Working Memory Capacity and its Relation to Passive Sentence Comprehension in Persons with Mild Cognitive Impairment

Abstract

The purpose of the study was to investigate working memory capacity (WMC) and its relation to Korean passive sentence (PS) comprehension in persons with mild cognitive impairment (MCI). Results revealed that persons with MCI performed significantly more poorly than normal elderly individuals (NEI) in PS compared to active sentences with intransitive verbs. However, the group differences were not significant between PS and active sentences with transitive verbs. WMC significantly predicted performance on PS for both groups. The current study indicated that Korean-speaking persons with MCI could use information of case markers and WMC was related to PS comprehension abilities.

Introduction

Several studies have been reported on sentence comprehension deficits in individuals with Alzheimer's disease (AD). Researchers suggested that their deficits were related to reduced WMC (Bickel, Pantel, Eysenbach & Schröder, 2000; Rochon, Water & Caplan, 1994; 2000; Small, Kemper & Lyons, 1997; Waters, Caplan & Rochon, 1995), Working memory (WM) being defined as a cognitive construct engaged in maintaining and computing linguistic information in sentence processing (e.g., Caplan & Waters, 1999; Just & Carpenter, 1992). In recent years some researchers suggested that individuals with mild cognitive impairment (MCI), who is mostly converted to AD, showed sentence comprehension deficit (Griffith, Netson, Harrell, Zarnrini, Brockington & Marson, 2006; Riberio, de Mendonca & Guerreiro, 2006). However, the relationship between passive sentences (PS) comprehension and WM was relatively less addressed in persons with MCI.

PS has been of interest in sentence processing literature, because the passive structure has a non-canonical word order in English grammar. Language-specific grammatical features may induce differential language deficits in clinical populations. Bates and colleagues (1989; 1991) suggested crosslinguistic differences in sentence processing were accounted for by the cue validity component of the competition model. The cue validity was defined as the ratio of reliability over availability of cues that determine the relationship between meaning and form. In Korean, case markers are more valid cue rather than word order to successfully assign the thematic roles. These grammatical features would reveal differential patterns of PS comprehension between English-speakers and Korean-speakers with MCI.

The purposes of the current study were 1) to investigate whether there are significant differences between normal elderly individuals (NEI) and persons with MCI in PS comprehension compared to active sentences with intransitive and transitive verbs and 2) to examine whether WM significantly predict performance on passive and active sentences for each group.

Methods

Thirty-six individuals (18 NEI and 17 MCI) participated in the study. Persons with MCI met Petersen's most recent criteria (Petersen, 2003) based on the standardized Seoul Neuropsychological Screening Battery (SNSB) (Kang & Na, 2003) and clinical diagnosis carried out by trained neurologists. They showed impairments on memory tests and/or other cognitive domains (1.5SD below normal), preserved basic day to day functioning, and insufficient findings to warrant a diagnosis of dementia. The NEI group showed normal range of performance on the Korean Mini-Mental State Examination (K-MMSE) (Kang, Na, & Hahn, 1997). They had no history of brain injury, a self-report of normal language development. Demographical data of participants were provided in **Table 1**.

A sentence comprehension test consisted of three syntactic structures: 1) active sentence with intransitive verbs (AS-I) (6 syllables), 2) active sentence with transitive verbs (AS-T) (10 syllables), and 3) passive sentence (PS) (10 syllables). All sentences were semantically reversible. In active sentences the subject particle *i/ka* is added to the end of a noun to express a subject case, and the object particle e*ul/leul* is added to the end of a noun to express an object case. , The order of noun phrases is relatively free, but case markers play an important role to correctly assign the thematic roles in Korean. Korean PS is derived from their corresponding active sentences. Passive suffix *i/hi/li/ki* is attached to the transitive verb stem. *Eykey/hanthey* 'by' is added to the noun that was the subject in the active sentence to express dative, and *i/ka* is added to patient to express subject.

Each syntactic structure consisted of 8 stimuli. Examples of sentence stimuli and the sentence length for each syntactic structure were presented in **Table 2**. For each sentence, one target picture and three distracter pictures were presented on the computer monitor, and the stimuli were auditorily presented.

All participants performed four WM tasks: 1) digit backward (DB), 2) word backward (WB), 3) subtract-2(Sub-2), and 4) alphabet (ALP) span tasks.

Results

In order to examine the effects of syntactic structures on a sentence-picture matching (SPM) task, a two-way mixed ANOVA was performed with Group as a between-subject factor and the syntactic structure as a within-subject factor. Accuracy in the SPM task served as a dependent measure.

A main effect for the syntactic structure was significant, $F(2, 66)=16.024$, $p<.000$, with lower accuracies observed in AT and PS than AI. A main effect for the Group was also significant, $F(1, 33)=13.953$, $p<.005$, with persons with MCI showing lower accuracy than NEI.

There was a significant two-way interaction, $F(2, 66)=3.757$, $p<.05$. Interaction contrasts were performed using LMATRIX and MMATRIX syntax. The two-way interaction was due to significant group differences between AI and PS, $F(1, 33)=5.903$, $p<.05$, with higher accuracy in AI than PS in persons with MCI compared to NEI. Accuracy of each syntactic structure in both groups was presented in **Figure 1**.

In order to examine whether the four WM tasks loaded on a single construct, principal component analyses were performed for each group. Both groups generated a one-factor solution with 64.45% and 63.59% of the total variance explained for the MCI and NEI groups, respectively. Based on the results, the averaged score of the four WM measures served as a single index of WMC. One-way ANOVA revealed that the MCI group showed significantly worse performance on the WM index than NEI, $F(1, 33)=9.530$, $p<.005$. WM scores of each task and WM index were presented in **Figure 2**.

Simple linear regression analyses were performed to examine whether WMC significantly predicted performance on each syntactic structure for each group. In the NEI group, WMC significantly predicted performance on AT, $F(1, 16)=6.034$, $p<.05$, $R^2=.274$, and PS, $F(1, 16)=9.073$, $p<.005$, $R^2=.362$, but not on AI, $F(1, 16)=4.343$, $p>.05$, $R^2=.213$. For the MCI group, WMC significantly predicted performance only on PS, $F(1, 15)=11.335$, $p<.005$, $R^2=.430$.

Discussion

The current results revealed that persons with MCI showed lower accuracy of sentence comprehension in overall than NEI. Both groups presented significantly lower accuracy in PS compared to AI. However, there were not significant differences between PS and AT. The MCI group performed significantly higher accuracy in AI than PS compared to NEI. These results indicated that Korean-speaking individuals with MCI were less accurate in sentence comprehension in overall than the NEI. However, persons with MCI successfully used information of case markers to interpret PS. These results were consistent with the competition model, which suggested that sentence comprehension deficit patterns differ across languages (Bates et al., 1989; 1991). The current study was also consistent with the previous findings that the mild to moderate AD did not show significant differences between active and PS in German, which is rich in grammatical morphemes (Bickel, Pantel, Eysenbach & Schröder, 2000)

WMC significantly predicted performance on PS and AT in the NEI, but not on AI. The sentence length effects may account for the results, given that PS and AT are longer than the AI. In contrast, WM predicted performance only on PS in the MCI. It is speculated that processing load imposed on the PS may play a greater role in sentence comprehension than the sentence length for the MCI, given that the computational load is higher in the PS than AT, but the two sentence types were controlled for the sentence length. More studies are needed to examine crosslinguistic differences in sentence comprehension deficits for persons with MCI.

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Table 1. Descriptive information for NEI and MCI

	NEI		MCI	
	Mean	SD	Mean	SD
Age	73	1.5	71	1.5
Education	8	0.9	5	0.9
K-MMSE	26.6	0.7	21.3	0.7

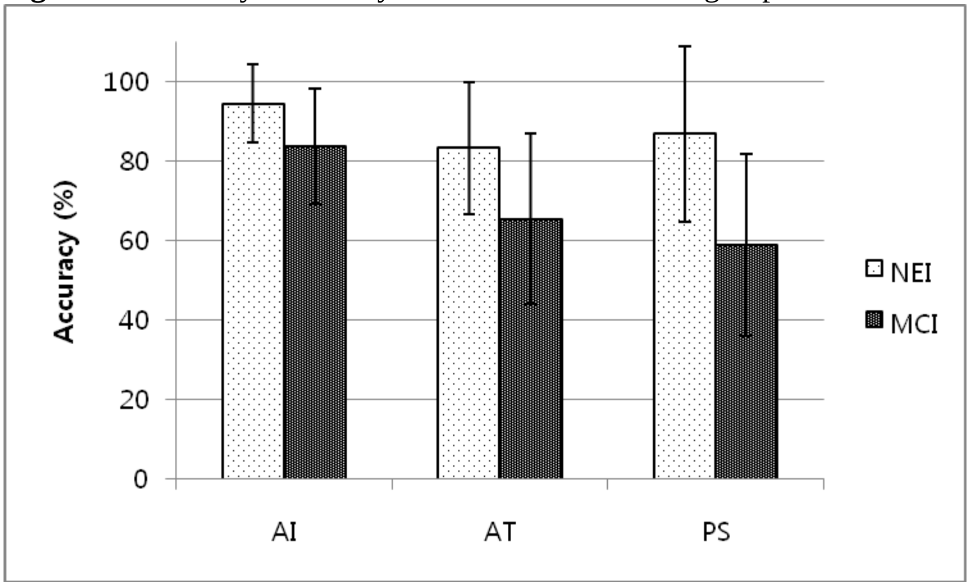
Note: NEI=Normal Elderly Individuals; MCI=individuals with Mild Cognitive Impairment; SD=Standard Deviation; K-MMSE= Korean Mini-Mental State Examination (Kang, Na, & Hahn, 1997)

Table 2. Examples of sentence stimuli for each sentence type.

Type	Example of sentence stimuli	Number of syllable
AI	Gangaji-ka ul-ta. S V *The dog cries.*	6
AT	Gangaji-ka tokki-leul mul-ta. S O V *The dog bites the rabbit.*	9
PA	Tokki-ka saseum-eykey mul-li-ta. S D V *The rabbit is bitten by the deer.*	9

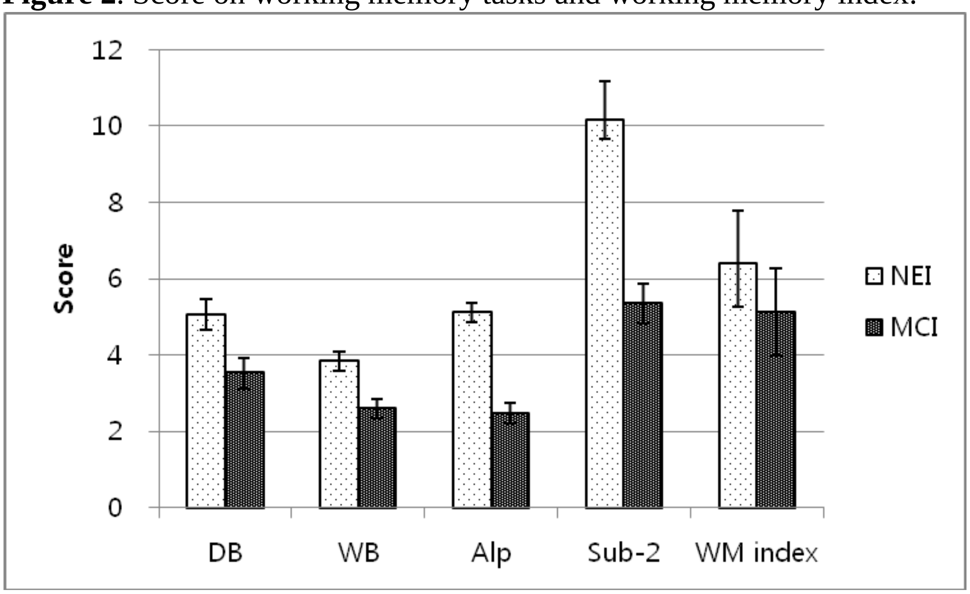
Note: AI=Active sentence with intransitive verb; AT=Active sentence with transitive verb; PA=Passive sentence; S=Subject; V=Verb; O=Object; D=Dative.

Figure 1. Accuracy of each syntactic structure in both groups



Note: NEI=Normal Elderly Individuals; MCI=Mild Cognitive Impairment; AI=Active sentence with intransitive verb; AT=Active sentence with transitive verb; PS=Passive sentence.

Figure 2. Score on working memory tasks and working memory index.



Note: NEI=Normal Elderly Individuals; MCI=Mild Cognitive Impairment; DB=Digit backward span; WB=Word backward span; Alp=Alphabet span; Sub-2=Subtract 2 span; WM index=Working memory index.