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Non-transcription analysis of connected speech in mild cognitive impairment using an information unit scoring system

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ABSTRACT

Purpose: The purpose of the current study was (1) to compare the performance of individuals with mild cognitive impairment (MCI) and cognitively healthy adults (CHA) on story retelling tasks consisting of familiar and novel stories, and (2) to examine potential utility of information unit scoring by demonstrating concurrent validity of the measure.
Method: Fifteen individuals with MCI and 15 age- and education-matched CHA who are monolingual, Korean speakers participated in this study. The task consisted of two different stories: (1) familiar story and (2) novel story. Each story was presented auditorily with sequential pictures. All participants were required to retell as much of the story as they could remember after listening to recorded audio files. Language samples were quantified using Information Unit (IU) checklists. Concurrent validity was computed by correlating IU measures (percent of information units [% IU] and percent of information units per minute [%IU/Min] and other linguistic measures (e.g., correct information units [CIU]).
Result: There were greater differences between the two groups in the familiar story than the novel story. Correlations for IU measures in the familiar story were significant and moderate to high, ranging from 0.644 to 893 for the MCI group and from .582 to .745 for the CHA group. In the novel story, one moderate correlation was found between the %IU/Min to %CIU/Min.
Conclusion: This evidence supports that the IU scoring system serves as a valid and efficient tool to analyze connected speech in clinical settings.

1. Introduction

Incidence and prevalence of aging-related degenerative diseases are on the rise with a rapidly expanding aging population. Since Petersen et al. (1999) introduced the concept of Mild Cognitive Impairment (MCI) as a transition stage between normal aging and dementia, MCI has received attention because of its clinical importance for early detection of dementia. MCI denotes cognitive decline beyond that of normal aging and is regarded as a prodromal stage of Alzheimer's disease (AD); however, it should be noted that MCI does not always progress to a diagnosis of AD. Unfortunately, there is still a lack of consensus on the diagnostic criteria for MCI (e.g., Breton, Casey, & Arnaoutoglou, 2019). Moreover, in clinical settings, detecting subtle cognitive impairment with neuropsychological

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test batteries is challenging as these tests are not sensitive enough for MCI (Tóth et al., 2015).

Connected speech represents a process by which thinking is converted into language (Chafe, 1990; Chapman et al., 2002; Duchan, 1994). As such, analysis of connected speech has been considered a useful method to identify cognitive-linguistic changes associated with MCI. However, there are relatively few studies directly focusing on MCI and connected speech (Ahmed, Haigh, de Jager, & Garrard, 2013; Beltrami et al., 2018; Bschor, Kühl, & Reischies, 2001; Drummond et al., 2015; Fleming, 2014; Fleming & Harris, 2008; Forbes-McKay & Venneri, 2005; Joyce, Kiran, Marquardt, & Fleming, 2008; Mueller et al., 2016a), and the findings to date have been inconsistent across studies.

One primary aspect that influences the inconsistent findings is the choice of tasks to elicit connected speech from the MCI group. A majority of studies using a simple picture description task (e.g., the Cookie theft picture) reported no statistically significant difference between the MCI group and cognitively healthy group (CHA) (Ahmed et al., 2013; Bschor et al., 2001). Contrarily, studies that utilized complex tasks that impose cognitive/linguistic burdens detected subtle linguistic changes in connected speech by MCI (Beltrami et al., 2018; Drummond et al., 2015; Fleming, 2014; Fleming & Harris, 2008; Forbes-McKay & Venneri, 2005; Joyce et al., 2008). In the current study, we manipulated the complexity of two story tasks based on familiarity – one is to retell a familiar story, and the other is a retelling of a novel story from Nicholas and Brookshire (1993). Retelling a well-known fairy tale story that speakers have first listened to requires incorporation of previously consolidated knowledge of the story in a refined, structured story frame, drawing heavily on episodic memory (Dixon & Gould, 1998). Given that episodic memory is the most commonly reported type of memory to suffer cognitive decline in individuals with MCI (e.g., Anderson & Schmitter-Edgecombe, 2010; McCullough, Bayles, & Bouldin, 2019), using tasks that challenge episodic memory is likely to increase the likelihood of detection of MCI (Beltrami et al., 2018).

To date, no MCI studies have directly targeted differential performance of connected speech between familiar stories and novel stories. Attali, De Anna, Dubois, and Barba (2008) administered three story retelling tasks to discriminate the AD group from the healthy adult group, using a novel story, a well-known story (Cinderella), and a modified well-known story. Both groups performed better on the retelling of the well-known story compared to that of the novel story and retold the least amount of total story elements for the modified well-known story. These results indicate that the performance of both groups is affected differentially by the type of story. Further, there was a significant difference in total story elements produced in well-known story retelling performance between the AD group and the healthy adult group. Researchers attributed this finding to disease-related damage of the hippocampus and related structures that play a significant role in encoding new information and consolidation of episodic memories.

Despite of the growing interest to potential clinical value of connected speech for early detection of individuals with MCI, its clinical usability is limited. To facilitate connected speech assessment in clinical settings, McNeil, Doyle, Fossett, Park, and Goda (2001) introduced an information unit (IU) metric, a simplified method of analyzing connected speech samples which was designed based on the Correct Information Unit (CIU; Nicholas & Brookshire, 1993). According to McNeil et al. (2001), IU metric is a result of transformation of the CIU metric on the Story Retell Procedure (SRP; Doyle et al., 1998), with the clear purpose of minimising speech-language pathologists (SLPs)' workloads. Previous studies using the IU metrics have focused on individuals with aphasia, and its psychometric properties also have been investigated mostly in aphasia studies. (Hula, McNeil, Doyle, Rubinsky, & Fossett, 2003; McNeil et al., 2001, 2007). To the best of our knowledge, this study is the first attempt to use IU metrics to quantify individuals with MCI's story retelling abilities and to examine whether IU metrics discriminate individuals with MCI from CHA using two different levels of complexity in tasks.

The purpose of the current study, then, was to examine the effects of story familiarity in story retelling tasks using the IU scoring, and the potential clinical utility of the measure. The specific aims of the study were two-fold: 1) to investigate which story-retelling tasks can reveal clear differences between the MCI and CHA groups using novel or familiar story levels and 2) to explore concurrent validity of the IU scoring and other linguistic measures by story familiarity across the MCI and CHA groups. We assumed the two tasks differentially tapped into the short-term and episodic memory systems. Short-term memory is involved in retelling a novel story, given that listeners need to hold the new story in their memory for a short period to successfully retrieve the story. Considering that participants of the current study were native-born Korean monolinguals who were living in Korea, we employed a Korean traditional folk story to account for cultural and linguistic differences for the familiar story. Familiar story retelling involves episodic memory that is known to deteriorate in early AD. Based on the findings of Attali et al. (2008), we expected that both groups would retell more IUs in the familiar story task than in the novel story task. Moreover, we hypothesized that differential performance in story retelling between the MCI group and the CHA group would be more prominent in the familiar story. Further, based on previous studies investigating validity of the IU metric for persons with aphasia (Doyle et al., 1998; McNeil et al., 2001, 2007), linguistic measures of verbal productivity and of information content were selected. Verbal productivity measures included number of utterances, number of words, number of words per minute, and mean length of utterances. Information content measures included number of correct information units, percent of correct information units, number of correct information units per minute, and percent of correct information units per minute. In agreement with previous studies, we expected to find concurrent validity of the IU scoring method. Potentially, this can serve to evaluate linguistic changes in connected speech of individuals with MCI who use Korean as their primary language.

2. Method

2.1. Participants

A total of 30 elderly individuals (15 amnestic MCI, 15 age- and education-matched controls) participated in the study. The CHA group (Male = 7, Female = 8) had a mean age of 72.2 (SD = 7.42) years and a mean education of 11.07 (SD = 2.77) years. The MCI group had a mean age of 72.4 years (SD = 6.9) and a mean education of 10 (SD = 3.78) years. The two groups were not significantly

different in terms of age, $F(1,28) = 0.006$, $p > .05$, or education, $F(1.28) = 0.778$, $p > .05$ (see Table 1). All participants (a) were native, monolingual Korean speakers, (b) were all right-handed, (c) had aided or unaided normal hearing acuity, (d) had corrected or uncorrected normal visual acuity, (e) presented within the normal range on the Geriatric Depression Scale (GDS; Jung, Kwak, Joe, & Lee, 1997), the Seoul -Instrumental Activities of Daily Living (S-IADL; Gu et al., 2004), and the Korean version of the Mini-Mental State Examination (K-MMSE; Kang, 2006). Additionally, The CHA group presented a normal range of scores in the Seoul Verbal Learning Test (SVLT) from the Seoul Neuropsychological Screening Battery (SNSB; Kang & Na, 2003).

The individuals with MCI went through neurological examinations and were diagnosed as amnestic single domain by trained neurologists. The MCI group met the following clinical criteria suggested by Petersen (2004): (a) subjective complaints of memory decline reported by the patient and/or confirmed by the caregiver, (b) objective memory impairments (<16th percentile of memory domain subtests from SNSB), (c) a normal range of general cognition as indicated by scores on the K-MMSE (≥16th percentile with age- and education-adjusted norms) (d) functional daily life and social life activities (<0.43 based on S-IADL), (e) without dementia, and (f) without other medical, neurological, or psychiatric disease. Their Clinical Dementia Rating score was 0.5 (Hughes, Berg, Danziger, Coben, & Martin, 1982). Moreover, all individuals with MCI fulfilled the recent criteria of the 2018 National Institute on Aging-Alzheimer's Association (NIA-AA) research framework (Jack et al., 2018).

All participants were voluntarily recruited from community welfare centers or Ewha Womans University Medical Center in Seoul. None were excluded from data analysis. Table 2 presents neuropsychological test results of SNSB for all participants. This study was conducted in accordance with the Declaration of Helsinki, which was approved by Ewha Womans University Institutional Review Board.

2.1.1. Stimuli development and selection

For this experiment, two stimuli of sequential pictures were used in this experiment: a well-known Korean folk tale and a novel story from Nicholas and Brookshire (1993). Both stimuli contained six sequential pictures that were black and white line drawings to facilitate responses and limit significant influence from working memory capacity.

For the familiar story, a well-known Korean folk tale, *Hungbu wa Nolbu (Hungbu and Nolbu)* was selected. This story is commonly used to elicit spoken language samples from Koreans (e.g., Ha, Jung, & Sim, 2009; Kim & Sung, 2017). To develop a script for the story stimulus, we compared five children's books from different publishers having the same title, and then selected the same content depicted in all five books. An example picture for the familiar story was provided in Fig. 1.

Given the Nicholas and Brookshire stimuli were developed for English speakers, we collected pilot data to determine cultural appropriateness for use of the pictures for Korean speakers. Five Korean monolingual, cognitively healthy older adults who were older than 60 years of age participated. Two picture stimuli were used (*Argument* and *Directions*) from Nicholas and Brookshire, and participants were asked to make a story based on the pictures. Based on the quantity and quality of language and a brief interview with participants, *Argument* was found to be a better picture stimulus for older Korean speakers. The language samples obtained from the pilot study were used to develop the script of the story stimulus.

Prior to the experiment, all IUs were identified for each story. Since performance on story retelling tasks is affected by the amount of information that speakers comprehend and remember, we intentionally assigned only two sentences to each of the six drawings within the picture stimulus. Both stories consisted of four simple sentences and eight complex sentences. The corresponding sentences in each of the two stories had the same number of IUs. The number of nouns, verbs, adverbs, and Korean grammatical markers were not statistically different. The information is described in Table 3. The stories were recorded at approximately three syllables per second by a trained female speaker. See Appendix 1 for story scripts.

2.1.2. Procedures

Prior to the story retelling task, all participants completed screening measures to confirm that they met inclusion criteria. For the story retelling task, participants were seated individually in a quiet experiment room. They were asked to listen to one of the recorded short stories and then retell the story freely using as many exact words as possible, to the best of their memory. The procedure was repeated for the second story with the order of stimulus being randomized across participants. In the case that the participants produced language samples shorter than 15 s, the investigator prompted them by asking if they had more information to provide. Picture stimuli were viewable while participants were listening to and retelling the stories.

Table 1
Demographic information for study participants.

	CHA (N = 15)	MCI (N = 15)
Age (SD)	72.2 (7.42)	72.40 (6.9)
Range	62–86	63–57
Gender (M:F)	7:8	5:10
Years of Education (SD)	11.07 (2.77)	10 (3.78)
Range	6–16	2–16

Note. CHA = cognitively healthy adults; MCI = individuals with mild cognitive impairment; M = male; F = female.

Table 2
Neuropsychological test scores in CHA and MCI groups (%ile score).

		CHA (range)		MCI (range)	
Domain	Measure	M	SD	M	SD
Language ability	S–K-BNT	85.30 (51.03–99.87)	14.84	35.50 (1.96–80.01)	20.34
Attention	Digit span (Forward)	77.25 (50.06–98.45)	16.00	37.25[a] (12.73–69.71)	27.51
Executive function	COWAT	63.95 (22.66–88.03)	16.77	54.90 (16.7–99.31)	25.91
	K-CWST	84.88 (64.66–96.73)	9.50	60.82[a] (13.38–93.19)	23.16
Memory Verbal	SVLT	66.93 (33.95–93.77)	17.00	11.74[a] (0.57–22.43)	6.78
Visuo-spatial (RCFT)	Delayed recall	66.23 (34.09–96.06)	20.87	25.18 (9.14–76.18)	19.16

Note. CHA = cognitively healthy adults; MCI = individuals with mild cognitive impairment; S–K-BNT = Short version of the Korean-Boston Naming (Kim & Na, 1997); Digit span Forward = Korean-Wechsler Adult Intelligence Scale- IV (Yeom, Park, Oh, Kim, & Lee, 1992); COWAT = Controlled Oral Word Association Test (Kang, Chin, Na, Lee, & Park, 2000); K-CWST = Korean-Color Word Stroop (Lee, Kang, & Na, 2000); SVLT = Seoul Verbal Learning Test from Seoul Neuropsychological Screening Battery (Kang & Na, 2003); RCFT = Ray Figure Test (Meyers & Meyers, 1995).
[a] Statistically different from normal at the .05 level.

Fig. 1. A picture of the familiar story task.

Table 3
Information on story tasks.

	Simple sentence	Complex sentence	IUs	words	nouns	verbs	adverbs	Gramma-tical markers
Familiar story	4	8	132	132	48	34	5	39
Novel story	4	8	132	132	49	34	5	39

2.1.3. Language sample transcription, and measures, and scoring

2.1.3.1. Information units (IUs). IUs provide a simplified scoring method of Nicholas and Brookshire's (1993) CIU for quantifying speech informativeness and efficiency. An IU is defined as an "identified word, phrase, or acceptable alternative from the story stimulus that is intelligible and informative and that conveys accurate and relevant information about the story" (McNeil et al., 2001, p. 994). A difference between the CIU and IU is that possible IUs including direct IUs and synonyms to target IUs are predetermined in a checklist for each story. In addition, the IU metric is administered in the SRP, which is used to elicit language with auditory presentation of stories. In doing so, words that are or seem to be related to the stimuli, but that are not included in the recorded audio file as direct IUs or are not determined as synonyms of direct IUs are *not* counted as IUs. This potentially allows SLPs to finish scoring in a shorter period of time by bypassing transcription of language samples, and prevents the inflation of measurement of information content (McNeil et al., 2001).

Participants' responses were recorded and then transcribed. Transcription of language samples was not used for the IU scoring, but

used for other linguistic measures. That is, for the IU scoring, raters listened to recorded files to quantify IUs in participants' connected speech samples. IU scores were calculated in two different ways: percent of information units (%IU) and percent of information units per minute (%IU/Min). For the %IU, scoring was computed by totalling the IUs produced within the language sample and dividing it by the total number of predetermined IUs for each story. The %IU/Min score was calculated by dividing %IU by the time that the participant spent to complete the task for each story. Once an IU was counted, repetition of the same IU was not counted. Moreover, considering the definition of IUs suggested by McNeil et al. (2001), synonyms to target IUs were counted.

Rules for scoring and counting IUs and synonyms to target IUs were altered in response to language specific properties. Korean is a verb final language with overt case markers. Although the canonical word order for Korean is subject-object-verb, linguistic constituents can have flexibility in its order as long as the subject and predicate are placed in the first and the last position, respectively. Given that Korean permits variation in the order of a verb's arguments, each IU in a different order of construction received a point in the case that speakers' utterances were grammatically correct. Korean morphemes are attached to verbs and nouns. For verbs, all types of grammatical deviation caused by morphological inflection were acceptable. For serial verb construction, when the verb produced by a speaker semantically shared the main verb stem of the target IU, the verb was counted as an IU. For example, if *chase* was a target verb IU, *chase-out*, and *chase-up* were counted because they share the core stem of *chase*. For nouns, a limited range of synonyms were allowed to be counted. In the case that a target word in the familiar story was *jewels, gems* and *gemstones* were also counted. However, use of semantic circumlocution (e.g., *precious things*) or less specified words (i.e., hypernymy of target IUs) were not counted. Pronouns were counted when speakers correctly used their antecedents in a preceding utterance. For example, *husband* and *wife* should be present prior to the use of *he* and *she* for speakers to receive a credit for the IUs. An example of IU checklists was provided in Fig. 2.

2.1.3.2. Other linguistic measures. A total of 8 variables were included in this study: four measures of verbal productivity (number of utterances, number of words, number of words per minute, mean length of utterances [MLU]), and four measures of information content (number of correct information units [CIU], percent of correct information units [%CIU], number of correct information units per minute [CIU/Min], percent of correct information units per minute [%CIU/Min]). Since few linguistic measures used in English studies have been adapted for use in Korean language, we selected the measures that have been well investigated in Korean-speaking individuals with aphasia (e.g., Im, Kwon, & Sim, 2001; Koo & Choi, 2015) from the measures used in IU validation studies (McNeil et al., 2001, 2007). Criteria for utterances and words for Korean were based on previous studies focusing on linguistic analyses of connected speech samples in Korea (Kim, Kwon, Na, Choi, & Chung, 1998; Lee & Kim, 2001). For CIU, Nicholas and Brookshire (1993)'s criteria were followed.

2.1.3.3. Reliability. Inter-rater reliabilities for transcription and scoring were measured by two trained graduate research assistants. Three participants for each group were randomly selected. Reliability was calculated by dividing the total number of agreements by the total number of agreements plus disagreements, and multiplying by 100 for the following measures: word-by-word transcription (98.2%), utterance segmentation (97.4%), correct information units (95%), and IUs (98.5%). For intra-rater reliability, all agreements were higher than 98%.

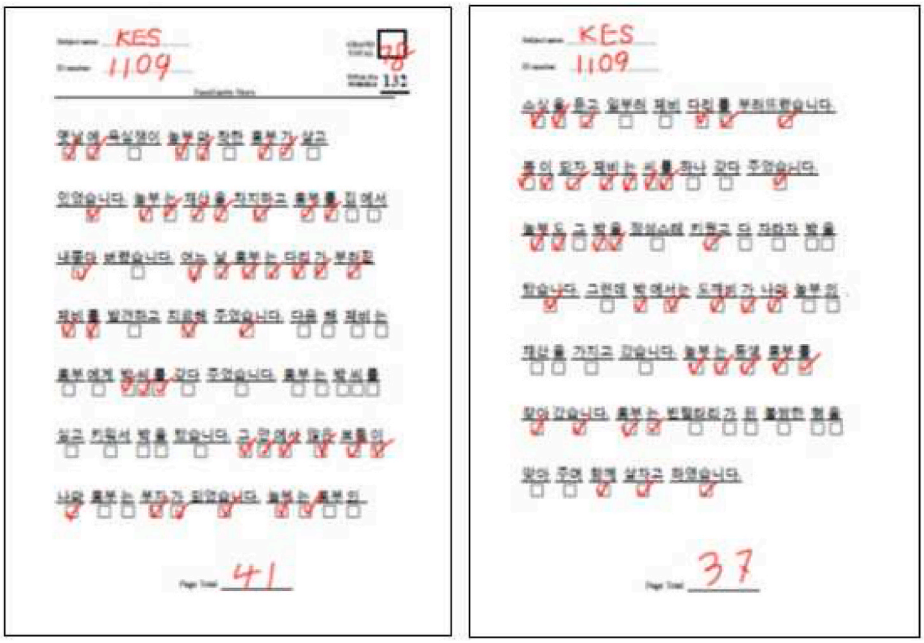

Fig. 2. An example of IU checklists.

2.1.3.4. Statistical analyses. To examine the differences between individuals with MCI and CHA depending on story type, a 2 × 2 mixed ANOVA was performed with group (MCI vs CHA) as a between-subject factor and the type of story (novel story vs familiar story) as a within-subject factor for %IU and %IU/Min. For the second research question, Pearson's correlation coefficients were computed to examine the reliability of the IU scoring system by using linguistic measures (%IU, %IU/Min, CIU, %CIU, CIU/Min, %CIU/Min, Number of Utterances, Number of Words, Number of Words/Min, MLU).

3. Results

3.1. Group comparisons depending on the story type

3.1.1. %IU

There was a significant main effect for group, $F(1,28) = 347.005$, $p < .001$, and for story type, $F(1,28) = 100.566$, $p < .001$. The MCI group produced fewer %IUs than the CHA group. Participants recalled more %IUs in a familiar story than in a novel story. Data analysis yielded a significant two-way interaction, $F(1,28) = 367.462$, $p < .005$. Greater group differences emerged in the familiar story than the novel story. (Fig. 3). See Table 4 for descriptive information of means and standard deviations for each group and story type.

3.1.2. %IU/Min

Significant main effects were found for group, $F(1,28) = 7.352$, $p < .05$, and for story type, $F(1,28) = 25.848$, $p < .001$. The MCI group produced more % IUs per minute than the CHA group. Participants recalled more %IUs per minute in a familiar story than in a novel story. There was no significant two-way interaction, $F(1, 28) = 0.030$, $p = .862$ (Fig. 4).

3.2. Correlation analysis

3.2.1. %IU

For %IU, there were moderate correlations with CIU, $r = 0.680$, $p < .01$, with the number of words, $r = 0.548$, $p < .05$, and with MLU, $r = 0.669$, $p < .01$, for the MCI group with familiar story retelling (see Table 5).

3.2.2. %IU/Min

There were significant correlations for %IU/Min with CIU/Min, $r = .582$, $p < .05$, and %CIU/MIN, $r = 0.745$, $p < .01$, for the CHA group with familiar story retelling. For the MCI group, %IU/Min for the familiar story was correlated with the number of CIU/Min, $r = .893$, $p < .01$, %CIU/Min, $r = 0.644$, $p < .01$, the number of words per minute, $r = 0.692$, $p < .01$, and MLU, $r = 0.721$, $p < .01$. However, the MCI group in novel story retelling had one moderate correlation for %CIU/Min, $r = .570$, $p < .05$ (see Table 6).

4. Discussion

The purpose of this study was to investigate the effect of story familiarity on story retelling performance of the MCI and CHA groups, and examine the linguistic validation of the IU scoring system. We manipulated a level of story familiarity by employing both a novel and a familiar story. Group difference on story retelling tasks was greater in the familiar story task than in the novel story task. Further, multiple significant relationships among the IU measures and other linguistic measures were found for both groups.

4.1. Overall group differences in informativeness and efficiency

Results indicated overall differences in both measures of informativeness (%IU) and efficiency (%IU/min) between the MCI and CHA groups. The results that the MCI group was less informative in connected speech compared to the CHA group are consistent with

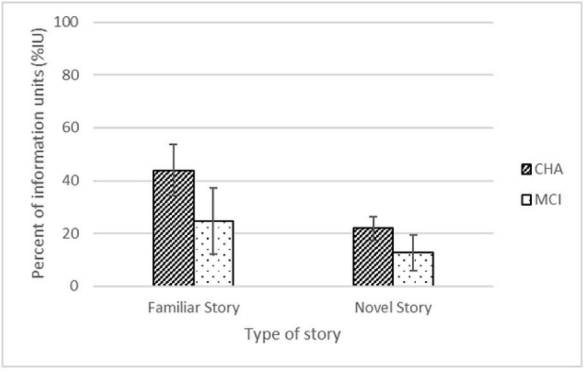

Fig. 3. Percentage of information units for type of story and two groups.

Table 4
Mean and standard deviations in each story task for both groups.

	Familiar story (SD)		Novel story (SD)	
Group	%IU	%IU/min	%IU	%IU/min
CHA	43.84 (9.74)	.88 (.25)	21.97 (4.42)	.63 (.18)
Range	53.78–26.52	1.56–0.51	31.82–15.15	1.06–0.41
MCI	24.70 (12.48)	.64 (.35)	12.73 (6.75)	.41 (.23)
Range	50–5.3	1.15–0.11	30.3–3.79	0.93–0.8

Note. CHA = cognitively healthy adults; MCI = individuals with mild cognitive impairment.

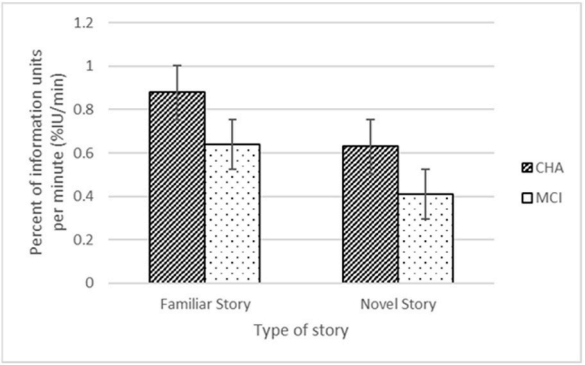

Fig. 4. Percentage of information units per minute for type of story and two groups.

Table 5
Correlations between linguistic measures and information units (%IU).

	CHA (N = 15)		MCI (N = 15)	
Linguistic Measures	Familiar	Novel	Familiar	Novel
CIU	.219	.158	.680[b]	.241
%CIU	.463	-.021	.477	.061
CIU/min	-.071	.302	.340	.106
%CIU/min	-.014	-.050	.005	-.013
# of Utterance	-.244	-.166	.186	-.014
# of Words	-.082	.028	.548[a]	.343
#of Words/in	-.280	-.179	.152	.023
MLU	.137	.134	.669[b]	.320

Note. CHA = cognitively healthy adults; MCI = individuals with mild cognitive impairment.
[a] Statistically different at the .05 level.
[b] Statistically different at the .01 level.

Table 6
Correlations between linguistic measures and information units (%IU/min).

	CHA (N = 15)		MCI (N = 15)	
Linguistic Measures	Familiar	Novel	Familiar	Novel
CIU	.022	-.155	.382	-.037
%CIU	.350	.068	.153	.237
CIU/min	.582[a]	.183	.893[b]	-.005
%CIU/min	.745[b]	.130	.644[b]	.570[a]
# of Utterance	.132	-.328	-.019	-.380
# of Words	-.195	-.288	.492	-.198
#of Words/min	.381	.193	.692[b]	.295
MLU	-.184	-.134	.721[b]	.048

Note. CHA = cognitively healthy adults; MCI = individuals with mild cognitive impairment.
[a] Statistically different at the .05 level.
[b] Statistically different at the .01 level.

the general consensus (Beltrami et al., 2018; Drummond et al., 2015; Forbes-McKay & Venneri, 2005; Fleming, 2014; Fleming & Harris, 2008; Mueller et al., 2016b; Kiran, Marquardt, & Fleming, 2008), although different tasks to elicit language samples and different linguistic variables were utilized in previous studies. The fact that the IU scoring metric is capable of detecting subtle linguistic changes in individuals with MCI supports potential utility of it in clinical settings.

The differences in efficiency of connected speech between the MCI and CHA groups suggest that the MCI group was less efficient in presenting information than the CHA group within the given time. Previous findings on reduced efficiency in connected speech of individuals with MCI are conflicting. For example, Beltrami et al. (2018) used three different tasks considering the level of complexity. In a complex task that involved episodic memory, the researchers found reduced efficiency in the individuals with MCI and reported that it was one of the most important factors in discriminating individuals with MCI from CHA. Fleming (2014) reported more mazes produced in the MCI group than in the CHA group when the participants were asked to perform a complex connected speech task. However, Ahmed et al. (2013) measured efficiency in a simple picture description task by counting the total number of semantic units divided by duration of the speech, and did not find differential performance between the MCI and CHA groups. The differences in findings regarding the efficiency may be attributed to different types of tasks used to elicit language samples. Overall, these findings suggest that the degree to which cognitive demands are involved in connected speech tasks may be crucial when detecting subtle changes in efficiency in connected speech of MCI.

4.2. *Effect of story familiarity on story retelling performance*

Regarding the effects of story type on retelling abilities, both groups showed significantly better performance in the familiar story than in the novel story. These findings are consistent with the results of Attali et al. (2008) that the CHA and the mild AD groups recalled more story elements in a familiar story task than in a novel story task. In the current study, the manipulation of the story type was derived from the assumption that cognitive burden from each story is associated with different memory systems. It was reasonable to assume that the novel story task required greater cognitive demands compared to the familiar story task considering the story retelling process. When listening to a familiar story and retelling it, prior information stored over the long-term in an inactive state will be changed to an active state. Familiar stories tend to be spoken repeatedly in an individual's life. This rehearsal effect allows people to easily retell the story, compared to a novel story which has never been told. It is likely that the familiar story, which involves episodic memory, is less cognitively demanding because a portion of the familiar story can be automatically processed with prior rehearsal opportunities. However, for the novel story, the participants need to rely on their short-term memory to learn new information without any background knowledge about the story. Our findings also add empirical support to previous studies (Britton & Tesser, 1982; Li, Williams, & Della Volpe, 1995) that topic familiarity is a potential source of variance, which helps elicit abundant language samples from speakers.

One of the critical findings from the current study was a significant two-way interaction in the informativeness (%IU) between story type and group. Consistent with our hypothesis, group differences were greater in the familiar story task compared to the novel story task. Interestingly, both groups showed greater difficulties in the novel story, but the familiar story was the task which significantly differentiated the two groups. The findings suggest that overly complex tasks are not suitable to differentiate the CHA group from a potential clinical population at risk. Even for healthy aging adults, it is cognitively demanding to retell a story after listening to it only once. However, previously known thematic elements of a story give hints of things to come when retelling a familiar story. Activated information from the initial utterance may be held in storage and serve as a prime to elicit the following utterances in context for cognitively healthy speakers. Individuals with MCI do not seem to be primed with preceding story elements.

The effect of story familiarity between the two groups was not evident in efficiency in connected speech. These findings indicate that the group difference that emerged clearly in the familiar story with the measure of informativeness, appeared to be offset when the amount of information transmitted was normalized by time. There is evidence that elderly adults show persistent deficits in processing speed (Wright, Capilouto, Srinivasan, & Fergadiotis, 2011), which may have influenced the pattern of results. In the current study, it is not possible to determine if the CHA group and their reduced processing speed contributed to the findings and this should be explored in future studies.

From a task development standpoint, the CHA group failed to perform at or near ceiling level on IU measures. This finding is similar to previous studies (Brodsky et al., 2003; McNeil et al., 2001) which reported that the control group produced less than 50% of IUs in two of the four story tasks, and slightly over 50% in the other two tasks. This may be due to the story retelling process, which is cognitively demanding even for cognitively healthy adults compared to story description tasks. For speakers to retell a story, comprehending the picture stimuli and story structure with characters needs to be properly preceded. Further, within the scoring framework of the IU metric, speakers are expected to produce nearly accurate words or phrase provided by investigators. Thus, further investigations are warranted to adjust complexity level of the task by reducing the number of IUs provided at one time.

4.3. *Concurrent validity of the IU metric*

The current study examined the validity of an IU metric for the MCI and CHA groups. The measure of %IU was highly positively correlated with CIU ($r = 0.68$), number of words ($r = 0.548$), and mean length of utterance ($r = 0.669$) in the MCI group, whereas none of the correlations were significant in the normal control group for %IU. The patterns of %IU/Min for both groups were similar to that of %IU. The measure of %IU/min showed moderate to high correlations with CIU/Min ($r = .644$), number of words per minute ($r = 0.692$), and mean length of utterance ($r = 0.721$) in the MCI group. There was only a correlation between %IU/min and CIU/Min ($r = 0.745$) in the CHA group.

The differences observed between the two groups were consistent with the findings of McNeil et al. (2001) in that concurrent validation for the CHA group did not hold. The nature of the IU measure may account for the limited number of significant relationships with other linguistic measures for the CHA group. Only pre-selected IUs and their synonyms were counted in the IU metric, whereas any accurate and informative words or phrases related to the stimuli provided were counted for scoring other measures. The results reported here indicate that the CHA group produced around 44% of the IUs and produced 86% of the CIU for the familiar story. Thus, it is possible that the CHA group delivered an informative story, but did not recall the precise IUs. The reduced range of IU scores for the CHA group may also contribute to the limited number of correlation coefficients.

However, the IU metric (i.e., %IU and %IU/Min) was concurrently validated for the MCI group. The findings demonstrated that the IU measure was a sensitive tool to capture some linguistic features especially associated with length-related syntactic components reflected in the correlations with number of words and mean length utterance. Further, it also captured the semantic component, resulting in high correlations between %IU and numbers of CIU. Interestingly, the moderate-to-high correlations between %IU and some linguistic measures were observed only in the familiar story for the MCI group. The correlation disparity among two-story tasks may be accounted for by the topic familiarity, which was found to be a potential source of variance (Britton & Tesser, 1982; Li et al., 1995). It is apparent that retelling a story placed a more significant strain on processing load for individuals with MCI. To retell a story in the IU scoring framework, individuals must correctly comprehend the story and store the information units. Among the two story tasks, the familiar story is generally overlearned, which requires less cognitive load on semantic activation compared to the novel story task. Thus, the familiar story task does not challenge a speakers' processing ability and may place on them an appropriate story processing load.

Compared to the informativeness of connected speech (%IU), more significant correlations were found when considering the efficiency of connected speech (%IU/Min). Moderate to high correlations with %CIU/Min and the number of words per minute demonstrated the concurrent validity of the %IU/Min measure that captured the same underlying mechanisms of efficiency in connected speech. In a recent study, acoustic features of speech (e.g., standardized pause rate) were shown to be important factors in discriminating the MCI group from the CHA group in the connected speech task, with a significantly longer pause found for the MCI group (Beltrami et al., 2018). Using the constrained context and pre-identified IUs, SLPs may reduce their time and effort for measuring efficiency of connected speech in clinical settings.

5. Limitations and future directions

Limitations and implication of the current study are well recognized. The decision to choose the IU scoring metric to quantify connected speech in the current study was motivated by the clinical potential of this measure, with respect to non-transcription requirements that ultimately lead to precise measurement. However, since the IU metric is derived from the CIU measure, it evaluates informativeness of connected speech without consideration of whether the macro-level linguistic skills of the connected speech are addressed (e.g., main concept; Nicholas & Brookshire, 1995). Further, because our participants are monolingual Korean speakers, we have cautiously selected linguistic variables to investigate validity of the IU metric. Although a great deal of linguistic measures have been used in research of connected speech for English speaking populations, these measures are not readily applicable to different languages. Thus, more detailed analysis is needed to investigate validity of the IU metric with more sophisticated linguistic measures that are linguistically and culturally well adapted. Simultaneously, further exploration of the relationship between the IU metric and macro-level measures should be considered as well.

In the current study, the CHA group did not retell more than 50% of IUs in both story tasks, which is similar to findings in previous studies (Brodsky et al., 2003; McNeil et al., 2001). Most likely, it is a combination of task difficulty and cognitive abilities that affect story retelling performance. Although the presence of picture stimuli in story retelling tasks reduces working memory loads and assists clinical populations in understanding and restructuring contents (Doyle et al., 2000), integrating multiple processing streams to successfully produce connected speech is necessary. For example, speakers need to comprehend visually presented stimuli with auditory information, and shift their attention from scene to scene, even in the familiar story task. The nature of stimuli also can influence the pattern of results. Introducing a new story in story retelling tasks requires higher cognitive and processing demands, which reveals difficulties in normal aging processing as well. Moreover, our rigorous rules for accepting synonyms in the scoring system may have provided a restriction for our participants to earn a point in the tasks. Thus, future work should consider the refinement of story retelling tasks to enhance sensitivity and specificity of the test, such as a shortened script for story retelling tasks and/or refinement of range of acceptable IUs.

Additionally, it is well known that how instructions are provided to patients matters when eliciting language samples (Olness, 2006; Wright & Capilouto, 2009). The instruction that we provided to our participants were developed based on previous studies investigating the IU metric for an English speaking population, and other studies regarding connected speech in Korean speaking populations. At the same time, Korean language properties were considered, such as omission of the substantial subject and/or the sentential object that provide credits in the IU scoring system. In the familiar story task in which our participants listened to and retold, a sentence contains "Nolbu visited Hungbu". When retelling the story, Korean speakers may only say "Nolbu visited", "Visited Hungbu", or "Visited". Without the instruction of using exact words, our speakers' ability to produce stories could be underestimated. However, this is not to say that researchers investigating the IU metric with a Korean speaking population should continue to use the same instruction. A systematic approach to potential linguistic, cultural, and methodological confounds that potentially influence speakers' performance in the IU metric should be considered in future investigations.

6. Conclusions and clinical implications

We have focused on preliminary evidence of the effect of story familiarity in story retelling tasks, and utility of IU scoring for clinical use. Clearly, the IU scoring system is viable for use as a simplified, non-transcription tool and has so far proven to be valid and reliable in studies including the current investigation. Use of the IU metric may discern subtle linguistic changes in clinical settings and lower barriers for SLPs to implement connected speech-level assessment. However, high inter-rater reliability for scoring in the current study and previous study (Hula et al., 2003) was experimentally achieved with audio recorded files of language samples. Thus, we suggest that SLPs still need to consider recording language samples to quantify connected speech in the IU metric.

Critical to language assessment, especially for connected speech, is the types of stimuli/tasks to elicit language samples, in that the materials manipulate the degree of cognitive and linguistic demands (e.g., Bliss & McCabe, 2006; Brady, Armstrong, & Mackenzie, 2005; Nicholas & Brookshire, 1993). Recall that there was a greater difference found between the MCI and the CHA groups in the familiar story task compared to the novel story. With respect to the finding, it is important to recognize that one key difference of the story tasks is whether or not episodic memory was involved. Given the well-known deterioration of episodic memory in individuals with MCI, a familiar, fairy tale-like story may be particularly useful for this population. It should be noted that due to the lack of studies using familiar story tasks for individuals with MCI, it is premature to draw a clinical determination at this point.

To the best of our knowledge, this is the first time the IU metric originally developed for persons with aphasia who are native English speakers has been adapted and translated for Korean speakers with MCI. When translating an existing language test into a new language version of the test, cultural and linguistic aspects that can potentially affect examinee' test performance should be considered, and the direct translation of the test is not appropriate (Ivanova & Hallowell, 2013). As such, we highlight that instructions and guidelines for scoring used in the current study were adapted for a Korean speaking population, and should not be directly applied to different ethnic groups. Given the increasing number of elderly immigrant populations in the United States, how to evaluate and intervene these populations is an emerging clinical issue (Nanchen et al., 2017). Hopefully, story retelling tasks that we developed based on the IU metric will be a foundation for promoting better service and eventually help SLPs facilitate implementation of language assessment for immigrant populations.

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CRediT authorship contribution statement

Hana Kim: Conceptualization, Methodology, Data collection, Data processing, Formal analysis, Visualization, Writing - original draft, Writing - review & editing. **Jee Eun Sung:** Supervision, Conceptualization, Methodology, Writing – review & editing, Funding acquisition. **Jee Hyang Jeong:** Data collection.

Declaration of competing interest

Authors claim no conflicts of interests.

Appendix

	Familiar story (Hungbu wa Nolbu)
1	옛날에 욕심쟁이 놀부와 착한 흥부가 살고 있었습니다. 놀부는 재산을 차지하고 흥부를 집에서 내쫓아 버렸습니다. Once upon a time, there were brothers, greedy older brother, Nolbu and his nice younger brother, Hungbu. After their father died, Nolbu kept his family fortune to himself and kicked his younger brother out of their house.
2	어느날 흥부는 다리가 부러진 제비를 발견하고 치료해 주었습니다. 다음 해 제비는 흥부에게 박씨를 갖다 주었습니다. One day, Hungbu saw a swallow that had injured its leg, and treated it. The following spring, the swallow came back to Heungbu with a seed.
3	흥부는 박씨를 심고 키워서 박을 탔습니다. 그 안에서 많은 보물이 나와 흥부는 부자가 되었습니다. Hungbu planted and tended the seed. After the seed grew into gourds, Hungbu split the gourds in half. Inside the gourds was money and jewels, which made Hungbu wealthy.
4	놀부는 흥부의 소식을 듣고 일부러 제비 다리를 부러뜨렸습니다. 봄이 되자 제비는 씨를 하나 갖다 주었습니다. Nolbu heard how Hungbu suddenly became rich. Nolbu intentionally broke a swallow's leg and splinted it up. Next Spring, the swallow gave Nolbu a seed.
5	놀부도 그 박을 정성스레 키웠고 다 자라자 박을 탔습니다. 그런데 박에서는 도깨비가 나와 놀부의 재산을 가지고 갔습니다. Nolbu also planted and tended the seed as Hungbu had. When Nolbu split his gourds, goblins came out of the gourds and took all of his money and jewels.
6	놀부는 동생 흥부를 찾아갔습니다. 흥부는 빈털터리가 된 불쌍한 형을 맞아 주며 함께 살자고 하였습니다. Nolbu visited Hungbu and asked Hungbu to forgive him. Hungbu welcomed his brother and they lived together happily ever after.
	Novel story (Argument)
1	주말 오후 남편은 아무 것도 하지 않고 신문만 보았습니다. 아내는 그런 남편에게 소리를 지르기 시작했습니다. On a weekend afternoon, a husband was sitting in his chair, just reading the newspaper. His wife started fussing at him

(*continued on next page*)

(*continued*)

	Familiar story (Hungbu wa Nolbu)
2	화가 난 아내는 짜증을 내며 짐을 싸서 친정으로 돌아갔습니다. 그래도 남편은 의자에 가만히 앉아있었습니다. The wife became angry, storming out the door with her suitcase. The husband turned away from her and continued to read the newspaper in his chair.
3	시간이 지난 후 남편은 괜히 미안한 마음이 들어 생각에 잠겼습니다. 지금이라도 빨리 아내를 쫓아가 붙잡으려고 했지만 그만두었습니다. After a while, he felt some remorse, thinking about her leaving. He was going to go after her, but he didn't.
4	잠시 후 문이 열리는 소리가 들렸습니다. 남편이 뒤를 돌아보니 슬픈 얼굴의 아내가 서 있었습니다. A few minutes later the door reopened. The wife came in and stood still, with a sad look on her face.
5	아내는 가방을 내려 놓은 채 엉엉 울고 있었습니다. 남편은 아내에게 다가가 방금 전의 행동에 대해 사과를 하였습니다. She put down her suitcase and started crying. Her husband reached out to hold her, and apologized.
6	남편은 아내를 안아주면서 문 사이로 나무에 부딛힌 무언가를 보았습니다. 그것은 자신의 새 차였습니다. As he put his arms around her, he looked out to the driveway, where his wife had crashed something into a tree. It was his new car.

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