Chapter 24

A Speech Prosody-Based Approach to Early Detection of Cognitive Impairment in Elderly Subjects: A Preliminary Study

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ABSTRACT

This chapter presents a novel approach for early detection of cognitive impairment in the elderly. The approach incorporates the use of speech sound analysis and multivariate statistical techniques. The focus is on the prosodic features of speech. One hundred and fifteen Japanese subjects (32 males and 83 females between the ages of 38 and 99 years) participated in this study. The authors collected speech sounds from segments of dialogue during an HDS-R examination. The segments correspond to speech sounds from answers to questions about time orientation and number counting. One hundred and thirty prosodic features were extracted from each of the speech sounds. These prosodic features consisted of spectral and pitch features (53), formant features (56), intensity features (19), and speech rate and response time (2). These features were refined by principal component analysis and/or feature selection. In addition, the authors calculated speech prosody-based cognitive impairment rating (SPCIR) by multiple linear regression analysis. The results indicate that a moderately significant correlation exists

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between the HDS-R score and the synthesis of several selected prosodic features. Consequently, the adjusted coefficient of determination ($R^2 = 0.50$) suggests that prosody-based speech sound analysis could potentially be used to detect cognitive impairment in elderly subjects.

**INTRODUCTION**

Japan has a rapidly aging society and in 2005 had 2.05 million elderly patients with dementia. The number of patients with dementia is expected to increase to more than 3 million over the next 10 years (Awata, 2009). Thus, the Ministry of Health, Labour and Welfare (MHLW) has begun projects to improve dementia treatment and quality of life. These projects are focused on the development of early detection methods for dementia that are both sensitive and specific.

To screen for dementia and cognitive impairment, a questionnaire test such as the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975), Revised Hasegawa’s Dementia Scale (HDS-R) (Katoh et al., 1991), Clinical Dementia Rating (CDR) (Morris, 1993), or Memory Impairment Screen (MIS) (Buschke et al., 1999) is commonly used, in addition to a neurophysiological test (e.g., using MRI, FDG-PET, and CSF biomarkers). Questionnaire tests have some disadvantages and their use is limited in the clinic. The MMSE, HDS-R, and CDR are more time-consuming than a general practitioner’s consultation. In general, the questionnaire cannot completely dismiss the influence of education, social class, and gender difference on the results. In addition, there is a possibility that practitioner subjectivity may affect the scoring. Thus, we believe that the development of a simple, non-invasive examination that is objective and combined with a physiological test could enable the early detection of dementia in a broad population.

In a pilot study, we focused on speech sounds during the subject’s answers to the questionnaire. Taler et al. reported language (Taler & Phillips, 2007), grammatical, and emotional prosodic impairment (Taler, Baum, Chertkow, & Saumier, 2008), as well as mild cognitive impairment (MCI), in elderly patients with Alzheimer’s disease (AD). Hoyte et al. (Hoyte, Brownell, & Wingfield, 2009) reported that the components of speech prosody are useful for detecting the syntactic structure of speech. These reports suggest the possibility of using speech prosodic feature analysis to screen for dementia. This paper presents a novel approach to the early detection of cognitive impairment in the elderly that uses speech sound analysis in combination with a multivariate statistical technique. In this paper, we focused on the prosodic features of speech sound. We expect that the computation and information technology of this approach will enable general practitioners to easily screen for dementia. In our preliminary study, we examined the relationship between the HDS-R score and speech prosodic features. In addition, we addressed the effectiveness of speech prosody in discriminating between elderly individuals with normal cognitive abilities (NL) and patients with cognitive impairment (CI).

**METHOD**

**Design**

We recorded the speech sound of elderly patients while they provided answers for an HDS-R questionnaire test. We focused on questions about time orientation and numbering. In addition, we collected speech sounds while the patients were talking about the topics of hometown, childhood, and school.
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