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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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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 comprehension of 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. A discourse task was developed to assess the effect of syntactic complexity, among other factors, on discourse comprehension in PWA.
Method: Thirty-eight PWA and 30 neurologically healthy control participants 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 4 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 test correlated positively with comprehension accuracy on an existing test.
Conclusion: The presence of semantically reversible, syntactically complex sentences in a passage affects comprehension of the passage in both PWA and neurologically healthy individuals.

Key Words: aphasia, discourse analysis, syntax, functional communication assessment

Persons with aphasia (PWA) often have difficulty assigning thematic roles to noun phrases (NPs) in sentences when two conditions are met: (a) The sentence is "semantically reversible"; that is, either NP could reasonably play either thematic role around the verb; and (b) the sentence has a noncanonical word order (e.g., Ansell & Flowers, 1982; Caplan & Futter, 1986; Caramazza & Zurif, 1976; Grodzinsky, 1989). In English, the thematic role of <agent> is canonically assigned to the preverbal subject position, and the role of <patient> is canonically assigned to the postverbal object position. Thus, PWA often have trouble understanding sentences such as Example 1b but not Example 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 noncanonical word order are considered to have deficits in syntactically based comprehension. The reasons for such deficits are topics of research (see Caplan, Waters, DeDe, Michaud, & Reddy, 2007; Grodzinsky, 2000, for a discussion of some accounts).

To the best of our knowledge, no research has been conducted on the effect of the syntactic complexity of semantically reversible sentences on comprehension of discourse in PWA. One of the few studies of the effect of syntactic

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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 order; in the paired narrative, the sentences were presented exclusively with noncanonical word order. Caplan and Evans (1990) found that even among PWA with documented syntactic deficits, discourse comprehension was unaffected by the presence of sentences with noncanonical word order. However, Caplan and Evans' 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 examined the effect of semantically reversible sentences with noncanonical word order on discourse comprehension in PWA.

The present study also examined other factors that are known to affect discourse comprehension in PWA. Brookshire and Nicholas (1984, 1993, 2008; Nicholas & Brookshire, 1995) found that PWA answer questions about main ideas more accurately than they do questions about details. PWA also answer questions about propositions that are explicitly stated more accurately than they do propositions that are implied. Brookshire and Nicholas's tests, 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 individuals' 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 discourse in PWA provide measures of comprehension that can be incorporated into any new test of discourse comprehension. The tests developed by Brookshire and Nicholas also provide materials against which the performance of PWA on a new test of discourse comprehension can be compared. We capitalized on these results to validate the test of discourse comprehension that we developed.

The present study addressed the question of whether there is an effect of syntactic complexity on comprehension of discourse that contains semantically reversible sentences with noncanonical word order. In order to address this question, we devised a Test of Syntactic Effects on Discourse Comprehension (TSEDC). This paper describes the development of the test and the effects of manipulating syntactic complexity and semantic reversibility on discourse comprehension. The TSEDC 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.

Method

Materials

We created nine pairs of passages ranging in length from 9 to 16 sentences (69–149 words). The two versions were identical aside from two to three semantically reversible sentences, which differed in word order in the two versions. In the *syntactically simple* version of a passage, the reversible sentences were presented in canonical word order; in the *syntactically complex* version of a passage, the reversible sentences were presented in noncanonical word order. The remaining sentences were syntactically simple actives and were semantically constrained. We will refer to passages containing reversible sentences in canonical word order as *simple* passages and to passages containing reversible sentences in noncanonical 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; the second type of sentence has noncanonical word order. Examples of the four pairs are shown in Examples 2 through 5.

Active: The man hugged the boy.
Passive: The boy was hugged by the man. (2)

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

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

Transitive: The boy was shaking the girl.
Unaccusative: The boy was shaking. (5)

Like active and transitive sentences, the embedded clauses of the SR and SC sentences have canonical word order. Passives have noncanonical word order in the main clause, and OR and OC sentences have noncanonical 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 of the sentence types with noncanonical word order than with the sentence types with canonical word order (for passive, OR, and OC, see references above; for unaccusative sentences, see Lee & Thompson, 2004, and McAllister, Bachrach, Waters, Michaud, & Caplan, 2009). Comparison of comprehension of the reversible *sentences* with noncanonical word order to comprehension of the reversible sentences with canonical word

order allows us to determine whether these features of sentences affect the 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 noncanonical word order to comprehension of the passages with reversible sentences with canonical word order allows us to determine whether the presence of these sentences affects the ability of PWA to comprehend 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 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, although the semantically constrained sentences were occasionally embellished with temporal or thematic connectives (e.g., *suddenly* or *unfortunately*) to facilitate narrative pragmatics, the 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 measuring passage cohesion using Coh-Metrix software (Graesser et al., 2004). These measures are reported in Appendix B. These indices serve as measures of passage cohesion. For example, a passage containing Example 6b would have greater cohesion than a passage containing Example 6a due to the presence of a referential pronoun. If the thematic role of <patient> was 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 Example 6a.

a. The boy kicked the girl in the shin.
b. The boy kicked the girl in her shin. (6)

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 either was 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 (a) a constrained sentence conveying an explicitly stated proposition, (b) a constrained sentence conveying an implicitly stated proposition, (c) a reversible sentence conveying an explicitly stated proposition, and (d) 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 that had been 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 that was presented in the passage, as opposed to a reliance on world knowledge or information that was presented in the other questions, the passage dependency of each question was measured (Tuinman, 1974). The passage dependency of the questions was measured by presenting the questions to 19 healthy controls before and following 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 >60%.

Participants

Thirty-eight PWA ages 25–83 years (M_{age} = 61 years) and 30 control participants ages 27–82 years (M_{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 (SLP). The basis for the diagnosis varied as a function of the institution where each PWA was seen for clinical purposes, and included diagnostics such as the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) and the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983). 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 was thus a sample of PWA who were interested in participating in research studies.

To examine the effect of syntactically based comprehension deficits on the 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 noncanonical word order (for details of this battery, see Kiran et al., 2012). Demographic and clinical data for the 18 PWA who were tested for syntactically based comprehension of sentences in isolation are shown in Table 1.

The remaining 20 PWA were tested on Set A of the DCT–R. 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

TABLE 1. Demographic and clinical data for the 18 persons with aphasia (PWA) who were tested for syntactically based comprehension of sentences in isolation.

Participant	Age (in years)	Gender	Months post onset	Severity	Diagnosis	Sentence-picture matching comprehension	Object manipulation comprehension	Education (in years)	Racial identity	WAB auditory verbal comprehension yes/no questions	WAB auditory verbal comprehension sequential commands
03	67	Female	72	98.0	Anomic	83.64%	90.00%	N/A	White	100%	100.00%
05	54	Male	111	75.4	Broca's	73.64%	54.55%	12	White	100%	77.50%
07	29	Male	6	53.4	Broca's	47.27%	26.36%	12	Black	80%	58.75%
08	62	Female	54	74.4	Transcortical motor	42.73%	41.82%	16	White	100%	63.75%
10	65	Male	60	N/A	N/A	85.45%	46.36%	18	White	N/A	N/A
11	59	Male	147	71.4	Wernicke's	66.36%	39.09%	16	White	90%	33.75%
12	40	Male	16	92.2	Anomic	88.20%	90.90%	16	Black	100%	100.00%
13	63	Male	93	85.7	Anomic	51.82%	26.36%	16	White	95%	60.00%
14	63	Male	96	N/A	N/A	52.73%	30.91%	18	White	N/A	N/A
15	59	Male	18	78.6	Anomic	72.73%	62.73%	18	White	100%	78.75%
16	56	Male	76	77.7	Conduction	51.82%	41.82%	18	White	90%	72.50%
17	73	Female	36	N/A	N/A	62.73%	44.55%	14	White	N/A	N/A
18	58	Male	8	N/A	N/A	95.45%	91.82%	20	White	N/A	N/A
20	45	Male	15	93.8	Anomic	79.09%	77.27%	12	White	100%	93.75%
21	39	Female	9	N/A	N/A	84.55%	89.09%	14	White	N/A	N/A
23	65	Female	32	28.4	Broca's	48.18%	27.27%	18	White	70%	30.00%
24	59	Male	6	90.2	Anomic	44.55%	20.00%	18	White	85%	77.50%
25	75	Male	150	65.2	Wernicke's	50.91%	33.64%	18	White	100%	30.00%

Note. WAB = Western Aphasia Battery (Kertesz, 1982).

TABLE 2. Demographic and clinical data for the 20 PWA who were tested on the Discourse Comprehension Test—Revised (DCT–R; Brookshire & Nicholas, 2008).

Participant	Age (in years)	Gender	Months post onset	Description	Diagnosis	Education (in years)	Racial identity
26	81	Female	184	Mild fluent	Anomic	16	White
28	25	Female	25	Mild fluent	Anomic	17	White
29	57	Male	57	Mild fluent	Anomic	12	White
30	83	Female	80	Mild fluent	Anomic	12	White
32	51	Male	87	Mod–Severe nonfluent	Broca's	16	White
33	65	Male	49	Severe mixed nonfluent	Severe mixed nonfluent	18	White
34	65	Male	26	Mild fluent	Anomic with AOS	18	Black
35	59	Male	65	Mild fluent	Anomic	12	White
36	65	Male	45	Moderate fluent	Conduction	12	White
37	53	Female	45	Moderate nonfluent	Broca's	10	White
38	64	Male	171	Moderate fluent	Conduction	20	White
39	78	Male	57	Mild-Moderate fluent	Anomic	18	White
40	77	Male	51	Mod-Severe nonfluent	Broca's	16	White
41	54	Male	22	Mod-Severe nonfluent	Broca's	18	White
42	46	Male	66	Mild-Moderate fluent	Conduction	18	White
43	68	Male	117	Moderate nonfluent	Transcortical motor	16	White
44	60	Male	35	Moderate fluent	Conduction	14	White
45	67	Female	114	Moderate fluent	Anomic with AOS	12	Black
47	77	Male	122	Mild fluent	Anomic with AOS	16	White
48	66	Female	58	Severe nonfluent	Global aphasia	18	White

Note. AOS = apraxia of speech.

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 the PWA in this group were presented the DCT–R followed by the TSEDC; 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 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 the computer screen. Participants answered each question with a key press corresponding to the numerically assigned multiple-choice response (1–4). The response triggered the next question.

Following the presentation of a practice discourse to acclimate participants to the task, participants were presented with four simple passages and five complex passages, or vice versa. Presentation of simple and complex 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 recorded. 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 participant group and by factor. Group consists of the two subgroups of PWA and the controls. The remaining three factors are passage complexity (simple and complex), referring to passages with canonical and

TABLE 3. Percentage of correct responses (and standard errors) to the Test of Syntactic Effects on Discourse Comprehension (TSEDC) by participant group and factor.

	Passage complexity		Reversibility		Explicitness	
Group	Simple	Complex	Constrained	Reversible	Explicit	Implicit
Controls (30)	78.5 (.02)	76.9 (.02)	78.5 (.02)	76.9 (.02)	76.5 (.02)	78.9 (.02)
PWA (38)	60.8 (.02)	53.4 (.02)	63.5 (.02)	50.7 (.02)	60.1 (.02)	54.1 (.02)
Tested on DCT–R (20)	62.2 (.03)	51.1 (.03)	63.1 (.03)	50.3 (.03)	59.2 (.03)	54.2 (.03)
Tested on sentences in isolation (18)	59.1 (.03)	55.9 (.03)	63.9 (.03)	51.2 (.03)	61.1 (.03)	54.0 (.03)

noncanonical 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 a priori expectation that reversible syntactically complex sentences would be more difficult than reversible syntactically simple sentences, and 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 passage complexity, reversibility, and group. Questions pertaining to simple passages were more likely to be answered correctly than questions pertaining to complex passages, questions pertaining to constrained sentences were more likely to be answered correctly than questions pertaining to reversible sentences, and controls were more likely to answer questions correctly than PWA. 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 the information is presented in semantically reversible and syntactically complex sentences, a Reversibility × Explicitness × Group logistic regression was computed. The results are summarized in Table 5.

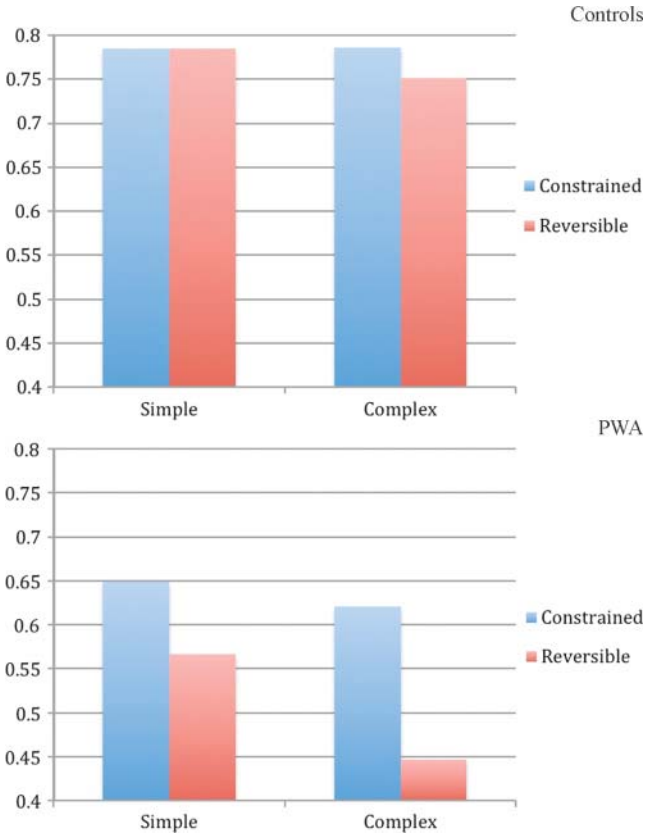
The results show a main effect of group, with controls being more likely to answer questions correctly than PWA. Additionally, there was an interaction between reversibility and explicitness (Figure 2). Questions about constrained sentences conveying explicitly stated propositions were

TABLE 4. Summary of the ordinary logit models for all PWA and controls (Passage Complexity × Reversibility × Group).

Predictor	Coefficient	SE coefficient	*z*	*p*
Reversible and constrained sentences				
Constant	–0.21	0.109	–1.95	.051
Passage Complexity Simple	**0.48**	**0.154**	**3.13**	**.002**
Reversibility Constrained	**0.70**	**0.156**	**4.51**	**<.001**
Group Control	**1.32**	**0.179**	**7.38**	**<.001**
Passage Complexity × Reversibility Simple × Constrained	–0.36	0.221	–1.64	.102
Reversibility × Group Constrained × Control	**–0.51**	**0.259**	**–1.99**	**.047**
Passage Complexity × Group Simple × Control	–0.30	0.256	–1.16	.246
Passage Complexity × Reversibility × Group Simple × Constrained × Control	0.17	0.367	0.47	.640
Reversible sentences only				
Constant	–0.69	0.201	–3.45	.001
Passage Complexity Simple	**0.34**	**0.134**	**2.57**	**.01**
Group Control	**1.32**	**0.202**	**6.53**	**<.001**
Passage Complexity × Group Simple × Control	0.32	0.268	–1.18	.2
Constrained sentences only				
Constant	–1.17	0.350	–3.37	.001
Passage Complexity Simple	0.06	0.141	0.47	.64
Group Control	**0.89**	**0.198**	**4.51**	**<.001**
Passage Complexity × Group Simple × Control	0.14	0.283	–0.48	.6

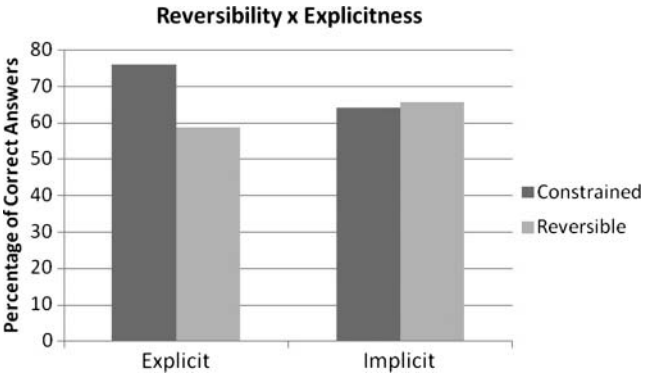
Note. Factors whose *p* values are ≤.05 appear bold.

FIGURE 1. Effect of reversibility (constrained, reversible) as a function of passage complexity (simple, complex) in controls (top panel) and persons with aphasia (PWA) (bottom panel).



more likely to be answered correctly than were questions about reversible sentences conveying explicitly stated propositions. Implicitly stated propositions exhibited equal comprehension accuracy when they were presented in reversible and constrained sentences.

FIGURE 2. Interaction of explicitness and reversibility, showing the effect of reversibility only on questions about explicit propositions.



Comprehension of Sentences in Isolation Compared to Sentences in the TSEDC

Analyses of the effect of complexity, reversibility, and group were undertaken with the 30 control 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 the 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, COs, and unaccusatives) in the sentence-picture matching (SPM) and object manipulation (OM) batteries of Kiran et al. (2012). 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

TABLE 5. Summary of the ordinary logit model for all PWA and controls (Reversibility × Explicitness × Group).

Predictor	Coefficient	SE coefficient	*z*	*p*
Constant	0.13	0.108	1.19	.235
Reversibility Constrained	0.07	0.153	0.46	.645
Explicitness Explicit	–0.20	0.153	–1.30	.194
Group Control	**1.38**	**0.192**	**7.19**	**<.001**
Reversibility × Explicitness Constrained × Explicit	**0.94**	**0.223**	**4.22**	**<.001**
Explicitness × Group Explicit × Control	–0.37	0.258	–1.43	.152
Reversibility × Group Constrained × Control	–0.43	0.262	–1.63	.102
Reversibility × Explicitness × Group Constrained × Explicit × Control	–0.06	0.371	–0.17	.866

Note. Factors whose *p* values are ≤.05 appear bold.

TABLE 6. Summary of the ordinary logit model for PWA tested on sentences in isolation and controls.

Predictor	Coefficient	SE coefficient	*z*	*p*
Constant	–0.15	0.159	–0.95	.343
Passage Complexity Simple	0.40	0.223	1.77	.077
Reversibility Constrained	**0.80**	**0.230**	**3.47**	**.001**
Group Control	**1.26**	**0.213**	**5.92**	**<.001**
Passage Complexity × Reversibility Simple × Constrained	–0.54	0.322	–1.69	.091
Reversibility × Group Constrained × Control	**–0.61**	**0.309**	**–1.96**	**.050**
Passage Complexity × Group Simple × Control	–0.21	0.303	–0.70	.486
Passage Complexity × Reversibility × Group Simple × Constrained × Control	0.35	0.435	0.81	.416

Note. Factors whose *p* values are ≤.05 appear bold.

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 noncanonical 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 who were 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, and 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, $r = 0.46$, $R^2 = 0.21$, $p = .003$; in complex passages, $r = 0.63$, $R^2 = 0.40$, $p < .001$. Correlations with the DCT–R were

TABLE 7. Correlation of performance of PWA on the sentence-picture matching (SPM) and object manipulation (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. Cells whose *p* values are ≤.05 appear bold.

nonsignificant for TSEDC questions about reversible sentences: in simple passages, $r = 0.15$, $R^2 = 0.02$, $p = .361$; in complex passages, $r = 0.18$, $R^2 = 0.03$, $p = .280$.

Discussion

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

The main effect of reversibility indicates that reversible sentences were less accurately understood than constrained sentences in these passages. Because 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 were less accurately understood by PWA than by neurologically 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 that were presented exclusively with a simple syntactic structure were more accurately understood than discourses in which a subset of sentences was semantically reversible and had a complex syntactic structure—the presence of as few as two to three 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 held for both the PWA and the neurologically healthy controls.

The lack of an interaction between passage complexity and reversibility in the first model of Table 4 is surprising. We expected this interaction to show that semantically reversible sentences with noncanonical word order were harder to understand than semantically reversible sentences with canonical word order, while the difficulty of semantically constrained and syntactically simple sentences did not differ as a function of the type of passage in which they were found. Such an effect of noncanonical 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 participant data were run separately from controls by subgroup. There was no interaction between passage complexity and reversibility for the PWA who were tested on sentences in isolation ($z = –1.69$; $p = .09$), nor for the PWA who were tested on the DCT–R ($z = –0.66$; $p = .51$). The absence of this interaction requires further study.

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

The correlation of performance of PWA on sentences in isolation and on sentence types in the TSEDC shows that the PWA performed similarly (relative to one another) on the same reversible sentence types (canonical, noncanonical) in the two contexts. In addition, performance on syntactically simple sentences was significantly correlated with overall performance on the TSEDC, as was 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 correlated significantly with the accuracy of DCT–R questions indicates that the constrained sentences of the TSEDC share common linguistic attributes with all of 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 were both semantically constrained and had meanings that were contextually supported by other sentences in the passage. These observations thus provide initial evidence for the construct validity of the TSEDC.

In contrast, the nonsignificant correlations between the accuracy of TSEDC questions about reversible sentences and the accuracy of DCT–R questions indicate that these two sets of sentences were 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—did in fact distinguish this test from other tests of discourse comprehension.

Conclusion

The TSEDC is a new test that investigates the effects of reversibility, syntactic complexity, and propositional explicitness on 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 discourse. The TSEDC also documents effects of the presence of semantically reversible and syntactically complex sentences on the comprehension of discourse. 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 PWA.

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Appendix A

Sample Passages and Questions From the Test of Syntactic Effects on Discourse Comprehension (TSEDC)

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 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

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