Korean Passive Sentence Comprehension Deficits and its Relation to Working Memory Capacity in Persons with Aphasia

Abstract

The current study investigated Korean passive sentence comprehension deficits in aphasia and its underlying processing mechanisms using three types of syntactic structures: 1) active sentences with a 2-argument structure, 2) active sentences with a 3-argument structure, and 3) passive counterparts of active sentences with a 2-argument structure. Persons with aphasia showed differentially greater difficulties in passive than 2-place active sentences compared to the normal elderly adults, but the group differences were not significant between the passive and 3-place active sentences. Working memory, not the short-term memory, was significantly correlated with overall aphasia severity and performance on sentence comprehension tasks.

Introduction

Sentence comprehension deficits are one of the critical linguistic symptoms in aphasia. Among various types of sentences, passive construction of sentences has been extensively studied in individuals with aphasia. A group of researchers argued that comprehension deficits of passive sentences in aphasia involved impaired representation or loss of syntactic knowledge of dependencies (e.g., Grodzinsky, 1984; 1986; 2002; Grodzinsky, Pinango, Zurif, & Drai, 1999). Another group of researchers claimed that the sentence comprehension deficits individuals with aphasia were attributed to processing resource deficits (e.g., Caplan, Baker, & Dehaut, 1985; Caplan, Waters, DeDe, Michaud, & Reddy, 2007; Dick, Bates, Wulfeck, Utman, & Dronkers, 2001; Miyake, Just, & Carpenter, 1994). Passive sentence comprehension deficits in aphasia have been reported across a variety of languages, including English, Dutch, German, Italian, and Turkish (c.f., Meyer, Mack, & Thompson, 2012). However, there have been relatively few attempts to investigating deficits in Korean passive sentences and their underlying mechanisms for Korean-speaking individuals with aphasia.

Choi (2012) recently examined sentence comprehension deficits in Korean active and passive sentences, using a sentence-picture paradigm. The results revealed that individuals with aphasia showed sentence comprehension impairment both in morphological and semantic passive sentences compared to the normal control group. However, the author did not examine underlying mechanisms related to the deficits. Furthermore, it was not clear whether difficulties of passive sentence comprehension in aphasia arose from reduced processing resources required for computing the syntactic movement involved in passive sentences or whether the deficits were related to reduced capacity of storage components in which the number of linguistics were temporarily available.

The current study investigated sentence comprehension deficits in aphasia and their underlying processing mechanisms using three types of syntactic structures with semantically reversible sentences: 1) active sentences with a 2-argument structure, 2) active sentences with a 3-argument structure, and 3) passive counterparts of active sentences with a 2-argument structure. Active and passive sentences have a 2-argument structure in common, but two syntactic structures are differentiated due to the displacement of the agent and the patient of each sentence. Active sentences with a 3-argument structure were hypothesized to require the greatest demands of storage components in working memory capacity, given that this type of sentences has greater number of arguments than the other two types. In contrast, passive sentences were assumed to tap more into the computational components of working memory capacity than their active counterparts when the number of arguments was equated. The current study attempted to specify the locus of impairment in sentence processing by comparing the storage costs to the computational components, and furthermore the study examined whether working memory capacity accounted for storage and computational components of sentence processing deficits in individuals with aphasia.

Specific research questions were addressed as below:

1. Do individuals with aphasia have significantly greater difficulties in processing passive sentences than active sentences either with a 2-place argument or 3-place argument structure compared to normal elderly adults?
2. Is the short-term memory or working memory significantly correlated with the overall aphasia severity and sentence processing abilities in individuals with aphasia?

Methods

Fifteen persons with aphasia (PWA) and 15 normal elderly individuals (NEI) participated in the study. All participants provided written informed consent before participation. The mean of age and education for each group was provided in **Table 1**. The two groups were not significantly different in terms of the age ($F(1, 28)=.001$, $p<.05$) and education ($F(1, 28)=2.10$, $p<.05$). The NEI group showed normal range of performance, defined as age- and education-adjusted scores above 1.5SD, on the Korean Mini-Mental State Examination (K-MMSE) (Kang, 2006).

All individuals with aphasia suffered a single, left hemisphere stroke. The diagnosis of aphasia was based on the administration of the Korean version of Western Aphasia Battery (K-WAB) (Kim & Na, 2001). Aphasia quotients (AQs) from the K-WAB ranged from 46.6 to 85, and the mean AQ was 67.113 (SD=12.40). Mean of months post onset ranged from 7 to 42 (Mean=22.4, SD=12.38). Demographic information of PWA was provided in **Table 2**. All participants were right-handed and native speakers of Korean. Participants- and Spouse (or caregivers)-reports indicated that they had no history of prior neurological disease, psychiatric disorder, and developmental speech/language disorders.

The sentence comprehension task (SCT) was developed using a sentence-picture matching paradigm. The agents and patients of the sentences were created using human-like symbols with three different colors such as “the Red”, “the Blue”, and “the Yellow” (see **Figure 1**). All of the sentences were semantically reversible. The Sentence comprehension task consisted of the target sentences and their syntactic foil sentences. The syntactic foil was created by switching the positions of the agent and patient. For example, a syntactic foil for the active sentence such as “The Blue chases the Yellow” was “The

Yellow chases the Blue". There were three types of syntactic structures: 1) active sentence with a 2-place argument structure, 2) active sentence with a 3-place argument structure, and 3) passive counterparts of active sentence with a 2-place argument structure. There were 8 items for each syntactic structure, resulting in a total of 24 items in the SCT. Participants were asked to point to the picture, which describes correctly what they have heard.

Short-term memory (STM) and working memory (WM) tasks were obtained from Sung (2011)'s study, in which pointing tasks were developed for clinical populations with speech and language disorders. All aphasic individuals were administered Digit Forward (DF), Digit Backward (DB), Word Forward (WF), and Word Backward (WB) pointing span tasks.

Results

1. Performance on the sentence comprehension task

A two-way mixed ANOVA was performed with the group as a between-subject factor and the syntactic structure as a within-subject factor. Accuracy on the SCT served as a dependent measure. Descriptive information on the mean and standard deviation for each condition was provided in **Figure 2**. Results revealed that there was a significant main effect for the group ($F_{(1, 28)}$=30.815, p<.0001, $\eta^2_{partial}$=.524) with worse performance observed in PWA than the NEI group. The main effect for the syntactic structure was also significant ($F_{(2, 56)}$=8.615, p<.005, $\eta^2_{partial}$=.235). Post-hoc comparisons using a Bonferroni procedure revealed that performance on the passive sentence was significantly worse than the active sentences with a 2-place argument structure (p<.0001) and the active sentences with a 3-place argument structure (p<.05), whereas there were not significant differences between the two types of active sentences.

The two-way interaction was significant ($F_{(2, 56)}$=3.314, p<.05, $\eta^2_{partial}$=.106). In order to examine the source of the interaction, the interaction contrasts were computed using the LMMATRIX and MMATRIX syntax. The group differences between the active sentences with a 2-place argument structure and passive sentences were statistically significant ($F_{(1, 28)}$=8.609, p<.01, $\eta^2_{partial}$=.235), indicating that individuals with aphasia showed differentially greater difficulties in processing passive sentences than the active sentences with a 2-place argument structure compared to the normal control group. In contrast, the group differences were not significant between the two types of the active sentences ($F_{(1, 28)}$=.062, p=.804, $\eta^2_{partial}$=.002) and between the passive sentences and active sentences with a 3-place argument structure ($F_{(1, 28)}$=3.532, p=.06, $\eta^2_{partial}$=.120).

2. Correlations of short-term and working memory tasks with the aphasia severity and sentence comprehension task in individuals with aphasia

Prior to the correlational analyses, a principal component analysis with a Varimax rotation was performed using SPSS (version 20) in order to verify the theoretically conceptualized two memory constructs (STM. Vs. WM) for persons with aphasia. DF and WF loaded on the first factor with the very high value of the factor loadings for DF=.941 and WF=.935, whereas DB and WB loaded on the second factor with the values of the factor loadings for DB=.921 and WB=.925. The results confirmed the hypothesis that the DF and WF reflected short-term storage and DB and WB tasks tapped into the working component of memory. Based on the results, the composite score of the DF and WF pointing tasks were used as a STM measure, and the composite score of DB and WB pointing span tasks served as a WM index.

Pearson correlation coefficients were computed among the variables: STM, WM, AQ from the K-WAB as an index of overall aphasia severity, overall scores of the SCT and subtest scores of each syntactic structure in the SCT task. WM capacity significantly and highly correlated with the overall severity of aphasia ($r=.765$, $p<.001$), indicating that the higher the WM capacity, the higher AQ scores were presented, whereas STM was not significantly correlated with the AQ ($r=.122$, $p=.665$). There was a significant and high correlation between WM and the overall score of the SCT ($r=.661$, $p<.01$), while there was a moderate correlation between the STM and overall score of the SCT, but it was not significant ($r=.401$, $p=.138$). WM was moderately and positively correlated with active sentences with a 2-place argument structure ($r=.419$), active sentences with a 3-place argument structure ($r=.408$), and the passive sentences ($r=.43$), but those correlation coefficients were not statistically significant. STM was significantly and moderately correlated with the active sentences with a 2-argument structure ($r=.527$, $p<.05$), but any other correlations of the SCT with the STM were not statistically significant. Correlational data were summarized in **Table 3**.

Discussion

Korean-speaking individuals with aphasia showed greater difficulties in passive sentences than 2-place active sentences compared to the normal group, consistently with the previous findings. However, it is interesting to note that the group differences were not significant different between the 2-place and 3-place active sentences. Although the group differences between the passive and 3-place active sentences failed to meet the statistical significance ($p=.06$), aphasic individuals clearly demonstrated worse performance on the passive than the 3-place active sentences compared to the normal group. The current results implicated that Korean-passive sentences required more processing resources than active sentences. However, the differences were marginal between the passive sentences and active sentences that were padded with additional linguistic constituents such as 3-place active sentences. WM better accounted for overall severity of aphasia and sentence comprehension deficits compared to the STM. More studies are required to examine locus of the processing difficulties driven from syntactic computations compared to the sentence length effects in Korean-speaking individuals with aphasia.

References

Caplan, D., Baker, C., & Dehaut, F. (1985). Syntactic determinants of sentence comprehension in aphasia. *Cognition, 21,* 117-175.

Caplan, D., Waters, G., DeDe, G., Michaud, J., & Reddy, A. (2007). A study of syntactic processing in aphasia I: Behavioral (psycholinguistic) aspect. *Brain and Language, 101*, 103-150.

Choi, S. Y. (2012). Comprehension of active and passive sentences in Korean aphasia: Evidence for processing deficit hypothesis. *The Korean academy of Speech-Language Pathology and Audiology. 17(2)*, 322-337.

Dick, F., Bates, E., Wulfeck, B., Utman, J. A., & Dronkers, N. (2001). Language deficits, localization, and grammar: Evidence for a distributive model of language breakdown in aphasic patients and neurologically intact individuals. *Psychological Review, 108,* 759-788.

Grodzinsky, Y. (1984). The syntactic characterization of agrammatism. *Cognition, 16*, 99-120.

Grodzinsky, Y. (1986). Cognitive deficits, their proper description, and its theoretical relevance. *Brain and Language, 27,* 178–191.

Grodzinsky, Y. (2002). The neurology of syntax: Language use without Broca's area. *Behavioral and Brain Sciences, 23*, 1-71.

Grodzinsky, Y., Pinango, M. M., Zurif, E. A., & Drai, D. (1999). The critical role of group studies in neuropsychology: comprehension regularities in Broca's aphasia. *Brain and Language, 67*, 134–147.

Kang, Y. (2006). A normative study of the Korean Mini-Mental State Examination(K-MMSE) in the Elderly. *Korean Journal of Psychology, 25*, 1-12.

Kim, H. H. & Na, D. L. (2001). *Korean version of Western Aphasia Battery(K-WAB).* Seoul: Paradise welfare foundation.

Meyer, A. M., Mack, J. E., & Thompson, C. K. (2012). Tracking passive sentence comprehension in agrammatic aphasia. *Journal of Neurolinguistics, 25*, 31-43.

Miyake, A., Just, M.A., & Carpenter, P.A. (1994). Working memory constraints on the resolution of lexical ambiguity: Maintaining multiple interpretations in neutral contexts. *Journal of Memory and Language, 33*, 175-202.

Sung, J. E. (2011). The Reliability and Validity of Short-term and Working Memory Pointing Tasks Developed for Clinical Populations with Speech and Language Disorders. *Korean Journal of Communication Disorders, 16,* 185-201.

Table 1. Demographic information of age, education and gender ratio for each group

	Age	Education	Gender Ratio (M : F)
PWA	44.67(13.17)	13.4(2.92)	11 : 4
NEI	44.53 (13.38)	14.8(2.33)	6 : 9

Note: PWA=Persons with Aphasia; NEI= Normal Elderly Individuals

Table 2. Descriptive information of individuals with aphasia

ID	MPO	AQ (K-WAB)	AQ subtest score				Aphasia Type
			Fluency /40	Comprehension /20	Repetition /20	Naming /20	
101	36	70.5	38	17.4	6.4	8.7	Conduction
102	36	64.6	22	17.6	9.6	15.4	Broca
103	42	60.7	24	11.7	11.2	13.8	Broca
104	34	84.3	30	18.3	20	16	Anomic
105	7	46.6	27	12.8	1.4	5.4	Wernicke
106	14	48.4	20	10.4	13.8	4.2	Broca
107	31	51.8	26	10.9	10.9	4	Wernicke
108	12	60.8	30	9.2	16	5.6	Wernicke
109	14	79.2	34	14.6	16.6	14	Anomic
110	10	71.4	30	15.6	12.2	13.6	Conduction
111	33	66.2	24	12	17.4	12.8	Anomic
112	31	78.6	24	19	20	15.6	Anomic
113	8	58.8	22	15.4	9.4	12	Conduction
114	12	85	30	17	20	18	TCSA
115	16	61.3	30	10.3	6.4	14.6	Wernicke

Note: MPO=Months Post Onset; AQ=Aphasia Quotient; K-WAB=Korean version of Western Aphasia Battery(Kim & Na, 2001); TCSA=Transcortical sensory aphasia

Table 3. Summary of the Pearson correlation coefficients

	STM	WM	AQ	SCT total	Active (2-place)	Active (3-place)	Passive
STM	1						
WM	.310	1					
AQ	.122	.765**	1				
SCT total	.401	.661**	.431	1			
Active (2-place)	.527*	.419	.145	.745**	1		
Active (3-place)	-0.45	.408	.336	.699**	.313	1	
Passive	.351	.430	.240	.847**	.770**	.535*	1

(* $p < .05$, ** $p < .01$)

Figure 1. An example of the sentence comprehension task: “The Blue chases the Yellow”.

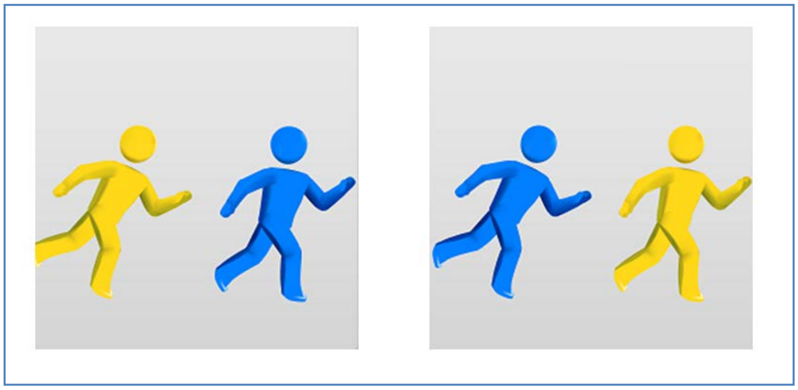

Figure 2. Performance of the Sentence Comprehension Task