Introduction

People with aphasia (PWA) often have impairments in sentence comprehension. Factor analysis (FA) is an analytic technique that is useful in characterizing the structure underlying these deficits. FA can show whether performance across a range of sentence types is attributable to a single latent construct or whether several such constructs are needed to account for performance. Caplan et al. (1985, 1996) showed that a single factor accounted for most of the variance in a group of PWA's accuracy on a range of sentence types, but these analyses were limited because they were based on accuracy data derived from one of task. The present study examined the underlying structure of a dataset that included five tasks and two types of measures: accuracy and response time.

Methods

Participants

42 PWA with single left hemisphere strokes and 25 non-brain damaged controls participated in the study. All were native English speakers. Participant characteristics are given in table 1. PWA completed background testing to ensure adequate single word comprehension to complete the tasks and to characterize their aphasic symptoms.

Procedure

Each participant completed five tasks. Two -- object manipulation (OM) and sentence picture matching (SPM) with whole sentence presentation -- assessed end-of-sentence comprehension. A grammaticality judgment task (GJ) was used with whole sentence presentation to assess the appreciation of grammatical well-formedness. On-line syntactic processing was assessed with the Auditory Moving Windows (AMW) technique (Ferreira et al., 1996). AMW presentation was used with two tasks -- sentence-picture matching and grammaticality judgment -- in separate experiments.

In the OM task, participants listened to sentences and indicated thematic roles and co-indexation by manipulating paper dolls. Responses were scored for accuracy.

In the whole sentence SPM task, participants listened to sentences and chose the drawing that matched the sentence by pressing a button on a timer interfaced with the computer. Responses were scored for accuracy and reaction time (RT).

In the whole sentence GJ task, participants listened to sentences and indicated whether they were grammatical by pressing a button on a timer interfaced with the computer. Responses were scored for accuracy and RT.

In the on-line tasks (SPM & GJ), the participants paced their way through the sentences by pressing a button on the response box interfaced with the computer, and, depending on the task, did either SPM or GJ. RT's for each button press and accuracy on the associated task were recorded.

Here we report on end-of-sentence accuracy and RT data from the 5 tasks.

Stimuli

Participants were tested on three types of constructions -- active/passive; subject/object relative; baseline sentences/sentences with reflexives -- using two pairs of baseline/experimental constructions for each contrast. Sentences in each contrast were generated in pairs to control for effects of lexical frequency and semantic meaning. There were 10 exemplars of each sentence type. Examples of sentence types are given in table 2.

Pictures in the SPM tasks were line drawings depicting the actors and actions in the correct and reversed thematic roles (foils). In the GJ tasks, additional sentence types that

violated syntactic rules of well-formedness were included in the experiment. Examples are included in table 2.

Sentences were recorded, and digitized using SoundEdit (Dunn, 1994). Stimuli for the AMW tasks were broken into words, also using SoundEdit. The waveforms were then entered into Psyscope (Cohen, MacWhinney, Flatt, & Provost, 1993) to create the experiment, which was run with a Macintosh PowerPC laptop.

Results

Exploratory factor analyses were performed on the correlation matrices derived from the patients' accuracy on each sentence in each task, and from the mean RTs for correctly interpreted sentences in each task for patients and controls. Factor analyses were not performed on the accuracy data from the control participants because accuracy was very high with little variance and the data showed multiple collinearity. Factors that accounted for a significant amount of variance (eigenvalues > 1; Kaiser's rule) were retained, and sentences were considered to contribute significantly to a factor if they loaded on that factor with a value of .40 or greater.

The eigenvalues and sentence type loadings for retained factors in the unrotated factor analysis of accuracy in each task are presented in Table 3. Two factors were retained in four cases, accounting for about 90% of the variance; in the SPM-whole sentence, the first factor alone accounted for 85% of the variance and was the only one retained. In the analyses with two retained factors, the first factor accounted for two-thirds to three-quarters of the variance. In all analyses, all sentence types loaded on the first factor at a level of .40 (except PT in object manipulation, with a value of .36). None of the retained second factors had sentence type loadings that correspond to linguistically interpretable sets of sentences.

Factors under Varimax rotation differed from the unrotated factors in three main ways: more factors were retained as significant contributors to the variance; the first factor accounted for less of the variance; and fewer sentence types loaded on the first factor. Only one of the rotated factors contained sentence loadings that correspond to sets of sentences with structural and/or parsing features in common. The second factor in the rotated analysis of GJ with whole sentence presentation generally distinguished sentences with two NP's (A, PF, PT, CS and CO sentences) from other sentence types.

Factor analyses were performed on the end-of-sentence RT data for the four tasks in which these data are available, separately for controls and patients (Table 4). In all eight unrotated analyses, the first factor was the only one retained, and all sentence types loaded on that factor. The rotated factors did not contain loadings that corresponded to sets of sentences with structural and/or parsing features in common.

Discussion

These analyses suggest that the main determinant of performance is a process that applies equally to all sentence types. This structure was observed not only in patients' accuracy data, but also in end-of-sentence RT data for patients and controls, suggesting that the groups differ qualitatively but not quantitatively (Dick et al, 2001). We conclude that the factor structure is not determined to any significant extent by individual variation in the ability to determine the structure and meaning of specific sentence types, but by a function that affects performance on all sentence types. Variability in available working memory/processing resources is a possible candidate for such a function.

References

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Table 1: Participant Information

	N	# Female	Age	Education
People with aphasia	42	16	Mean: 60.3 Range: 25-85	Mean: 14.7 Range: 9-22
Control	25	17	Mean: 68.9 Range: 53-90	Mean: 14 Range: 9-21

Table 2: Sentence Types

Abbreviation	Sentence Type	Example
A	Active	The father hit the man.
CO	Cleft Object	It was the mother who the girl kissed.
CS	Cleft Subject	It was the boy who tickled the aunt.
PF	Passive Full	The boy was kissed by the girl.
PT	Passive Truncated	The uncle was bitten.
RG	Reflexive Genitive	The wife of the man squeezed herself.
RGB	Reflexive Genitive Baseline	The brother of the woman tickled the wife.
RP	Reflexive Possessive	The girl's father hugged himself.
RPB	Reflexive Possessive Baseline	The woman's brother tickled the wife.
SO	Subject Object	The father who the girl hugged kicked the man.
SS	Subject Subject	The woman who squeezed the man followed the girl.
Foils for Grammaticality Judgment Task		
Active Passive Unacceptable		The mother was kicked the boy.
Cleft Subject/ Cleft Object		It was the girl who the man hugged the father.
Reflexive Genitive		The sister of the man kissed himself.
Reflexive Possessive		The woman's brother tickled herself.
Subject Subject/ Subject Object		The girl who the man hugged the father kicked the man.

Table 3: Factor loadings for Accuracy Data (Patients, Unrotated factor analyses)

	OM		SPM-Full	GJ - Full		SPM - AMW		GJ - AMW	
	F1	F2	F1	F1	F2	F1	F2	F1	F2
Eigen-value	5.4	1.2	6.7	6.8	1.8	5.9	1.3	7.1	1.3
Proportion Variance Explained	.74	.16	.85	.68	.18	.73	.17	.74	.13
Sentence Type									
A	.64	-.36	.82	.77	-.57	.40	.70	.78	.56
PF	.73	-.35	.84	.75	-.59	.87	-.29	.75	.63
PT	.36	.54	.73	.81	-.48	.74	.04	.74	.42
RG	.74	.40	.78	.79	.45	.80	-.16	.79	-.31
RGB	.87	-.30	.79	.68	.50	.79	-.48	.76	-.31
RP	.52	.54	.74	.77	.40	.65	.22	.89	-.11
RPB	.90	-.25	.78	.81	.48	.67	.30	.88	-.14
CO	.78	-.02	.91	.86	-.09	.91	-.11	.77	-.32
CS	.60	.03	.81	.82	-.12	.63	.32	.79	-.26
SO	.66	.13	.70	.79	.01	.86	-.29	.90	-.11
SS	.71	.16	.61	.79	.05	.61	.42	.81	.02

Table 4: Factor loadings for RT Data - Unrotated factor analyses
PWA = Patients with Aphasia, Cont = Non-brain damaged control group

	GJ-AMW		GJ-Full		SPM-AMW		SPM-Full	
	PWA	Cont	PWA	Cont	PWA	Cont	PWA	Cont
Eigen-value	7.46	6.78	9.31	8.39	7.08	7.96	7.74	8.95
Proportion Variance Explained	.79	.78	.93	.83	.81	.80	.84	.92
Sentence Type								
A	67	71	96	87	85	95	90	93
PF	94	86	94	92	85	95	83	94
PT	74	64	85	87	39	70	81	88
RG	93	83	89	87	87	82	67	86
RGB	79	87	89	90	83	87	83	96
RP	85	82	91	89	73	85	81	87
RPB	90	78	92	94	91	81	89	92
CO	75	81	94	75	84	76	90	93
CS	85	86	94	89	82	93	94	93
SO	87	77	96	77	70	87	73	84
SS	72	65	91	90	90	81	87	84