SPEECH DYSFLUENCIES IN NORMAL AND PATHOLOGICAL AGING: A COMPARISON BETWEEN ALZHEIMER PATIENTS AND HEALTHY ELDERLY SUBJECTS

Hyeran Lee[a], *Frédérique Gayraud*[b], *Fabrice Hirsh*[a] *& Melissa Barkat-Defradas*[a]

[a]Laboratoire Praxiling UMR5267 – CNRS & Université de Montpellier, France;
[b]Laboratoire Dynamique Du Langage UMR 5596 – CNRS & Université de Lyon, France
hye-ran.lee@univ-montp3.fr; Frederique.Gayraud@univ-lyon2.fr;
fabrice.hirsch@univ-montp3.fr; melissa.barkat@univ-montp3.fr

ABSTRACT

The aim of this study is to determine the speech characteristics of 20 patients with Alzheimer's disease (AD) in comparison with those of 20 age, sex, and socio-economic matched healthy controls. The first research is designed to study temporal organization of speech in the context of normal and pathological cognitive aging, and in the evolution of Alzheimer dementia using five variables: Verbal Rate, Transformed Phonation Rate, Mean Duration of Pauses, Standardized Phonation Time, and Standardized Pause Rate. We investigated also the frequency and the duration of pauses and lengthening considered as dysfluencies. The results show that patient's discourse is marked by frequent silent pauses and lengthening. A decline of productivity, measured with verbal rate; low effectiveness of time of phonation, reflected by transformed phonation rate measure; and an increase number of pauses, measured with standardized pause rate were observed in the group of Alzheimer patients more affected than the group of patients at mild to moderate stage.

Keywords: Alzheimer's disease, oral speech analysis, temporal organization, dysfluency

1. INTRODUCTION

Alzheimer's disease (AD) is a progressive neurodegenerative disorder, characterized by a decline of cognitive abilities. Many studies highlight deficits in language as a prominent symptom and a common clinical feature of AD ([7]). Pervasive disturbances in lexico-semantic domain ([12]), syntactic limitations ([1]), reduced discourse informativeness and/or coherence ([13]), and impairment in communicative performance have been hugely studied. But one area that has been less studied concerns the phonetic dimension of language.

Some previous studies however observed interesting trends in the temporal organization of Alzheimer patients' speech production. According to Illes [11], temporal characteristics of speech seem to be of critical importance to discriminate AD from other neurodegenerative illnesses. Studies by Hoffmann et al. [10] and Gayraud et al. [8] comparing temporal features and dysfluencies across AD patients and controls, found that discourse of AD patients has higher hesitation ratio than those of normal subjects. They concluded that these features are sensitive indicators to measure speech disorders in AD, even at the earliest stages of the disease.

Nevertheless, there is a lack of methodological consensus. In fact, some studies are based on very small sample ([16]); threshold for detecting silent pauses varies across studies (e.g. 200 ms in [8, 11]; 300 ms in [10]; 2 seconds in [16]); finally, different units are used for speech rate (e.g. number of words per minute *vs.* number of phonemes per second).

In an attempt to quantify the temporal characteristics of AD, we examined five variables, selected in Singh et al.'s [16] study, in the context of normal and pathological cognitive aging, and at different stages of dementia. We also considered pauses and vocalic lengthening as dysfluencies ([14]). These variables were calculated in terms of their frequency and duration using a strictly controlled methodology to explore their usefulness for quantifying speech fluencies and speech deficits in AD.

2. METHOD

2.1. Participants

Twenty patients clinically diagnosed with probable AD according to the NINCDS-ADRDA criteria ([13]), suffering from mild to moderate dementia ([6]) participated in this study. Twenty healthy

individuals without history of neurological and psychiatric disease matched with respect to age, gender and socio-economic level ([15]) served as controls subjects (CS).

As AD is a progressive disease, we examined production of 20 other patients at different stages of the disease (10 mild to moderate (16 < MMS < 26); 10 severe to very severe (MMS < 15)) to study the evolution of temporal variables according to stage of dementia.

All participants were native speakers of French. Information concerning the participants' social background is provided in Table 1.

Table 1: General information about patients and CS.

	Patients n=20		**CS** n=20		*p-value*
	Mean	SD	Mean	SD	
Age	76.6	9.2	76.9	5.3	n.s
NSC	2.2	1.2	2.2	1.3	n.s
MMS	22.62	2.5	30	0	<0.01

	Mild – Moderate n=10		**Severe – Very Severe** n=10		
	Mean	SD	Mean	SD	
Age	85.2	5	86.7	5.4	n.s.
NSC	2.4	1	2.1	1.3	n.s.
MMS	21.3	2.5	10.6	4.7	<0,01

2.2. Procedure

Spontaneous speech data were elicited by the experimenter asking the participants to talk freely about one of their life's remarkable event. The data were then carefully manually transcribed and annotated using Praat ([2]).

2.3. Coding

For the temporal measures, five variables were calculated:

- Verbal Rate (VR) = Text length / Total locution Time.
- Transformed Phonation Rate (TPR) = arc sin (Phonation Rate). PR= Total phonation time/ Total locution time.
- Mean Duration of Pauses (MDP) = Total pause time / Number of pauses.
- Standardized Phonation Time (SPT) = Text length / Total phonation time.
- Standardized Pause Rate (SPR) = Text length / Number of Pauses.

For the disfluencies:

- Any silence exceeding 250 ms was coded as a silent pause [5]. Filled Pauses and vocalic lengthening were also coded.
- These Dysfluencies were computed in terms of number and duration.

All the statistical analyses were performed using the Mann-Whitney U test.

3. RESULTS

Results from different measures reflecting temporal organization of speech show that these measures are not sensitive to AD compare to CS (see Figure 1).

Figure 1: Results of the five temporal variables between AD group and CS group.

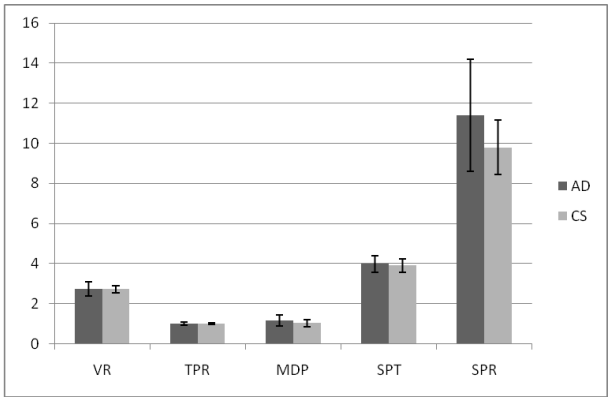
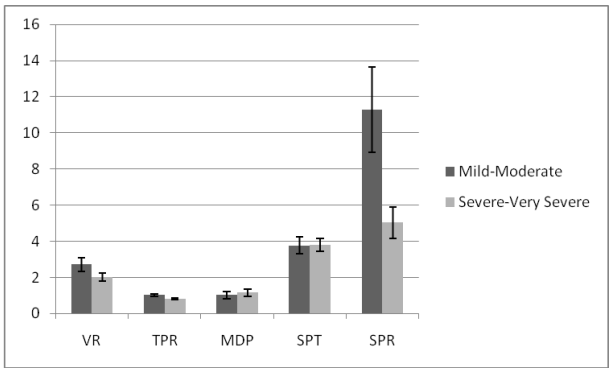


Figure 2: Results of the five temporal variables between group of mild-moderate patients and of severe-very severe patients.



However, the study of evolution of these parameters during the progression of AD reveals interesting results. Indeed, if the MDP and SPT reminds unchanged between group of patients at the mild and moderate stage and group of patients at the severe and very severe stage, other measures show progressive deterioration of the temporal organization of speech, which is based on the severity of the disease. As shown in Figure 2, the

differences in the VR ($p < 0,05$), the TPR ($p < 0,05$), and the SPR ($p < 0,01$) were significant between the group of mild-moderate patients and the group of patients more advanced.

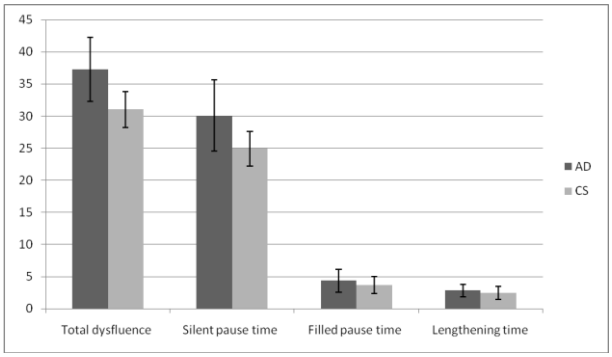
Results from dysfluencies data shows that silent pauses, lengthening are more frequent in patient's speech ($p < 0,01$) than healthy subjects'. However, no significant differences were found related to the number of filled pauses. Table 2 sums up the mean number per word of each type of dysfluency in patients and controls.

Table 2: Mean number per word of each type of dysfluency.

	AD	CS	
	Mean	Mean	*p-value*
Number of silent pauses	0,17	0,12	$p < 0,01$
Number of lengthenings	0,03	0,02	$p < 0,01$
Number of filled pauses	0,02	0,02	n.s.

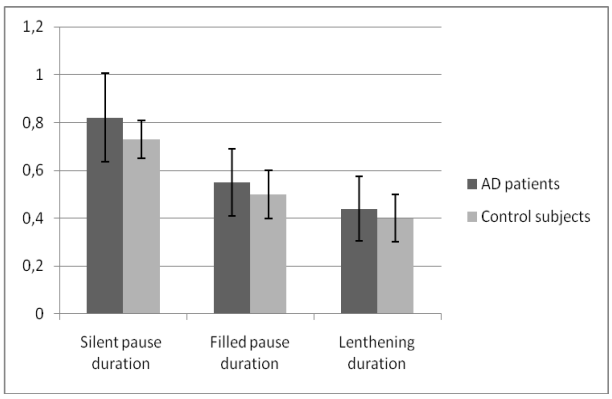
Figure 3 displays the results of the mean percentage of time dedicated to each type of dysfluency in the two groups. It reveals that patients dedicate significantly less time to speech and conversely more time to hesitation phenomena than controls ($p < 0,05$ for percentage of speech time and $p<0.01$ for dysfluency phenomena) while the difference fails to reach statistical significance for silent pauses, filled pauses, and lengthenings.

Figure 3: Mean percentage of time dedicated to dysfluencies in patients and controls.



Turning to the duration of each type of dysfluency, even though pauses and lengthenings appear slightly longer in patients than in controls, these differences are not statistically significant, as shown in Figure 4.

Figure 4: Mean duration of each type of dysfluency as function of population.



4. DISCUSSION

The results show that the variables of temporal organization did not differ significantly between AD and CS groups. However, the significant differences in the VR indicate a decline of productivity of the more affected AD patients; the lower TPR in the Severe-Very Severe patients group reflects that a time of phonation is less effective in this group; and finally, the SPR indicates an increase number of pauses during the progression of Alzheimer's disease.

Also, patient's discourse is marked by numerous silent pauses and lengthening which might reflect word-finding difficulties and limited cognitive resources. Contrary to our expectations, proportion of filled pauses does not increase accordingly. Patient tends to remain silent instead of using conventional signals in the collateral track ([4]) which is normally used in spontaneous speech to "*give audible evidence that he* [the speaker] *is engaged in speech-productive labor*" ([9]).

5. CONCLUSION

Our findings demonstrate that some temporal aspects in spontaneous speech of patients with Alzheimer's disease differ from those of healthy elderly individuals and according to the stage of dementia. Our results support the idea that discourse analysis based on temporal measurements can be a useful tool to discriminate between normal cognitive aging and pathological aging and to determine the progression of Alzheimer's disease.

6. REFERENCES

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