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Language Processing of Seniors with Alzheimer's Disease: From the Perspective of Temporal Parameters

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***Abstract*—**The present paper aims to examine the language processing of Chinese-speaking seniors with Alzheimer's disease (AD) from the perspective of temporal cues. Twenty healthy adults, 17 healthy seniors, and 13 seniors with AD in Taiwan participated in this study to tell stories based on two sets of pictures. Nine temporal cues were fetched and analyzed. Oral productions in Mandarin Chinese were compared and discussed to examine to what extent and in what way these three groups of participants performed with significant differences. Results indicated that the age effects were significant in filled pauses. The dementia effects were significant in mean duration of pauses, empty pauses, filled pauses, lexical pauses, normalized mean duration of filled pauses and lexical pauses. The findings reported in the current paper help characterize the nature of language processing in seniors with or without AD, and contribute to the interactions between the AD neural mechanism and their temporal parameters.

***Keywords*—**Language processing, Alzheimer's disease, Mandarin Chinese, temporal cues.

I. Introduction

OVER the past decades, more and more research has been conducted to examine the language structure of persons with AD. Temporal forms have, however, received the least attention, especially the temporal forms of AD persons when they are using natural languages. Recent studies have focused mainly on natural language production in order to quantify the phenomenon of lexical impairment for early AD persons. These impairments include word-finding difficulties and discourse impairments in daily conversation, most of which originate from the failure of successful language planning of production in the cognitive process. In regard to the quantification of language planning of production, to study "pauses" is a common and effective way in the preceding literature. According to [1], [2], pauses are considered an important index to reflect cognitive activities, practically, in discourse performance. A larger number of pauses, longer pauses, and inappropriate distribution of pauses practically reflect some extent of the obstruction in cognitive operation, and simultaneously, affects the performance of language fluency. Reference [3] found that the acoustic data of AD pauses can specifically reflect their difficulty with word-finding and the problems of language production planning.

Examination of natural acoustic phonetic data is a technique that costs relatively little and decreases the uncomfortable feelings of patients or participants at the same time [4]-[7]. These acoustic phonetic variables can provide reliable and concrete data for testing the cognitive developing process of AD persons, such as language production planning, structure and organization of semantic memory [8], the operation of naming [9], and the operating process of lexical semantics [10].

Currently, an increasing amount of research is being done to detect the acoustic features of AD persons (see [3], [11]-[17]). Studies have shown that a larger number of impairments are found in the group of AD persons than in the control group, and the specific phonetic features of AD persons have been identified. So far, the acoustic research on the temporal forms of Mandarin-speaking AD persons is still at the startup stage. It is important to investigate the acoustic phonetic parameters in natural language since it can clearly present the speech skills and language skills of participants using a reliable and scientific approach [18], [14]. This study aimed to examine the acoustic phonetic parameters of Mandarin-speaking AD persons and their healthy-control counterparts, and to analyze nine temporal cues, namely articulation rate, hesitation ratio, mean duration of pauses, mean duration of empty pauses, normalized mean duration of empty pauses, mean duration of filled pauses, normalized mean duration of filled pauses, mean duration of lexical pauses, and normalized mean duration of lexical pauses.

II. Method

This section introduces the design of the current research. The participants, procedures and data analysis are explicitly described below.

A. Participants

Fifty persons participated in the study. These participants were further divided into three subgroups: 20 healthy adults (HA), 17 healthy seniors (HS), and 13 seniors with AD. The adults in the HA group ranged from 20 to 30 years old, and the seniors in the HS group and the AD group ranged from 60 to 83 years old. All participants were born in Taiwan.

Participants with AD were recruited through memory clinics. They were diagnosed as having probable AD as defined by Kaohsiung Veterans General Hospital (KVGH), Taiwan, by following the NINCDS-ADRDA criteria [19]. According to the results of laboratory tests, the AD participants in this study were not suffering from other disorders. They were therefore reliably clinically-diagnosed as

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probable AD.

B. Procedures

Each participant was individually asked to tell stories based on two sets of pictures, Set 1 and Set 2 [20]. Each set included four pictures, marked by numbers one to four. The participants were encouraged to follow the sequence and to tell what was happening in the picture one by one. Examples of instructions were "Could you please tell me what is happening in these pictures?" or "Please describe any information conveyed in these pictures." Oral productions were tape-recorded. After the participants expressed that they had finished or after 30 seconds of silence, the recording was stopped.

C. Data Analysis

The participants' performance data in the story-telling task were analyzed. Temporal features of pauses were fetched and analyzed with the help of PRAAT [21]. Reference [22] (1982: 13) claims that a "pause is defined as an interval of the oscillographic trace, where the amplitude is indistinguishable from that of the background noise." According to [23], pauses were defined as a kind of empty speech of more than 0.25 seconds. Pauses were further divided into three types, empty, filled or lexical pauses [24]-[27]. Nine temporal cues, namely articulation rate, hesitation ratio, mean duration of pauses, mean duration of empty pauses, mean duration of filled pauses, mean duration of lexical pauses, normalized mean duration of empty pauses, normalized mean duration of filled pauses, and normalized mean duration of lexical pauses, were then calculated and compared.

Statistical analysis followed the fetch of acoustic data. Referential statistics, for example, One-way ANOVA and Post-hoc Scheffé analysis, were performed to examine possible significant group differences in the collected acoustic data.

III. Results & Discussion

This section provides statistical results and discussion of the way in which these groups (i.e., HA, HS, AD) differed significantly from the perspective of temporal parameters. Statistical reports of acoustic cues and a general discussion are offered.

A. Statistical Results of Temporal Cues in Story Telling

Temporal cues under examination in this study include articulation rate, hesitation ratio, mean duration of pauses, mean duration of empty pauses, mean duration of filled pauses, normalized mean duration of empty pauses, mean duration of lexical pauses, normalized mean duration of filled pauses and normalized mean duration of lexical pauses. Table I presents the results of the articulation rate in the story-telling task of Mandarin Chinese. Articulation rate is defined as the number of words per second (excluding the pauses of more than 30 seconds).

Judging from Table I, the AD group (Mean=2.91) produced a slower articulation rate than the HA group (Mean=3.50) and the HS group (Mean=3.33) in the story-telling task of Set 1. Similarly, the AD participants (Mean=3.21) were much slower in telling the story of Set 2 than the other participants (Mean=3.73 for HA, Mean=3.30 for HS). The overall pattern shows that the AD group (Mean=3.06) told the stories with a slower articulation rate than the other two groups (Mean=3.62 for HA, Mean=3.31 for HS). These differences, however, did not reach a significant level.

TABLE I
Articulation Rate in Story Telling of Mandarin Chinese

	Group	N	Mean	SD	F
Set 1	HA	20	3.50	0.74	2.50
	HS	17	3.33	0.60	
	AD	13	2.91	0.92	
Set 2	HA	20	3.73	0.98	1.41
	HS	17	3.30	0.69	
	AD	13	3.21	1.25	
Overall	HA	20	3.62	0.83	1.89
	HS	17	3.31	0.61	
	AD	13	3.06	1.01	

Note: N=number; SD= standard deviation

Hesitation ratio refers to the duration of pauses divided by the total speech production (in seconds). According to Table II, the AD group (Mean=0.41) had a higher hesitation ratio than the other two groups in the story-telling task of Set 1 (Mean=0.28 for HA, Mean=0.35 for HS). A similar pattern was found in the story-telling task of Set 2, in which the HA and HS participants (Mean=0.25 for HA, Mean=0.35 for HS) produced slightly shorter hesitation ratios than the AD participants (Mean=0.36). Overall, the AD participants were observed to have a longer hesitation ratio than the other participants in telling stories of these two sets, though the differences were not significant enough.

TABLE II
Hesitation Ratio in Story Telling of Mandarin Chinese

	Group	N	Mean	SD	F
Set 1	HA	20	0.28	0.09	1.27
	HS	17	0.35	0.35	
	AD	13	0.41	0.16	
Set 2	HA	20	0.25	0.10	1.99
	HS	17	0.35	0.23	
	AD	13	0.36	0.19	
Overall	HA	20	0.27	0.09	1.70
	HS	17	0.36	0.30	
	AD	13	0.39	0.17	

Note: N=number; SD= standard deviation

Table III summarizes the results of the mean duration of pauses in story telling in Mandarin Chinese. The mean duration of pauses is obtained when the total pause duration is divided by the number of pauses. Based on Table III, a significant distinction was identified in the story-telling task of Set 1. Judging from the mean values, the AD group (Mean=0.99) displayed significantly longer duration of pauses than the other two groups (Mean=0.73 for HA, Mean=0.76 for HS). Likewise, significant differences were discerned in the story-telling task of Set 2. The results of Post-hoc Scheffé

analysis further indicated that the HA group (Mean=0.71) produced significantly shorter pauses than the AD group (Mean=1.23), and that the HS group (Mean=0.78) uttered significantly shorter pauses than the AD group (Mean=1.23). A significant distinction was also found in the overall pattern. Post-hoc Scheffé analysis additionally revealed that the AD participants (Mean=1.05) told the stories with significantly longer pauses than the healthy adults (Mean=0.72).

TABLE III
MEAN DURATION OF PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.73	0.16	3.55*
	HS	17	0.76	0.36	
	AD	13	0.99	0.35	
Set 2	HA	20	0.71	0.18	7.46** HA<AD HS<AD
	HS	17	0.78	0.30	
	AD	13	1.23	0.67	
Overall	HA	20	0.72	0.16	4.88* HA<AD
	HS	17	0.79	0.33	
	AD	13	1.05	0.42	

Note: N=number; SD= standard deviation; * $p< 0.05$;** $p< 0.01$

TABLE IV
MEAN DURATION OF EMPTY PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.84	0.17	2.55
	HS	17	0.87	0.48	
	AD	13	1.24	0.88	
Set 2	HA	20	0.83	0.20	6.80** HA<AD HS<AD
	HS	17	0.95	0.36	
	AD	13	1.50	0.93	
Overall	HA	20	0.83	0.16	6.37** HA<AD HS<AD
	HS	17	0.96	0.40	
	AD	13	1.47	0.89	

Note: N=number; SD= standard deviation; ** $p< 0.01$

TABLE V
NORMALIZED MEAN DURATION OF EMPTY PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.27	0.09	0.19
	HS	17	0.31	0.33	
	AD	13	0.28	0.19	
Set 2	HA	20	0.24	0.09	1.44
	HS	17	0.32	0.23	
	AD	13	0.24	0.15	
Overall	HA	20	0.25	0.09	0.78
	HS	17	0.33	0.28	
	AD	13	0.26	0.16	

Note: N=number; SD= standard deviation

Table IV presents the results of the mean duration of empty pauses produced by the three groups of participants. Mean duration of empty pauses is calculated when the total amount of empty pause duration is divided by the number of empty pauses. Significant differences were identified in the story-telling task of Set 2 and the overall performance. The results of the Post-hoc Scheffé analysis additionally indicated that the HA group (Mean=0.83) produced significantly shorter empty pauses than the AD group (Mean=1.50), and that the HS group (Mean=0.95) uttered significantly shorter empty pauses than the AD group (Mean=1.50). Also, these three groups performed with significant differences in the overall pattern. Post-hoc Scheffé analysis further revealed that the AD participants (Mean=1.47) told the stories with significantly longer empty pauses than the healthy adults (Mean=0.83) and the healthy seniors (Mean=0.96).

The results of normalized mean duration of empty pauses produced by the three groups of participants are reported in Table V. Normalized mean duration of empty pauses is obtained when the total amount of empty pause duration is divided by the total speech production. No significant differences, however, were found in the results. Probably, the normalized data among these three groups were too close to reach any significant distinction.

TABLE VI
MEAN DURATION OF FILLED PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.23	0.34	4.51* HA<HS
	HS	17	1.65	2.42	
	AD	13	0.64	0.52	
Set 2	HA	20	0.27	0.40	3.27*
	HS	17	0.17	0.23	
	AD	13	0.48	0.34	
Overall	HA	20	0.38	0.40	5.16** HS<AD
	HS	17	0.26	0.25	
	AD	13	0.68	0.42	

Note: N=number; SD= standard deviation; * $p< 0.05$; ** $p< 0.01$

TABLE VII
NORMALIZED MEAN DURATION OF FILLED PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.01	0.01	9.21*** HA<AD HS<AD
	HS	17	0.01	0.02	
	AD	13	0.07	0.09	
Set 2	HA	20	0.01	0.01	5.18** HA<AD
	HS	17	0.01	0.02	
	AD	13	0.05	0.07	
Overall	HA	20	0.01	0.01	9.18*** HA<AD HS<AD
	HS	17	0.01	0.01	
	AD	13	0.06	0.07	

Note: N=number; SD= standard deviation; ** $p< 0.01$; *** $p< 0.001$

Table VI presents the results of mean duration of filled pauses (e.g., 'uh', 'um') produced by the three groups of participants. Mean duration of filled pauses is calculated when the total amount of filled pause duration is divided by the number of filled pauses. Significant differences were identified in the story-telling tasks of Set 1, Set 2 and the overall performance. Judging from the results of the Post-hoc Scheffé analysis, the healthy adults (Mean=0.23) produced significantly shorter filled pauses than the healthy seniors (Mean=1.65) in telling the story of Set 1. On the basis of the mean values of Set 2, the AD participants (Mean=0.48) uttered

significantly longer filled pauses than the other participants (Mean=0.27 for HA, Mean=0.17 for HS). Overall, the AD participants (Mean=0.68) told stories with significantly longer filled pauses than the healthy seniors (Mean=0.26).

Table VII summarizes the results of the normalized mean duration of filled pauses produced by the three groups of participants. Normalized mean duration of filled pauses is obtained when the total filled pause duration is divided by the total speech production. Significant differences were found in the story-telling tasks of Set 1, Set 2 and the overall performance. In Set 1, Post-hoc Scheffé analysis additionally indicated that the AD participants (Mean=0.07) told stories with significantly longer filled pauses than the healthy adults (Mean=0.01) and the healthy seniors (Mean=0.01). In Set 2, the HA group (Mean=0.01) produced significantly shorter filled pauses than the AD group (Mean=0.05). Overall, the AD participants (Mean=0.06) told stories with significantly longer filled pauses than the healthy adults (Mean=0.01) and the healthy seniors (Mean=0.01).

TABLE VIII
MEAN DURATION OF LEXICAL PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.02	0.02	11.86*** HA<AD HS<AD
	HS	17	0.07	0.13	
	AD	13	0.45	0.50	
Set 2	HA	20	0.01	0.02	20.05*** HA<AD HS<AD
	HS	17	0.05	0.05	
	AD	13	0.59	0.54	
Overall	HA	20	0.02	0.02	19.03*** HA<AD HS<AD
	HS	17	0.06	0.05	
	AD	13	0.52	0.48	

Note: N=number; SD= standard deviation; ***p< 0.001

TABLE IX
NORMALIZED MEAN DURATION OF LEXICAL PAUSES IN STORY TELLING OF MANDARIN CHINESE

	Group	N	Mean	SD	F
Set 1	HA	20	0.01	0.01	7.53** HA<AD
	HS	17	0.03	0.03	
	AD	13	0.07	0.09	
Set 2	HA	20	0.01	0.01	11.20*** HA<AD HS<AD
	HS	17	0.02	0.02	
	AD	13	0.07	0.08	
Overall	HA	20	0.01	0.01	11.87*** HA<AD HS<AD
	HS	17	0.02	0.02	
	AD	13	0.07	0.07	

Note: N=number; SD= standard deviation; **p< .01; ***p< .001

Table VIII reports the results of mean duration of lexical pauses produced by the three groups of participants. Mean duration of lexical pauses (e.g., 'na', 'nage', 'ranhou') is calculated when the total lexical pause duration is divided by the number of lexical pauses. Significant differences were discerned in the story-telling tasks of Set 1, Set 2 and the overall performance. Based on the results of Post-hoc Scheffé analysis, the healthy adults (Mean=0.02) and the healthy seniors (Mean=0.07) uttered significantly shorter lexical pauses than the AD participants (Mean=0.45) when telling the story of Set 1. In Set 2, the AD participants (Mean=0.59) produced significantly longer lexical pauses than the other participants (Mean=0.01 for HA, Mean=0.05 for HS). Overall, the AD participants (Mean=0.52) told stories with significantly longer filled pauses than the healthy adults (Mean=0.02) and the healthy seniors (Mean=0.06).

Table IX presents the results of normalized mean duration of lexical pauses produced by the three groups of participants. Normalized mean duration of lexical pauses is obtained when the total lexical pause duration is divided by the total speech production. Significant differences were observed in the story-telling tasks of Set 1, Set 2 and the overall performance. In Set 1, Post-hoc Scheffé analysis additionally revealed that the AD participants (Mean=0.07) told stories with significantly longer normalized lexical pauses than the healthy adults (Mean=0.01). In Set 2, the HA group (Mean=0.01) and the HS group (Mean=0.02) produced significantly shorter normalized lexical pauses than the AD group (Mean=0.07). A similar pattern occurred in the overall performance. The AD participants (Mean=0.07) told stories with significantly longer normalized lexical pauses than the healthy adults (Mean=0.01) and the healthy seniors (Mean=0.02).

B. Discussion

The current investigation revealed language processing of Chinese-speaking seniors with AD from the perspective of temporal cues. The effects of age and dementia are discussed below.

The age effects on story-telling performance were significant in one dimension of the temporal parameter, that is, filled pauses (Set 1). HS (Mean=1.65) produced significantly longer filled pauses than HA (Mean=0.23) in telling the story of Set 1. It can be argued that the descriptive discourse of healthy seniors differed significantly from that of healthy adults in the filled pauses. No significant age effects on the healthy participants' performance, however, were observed in other temporal parameters, including articulation rate, hesitation ratio, mean duration of pauses, mean duration of empty pauses, normalized mean duration of empty pauses, normalized mean duration of filled pauses, mean duration of lexical pauses, and normalized mean duration of lexical pauses.

Concerning the dementia effects, significant findings were revealed in terms of mean duration of pauses, mean duration of empty pauses, mean duration of filled pauses, mean duration of lexical pauses, normalized mean duration of filled pauses, and normalized mean duration of lexical pauses. With regard to the mean duration of pauses (Table III), the AD participants told the stories with significantly longer pauses than the healthy seniors (Set 2) and the healthy adults (Set 2 and Overall). A similar pattern was observed in the production of empty pauses (Table IV). Significantly longer empty pauses were produced by the AD participants than by the healthy controls (Set 2 and Overall).

Considering the filled pauses, the statistical results of both mean duration (Table VI) and normalized mean duration

(Table VII) were significant. It was found that the AD participants told stories with significantly longer filled pauses than the healthy seniors. Likewise, the normalized data of filled pauses showed that significantly longer normalized filled pauses were found in the AD group than in the groups of healthy adults (HA) and healthy seniors (HS).

Significant group differences were further found in the aspect of lexical pauses. In the story-telling performance, significantly longer lexical pauses were identified in the AD group than in the other two groups (i.e., HA and HS) (Table VIII). A similar pattern occurs in the statistical results of normalized mean duration of lexical pauses (Table IX). The AD participants told the stories with significantly longer normalized lexical pauses.

No significant differences among these three groups (i.e., HA, HS, and AD) were observed in the three dimensions of articulation rate (Table I), hesitation ratio (Table II) and normalized mean duration of empty pauses (Table V). It can be inferred that neither the age factor nor the dementia factor exerted a significant influence on the participants' story-telling performance in terms of articulation rate, hesitation ratio and normalized mean duration of empty pause.

In brief, it can be argued that the AD descriptive discourse is marked with significantly longer pauses, empty pauses, filled pauses, normalized filled pauses, lexical pauses, and normalized lexical pauses. These results manifested that the AD participants' comparatively impaired processing in phonetic representations of the story-telling tasks.

Findings in the current investigation are in agreement with those in previous studies on aging and language processing from the perspective of acoustic phonetics [1]-[3]. References [1], [2] claimed that pauses are referred to as an important index, reflecting cognitive activities, especially in the discourse performance. A larger number of pauses and longer pauses truly reflect certain obstructions in cognitive operation, and simultaneously affect the performance of language fluency. While [3] also argued that the acoustic data of AD pauses specifically reflected their difficulty with word-finding and the problems of language planning of production. The present study further contributes to the specific temporal cues of the AD oral performance and elaborates the issue of age and dementia on descriptive discourse in Mandarin Chinese.

IV. Conclusion

This paper aims to investigate the language processing of Chinese-speaking AD seniors, as compared with that of healthy adults and seniors, from acoustic perspectives. Based on their oral performances and statistical results, there are a number of significant findings. The major findings and conclusions are summarized below.

First of all, a significant effect of the age factor was identified in one temporal cue: filled pauses. The descriptive discourse of healthy seniors is produced with significantly longer filled pauses than that of healthy adults. The second finding concerns the dementia effects. Significant influences of the dementia factor were found in six temporal parameters, including mean duration of pauses, mean duration of lexical pauses, mean duration of empty pauses, mean duration of filled pauses, normalized mean duration of filled pauses, and normalized mean duration of lexical pauses.

On the basis of the major findings, this paper contributes to the following two issues. One concerns the extent to which and the way in which young adult speakers of Mandarin Chinese differ significantly from senior speakers in the story-telling tasks. The other issue is related to the extent to which and the way in which healthy adults and seniors of Mandarin Chinese perform differently from AD seniors in the story-telling tasks.

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References

[1] Goldman–Eisler, F. (1968). *Psycholinguistics: Experiments in spontaneous speech*. New York: Academic Press.
[2] Goldman–Eisler, F. (1972). Pauses, clauses, sentences. *Language and Speech*, *15*, 103-113.
[3] Bucks, R. S., Singh, S., Cuerden, J.M., & Wilcock, G. K. (2000). Analysis of spontaneous, conversational speech in dementia of Alzheimer type: Evaluation of an Objective technique for analyzing lexical performance. *Aphasiology*, *14*, 79-91.
[4] Appell, J., Kertesz, A., & Fisman, M. (1982). A study of language functioning in Alzheimer patients. *Brain Language, 17*, 73–91. http://dx.doi.org/10.1016/0093-934X(82)90006-2.
[5] Kemper, S., Thompson, M., & Marquis, J. (2001). Longitudinal change in language production: Effects of aging and dementia on grammatical complexity and propositional content. *Psychology and Aging*, *16*, 600-614.
[6] Kempler, D., Almor, A., Tyler, L. K., Andersen, E. S., & MacDonald, M. C. (1998). Sentence comprehension deficits in Alzheimer's disease: A comparison of off-line vs. on-line sentence processing. *Brain and Language*, *64*, 297-316.
[7] Kertesz, A., & Munoz, D. G. (2003). Primary progressive aphasia and Pick complex. *Journal of the Neurological Sciences*, *206*, 97-107.
[8] Hoffmann, I., Nemeth, D., Dye, C., Pakaski, M., Irinyi, T., & Kalman, J. (2010). Temporal parameters of spontaneous speech in Alzheimer's disease. *International Journal of Speech- Language Pathology, 12*, 29-34. http://dx.doi.org/10.3109/ 17549500903137256.
[9] Tirado, V., Muñoz, C., Aguirre, C., Pineda, D. A., & Lopera, R. (2004). Desempeño de portadores y no portadores de la mutación E280A para enfermedad de Alzheimer familiar en una prueba de denominación. (Performance of carriers and non-carriers of the E280A mutation for familial Alzheimer's disease in a naming test). *Revista de _eurología, 39*, 322-32.
[10] Valls-Pedret, C., Molinuevo, J. L., & Rami, L. (2010). Diagnóstico precoz de la enfermedad de Alzheimer. Fase prodrómica y preclínica. (Early diagnosis of Alzheimer's disease: the prodromal and preclinical phase). *Revista de _eurología, 51*, 471-480.
[11] Blanken, G., Dittman, J., Haas, J-C. & Wallesch, C-W. (1987). Spontaneous speech in senile dementia and aphasia. Implication for a neurolinguistic model of language production. *Cognition, 27*, 247-274.
[12] Bschor, T., Kuhl, K. P., & Reischies, F.M. (2001). Spontaneous speech of patients with dementia of the Alzheimer type and mild cognitive impairment. *International Psychogeriatrics*, *13*, 289-298.
[13] Forbes, K. E., Venneri, A., & Shanks, M. F. (2002). Distinct patterns of spontaneous speech deterioration: An mild predictor of Alzheimer's disease. *Brain and Cognition*, *48*, 356-361.
[14] Illes, J. (1989). Neurolinguistic features of spontaneous language production dissociate three forms of neurodegenerative disease:

Alzheimer's, Huntington's and Parkinson's. *Brain and Language, 37*, 628-642.
[15] Meilán, J.G., Martínex-Sánchez, F., Carro, J., Sánchez, J. A., & Pérez, E. (2012). Acoustic Markers Associated with Impairment in Language Processing in Alzheimer's Disease. *The Spanish Journal of Psychology*, *15*(2), 487-494.
[16] Romero, B. & Kurz, A. (1996). Deterioration of spontaneous speech in AD patients during a 1-year follow-up: Homeogeneity of profiles and factors associated with progression. *Dementia, 7*, 35-40.
[17] Singh, S., Bucks, R. S., & Cuerden, J. M. (2001). Evaluation of an objective technique for analysing temporal variables in DAT spontaneous speech. *Aphasiology, 15*, 571-583.
[18] Baum, S. R., Blumstein S. E., Naeser M. A., & Palumbo C. L. (1990). Temporal dimensions of consonant and vowel production: an acoustic and CT scan analysis of aphasic speech. *Brain and Language*, *39*, 33-56
[19] McKhann, G., Drachman D., Folstein M., Katzman R., Price D., & Stadlan Emanuel M. (1984). Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of the Department of Health and Human Services Task Force on Alzheimer's disease. *Neurology*, *34*, 939-944.
[20] He, W. Z. (2010). *The noun-verb deficits in Chinese-speaking aphasics.* Unpublished master's thesis. National Tsing Hua University
[21] Boersma, P., & Weenink, D. (2010). Praat: Doing phonetics by computer (version 5.1.29). (Computer program). Retrieved from http://www.praat.org/
[22] Duez, D. (1982) Silent and non-silent pauses in three speech styles. *Language and Speech*, *25*(1), 11-28.
[23] Hieke, A. E., Kowal, S., & O'Connell, D. C. (1983). The trouble with "articulatory" pauses. *Language and Speech*, *26*, 203–214.
[24] Fant, G., Kruckenberg, A., & Ferreira, J. B. (2003). Individual variations in pausing: A study of read speech. *Phonum*, *9*, 193-196.
[25] Hu, L. (2007). Long pauses in Chinese EFL learners' speech production. *Interlinguistica*, *17*, 606-616.
[26] Wu, C. H. (2008). Filled Pauses in L2 Chinese: A Comparison of Native and Non-Native Speakers. Proceedings of the 20th North American Conference on Chinese Linguistics (NACCL-20), Volume 1, Edited by Marjorie K.M. Chan and Hana Kang (pp. 213-227). Columbus, Ohio: The Ohio State University.
[27] Zellner, B. (1994). Pauses and the temporal structure of speech, in E. Keller (Ed.) *Fundamentals of speech synthesis and speech recognition.* (pp. 41-62). Chichester: John Wiley.