexity (Simple, Complex) in controls (top panel) and PWA (bottom panel).

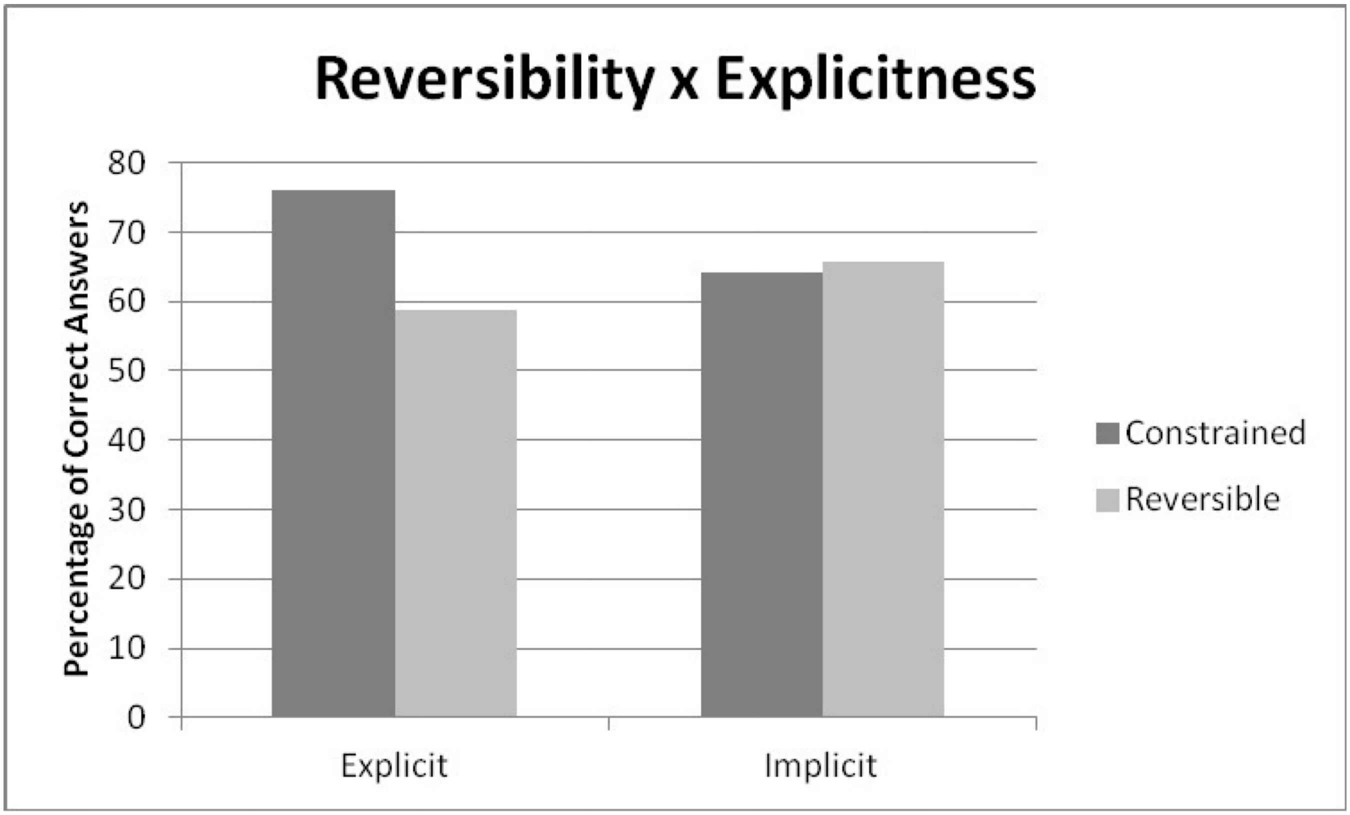

Figure 2.
Interaction of Explicitness and Reversibility, showing effect of reversibility only on questions about explicit propositions.

Table 1

Demographics and Comprehension Deficits of PWA tested for Syntactic Deficits on Sentences in Isolation

Subject #	Age	Gender	Months Post-Onset	Severity	Diagnosis	Sentence-Picture Matching Comprehension	Object Manipulation Comprehension	Years of Education	Racial Identity	WAB Auditory Verbal Comprehension Yes/No Questions	WAB Auditory Verbal Comprehension Sequential Commands
03	67	F	72	98	Anomic	83.64%	90.00%	N/A	White	100%	100%
05	54	M	111	75.4	Broca's	73.64%	54.55%	12	White	100%	77.5%
07	29	M	6	53.4	Broca's	47.27%	26.36%	12	Black	80%	58.75%
08	62	F	54	74.4	Transcortical Motor	42.73%	41.82%	16	White	100%	63.75%
10	65	M	60	N/A	N/A	85.45%	46.36%	18	White	N/A	N/A
11	59	M	147	71.4	Wernicke's	66.36%	39.09%	16	White	90%	33.75%
12	40	M	16	92.2	Anomic	88.2%	90.9%	16	Black	100%	100%
13	63	M	93	85.7	Anomic	51.82%	26.36%	16	White	95%	60%
14	63	M	96	N/A	N/A	52.73%	30.91%	18	White	N/A	N/A
15	59	M	18	78.6	Anomic	72.73%	62.73%	18	White	100%	78.75%
16	56	M	76	77.7	Conduction	51.82%	41.82%	18	White	90%	72.5%
17	73	F	36	N/A	N/A	62.73%	44.55%	14	White	N/A	N/A
18	58	M	8	N/A	N/A	95.45%	91.82%	20	White	N/A	N/A
20	45	M	15	93.8	Anomic	79.09%	77.27%	12	White	100%	93.75%
21	39	F	9	N/A	N/A	84.55%	89.09%	14	White	N/A	N/A
23	65	F	32	28.4	Broca's	48.18%	27.27%	18	White	70%	30%
24	59	M	6	90.2	Anomic	44.55%	20.00%	18	White	85%	77.5%
25	75	M	150	65.2	Wenicke's	50.91%	33.64%	18	White	100%	30%

Table 2

Profiles of PWA tested on the DCT-R

Subject #	Age	Gender	Months Post-Onset	Description	Diagnosis	Year of Education	Racial Identity
26	81	F	184	Mild Fluent	Anomic	16	White
28	25	F	25	Mild Fluent	Anomic	17	White
29	57	M	57	Mild Fluent	Anomic	12	White
30	83	F	80	Mild Fluent	Anomic	12	White
32	51	M	87	Mod-Severe Non-Fluent	Broca’s	16	White
33	65	M	49	Severe Mixed Non-Fluent	Severe Mixed Non-Fluent	18	White
34	65	M	26	Mild Fluent	Anomic with AOS	18	Black
35	59	M	65	Mild Fluent	Anomic	12	White
36	65	M	45	Moderate Fluent	Conduction	12	White
37	53	F	45	Moderate Non-Fluent	Broca’s	10	White
38	64	M	171	Moderate Fluent	Conduction	20	White
39	78	M	57	Mild-Moderate Fluent	Anomic	18	White
40	77	M	51	Mod-Severe Non-Fluent	Broca’s	16	White
41	54	M	22	Mod-Severe Non-Fluent	Broca’s	18	White
42	46	M	66	Mild-Moderate Fluent	Conduction	18	White
43	68	M	117	Moderate Non-Fluent	Transcortical Motor	16	White
44	60	M	35	Moderate Fluent	Conduction	14	White
45	67	F	114	Moderate Fluent	Anomic with AOS	12	Black
47	77	M	122	Mild Fluent	Anomic with AOS	16	White
48	66	F	58	Severe Non-Fluent	Global Aphasia	18	White

Table 3

Percentage of Correct Answers and Standard Errors by Subject Group and Condition

	Passage Complexity		Reversibility		Explicitness	
Group	**Simple**	**Complex**	**Constrained**	**Reversible**	**Explicit**	**Implicit**
Controls (30)	78.5%	76.9%	78.5%	76.9%	76.5%	78.9%
	(.02)	(.02)	(.02)	(.02)	(.02)	(.02)
PWA (38)	60.8%	53.4%	63.5%	50.7%	60.1%	54.1%
	(.02)	(.02)	(.02)	(.02)	(.02)	(.02)
Tested on DCTR (20)	62.2%	51.1%	63.1%	50.3%	59.2%	54.2%
	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)
Tested on Sentences in Isolation (18)	59.1%	55.9%	63.9%	51.2%	61.1%	54.0%
	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)

Table 4

Summary of the Ordinary Logit Models for All PWA & Controls

Predictor	Coefficient	SE Coefficient	*Z*	*P*
Reversible and Constrained Sentences				
Constant	−0.21	0.109	−1.95	0.051
Passage Complexity				
Simple	**0.48**	**0.154**	**3.13**	**0.002**
Reversibility				
Constrained	**0.70**	**0.156**	**4.51**	**<0.001**
Group				
Control	**1.32**	**0.179**	**7.38**	**<0.001**
Passage Complexity*Reversibility				
*Simple*Constrained*	−0.36	0.221	−1.64	0.102
Reversibility*Group				
Constrained*Control	**−0.51**	**0.259**	**−1.99**	**0.047**
Passage Complexity*Group				
*Simple*Control*	−0.30	0.256	−1.16	0.246
Passage Complexity*Reversibility*Group				
*Simple*Constrained*Control*	0.17	0.367	0.47	0.640
Reversible Sentences Only				
Constant	−0.69	0.201	−3.45	0.001
Passage Complexity				
Simple	**0.34**	**0.134**	**2.57**	**0.01**
Group				
Control	**1.32**	**0.202**	**6.53**	**<0.001**
Passage Complexity*Group				
*Simple*Control*	0.32	0.268	−1.18	0.2
Constrained Sentences Only				
Constant	−1.17	0.350	−3.37	0.001
Passage Complexity				
Simple	0.06	0.141	0.47	0.64
Group				
Control	**0.89**	**0.198**	**4.51**	**<0.001**
Passage Complexity*Group				
*Simple*Control*	0.14	0.283	−0.48	0.6

Note. Factors whose p-values are less ≤ 0.05 are in boldface.

Table 5

Summary of the Ordinary Logit Model for all PWA & Controls

Predictor	Coefficient	SE Coefficient	*Z*	*P*
Constant	0.13	0.108	1.19	0.235
Reversibility				
Constrained	0.07	0.153	0.46	0.645
Explicitness				
Explicit	0.20	0.153	−1.30	0.194
Group				
Control	**1.38**	**0.192**	**7.19**	**<0.001**
Reversibility*Explicitness				
Constrained*Explicit	**0.94**	**0.223**	**4.22**	**<0.001**
Explicitness*Group				
*Explicit*Control*	−0.37	0.258	−1.43	0.152
Reversibility*Group				
*Constrained*Control*	−0.43	0.262	−1.63	0.102
Reversibility*Explicitness*Group				
*Constrained*Explicit*Control*	−0.06	0.371	−0.17	0.866

Note. Factors whose p-values are less ≤ 0.05 are in boldface.

Table 6

Summary of the Ordinary Logit Model for PWA tested on sentences in isolation & Controls

Predictor	Coefficient	SE Coefficient	*Z*	*P*
Constant	−0.15	0.159	−0.95	0.343
Passage Complexity				
Simple	0.40	0.223	1.77	0.077
Reversibility				
Constrained	**0.80**	**0.230**	**3.47**	**0.001**
Group				
Control	**1.26**	**0.213**	**5.92**	**<0.001**
Passage Complexity*Reversibility				
*Simple*Constrained*	−0.54	0.322	−1.69	0.091
Reversibility*Group				
Constrained*Control	**−0.61**	**0.309**	**−1.96**	**0.050**
Passage Complexity*Group				
*Simple*Control*	−0.21	0.303	−0.70	0.486
Passage Complexity*Reversibility*Group				
*Simple*Constrained*Control*	0.35	0.435	0.81	0.416

Note. Factors whose p-values are less ≤ 0.05 are in boldface.

Table 7

Correlation of performance of PWA on the SPM and OM sentence batteries and on the TSEDC

TSEDC	SPM Overall		OM Overall	
		A		
Overall	**r = .71; R^2 = .51; p = .001**		**r = .75; R^2 = .56; p < .001**	
		B		
Simple	**r = .64; R^2 = .41; p = .004**		**r = .64; R^2 = .41; p = .004**	
Complex	**r = .54; R^2 = .29; p = .021**		**r = .64; R^2 = .41; p = .004**	
	SPM Simple	SPM Complex	OM Simple	OM Complex
		C & D		
Simple	**r = .69; R^2 = .47; p = .002**	r = .46; R^2 = .21; p = .055	**r = .71; R^2 = .51; p = .001**	r = .40; R^2 = .16; p = .099
Complex	**r = .52; R^2 = .27; p = .029**	r = .47; R^2 = .22; p = .051	**r = .51; R^2 = .26; p = .030**	**r = .60; R^2 = .36; p = .009**
		E & F		
Reversible Simple	**r = .58; R^2 = .34; p = .011**	**r = .47; R^2 = .22; p = .048**	r = .45; R^2 = .20; p = .062	r = .43; R^2 = .18; p = .079
Reversible Complex	r = .44; R^2 = .19; p = .070	**r = .56; R^2 = .32; p = .015**	**r = .59; R^2 = .35; p = .010**	**r = .57; R^2 = .32; p = .014**

Note. A = overall performance on the batteries and overall performance on the TSEDC; B = overall performance on the batteries and performance on the complex and simple passages; C = performance on the simple sentences in the batteries and performance on the complex and simple passages; D = performance on the complex sentences in the batteries and performance on the complex and simple passages; E = performance on the simple sentences in the batteries and performance on the reversible sentences in the complex and simple passages; F = performance on the complex sentences in the batteries and performance on the reversible sentences in the complex and simple passages

Note. Cells whose p-values are less ≤ 0.05 are in boldface.