A study on oculogyration evaluating system for objective diagnosis of the Alzheimer type dementia

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Abstract— **An oculogyration analyzing system is proposed in order to diagnose Alzheimer type dementia (DAT) objectively. 19 patients are studied, which shows that the changing time of internal and external rectus eye muscles is the most effective index for screening of the demented people. The threshold of the changing time to discriminate DAT is considered to be 0.35 second.**

Keywords— **Alzheimer type dementia, automated diagnosis, oculogyration, smooth pursuit, changing time.**

INTRODUCTION

Oculogyration that changes the human sight can also give physiological mechanism to enable sight itself. Human being adapts itself to the environment by visual recognition. The important functions will degraded according to the age. Especially it may be more serious in the demented elders. Though A.Jone (1983) reported that the visual reflex in Alzheimer patients were normal[1)], Hutton (1984) found that tracking dysfunction can evaluate the severity of Alzheimer-type dementia [2)]

After the two reports man has struggled to elucidate the role of oculogyration in order to apply it to the diagnosis of the dementia. In the oculogyration, there are two different kinds of movements, i.e. saccade and smooth pursuit. The research results are not inconsistent by now because of the difficulties of physiological measurements and analysis. We can notice the following findings in Alzheimer patients' oculogyration; (1) Disorders of averaged velocity distribution and total gazing time, (2) Balint syndrome resembling unique patterns in eye movements [3)–9)].

We have already reported that the light reflex may be a good diagnosing method for the demented[10)]. Eye muscles that elicit the light reflex are "internal" muscles such as m.sphincter pupillae and m.dilator pupillae. In this study we have paid attention to the "external" eye muscles, especially m.rectus lateralis and m.rectus medialis, which are the principal apparatus for the oculogyration. It is because that eye movements are considered to have closer relationship with "mind ", in which the demented people suffered than the brain stem reflexes including light reflex.

METHOD AND SUBJECTS

The smooth pursuit phenomena were detected by an automated eye tacking system (Fig.1). The system is composed of central unit and a gaugle.

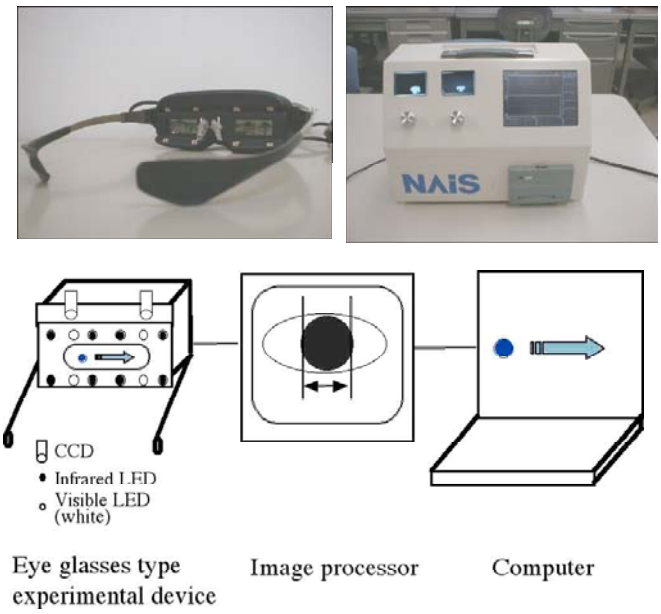

Fig.1 Eye tracking system

The gaugle is instrumented with CCD camera, infrared LED and visible LED (white). The subject's eye is constantly lightened by infrared LED light and the CCD camera visualizes a patient's pupil while a target runs from the left to right in the gaugle under visible white light. The tracking target moves at velocities of 300, 400, 500 pixel/s

The images of the pupil are automatically analyzed and the pupil position is shown on the display and printed out

The numbers of subjects are 11 young healthy control (NY), 19 old healthy control (NC) and 19 Alzheimer Dementia Patients (DAT). NC and DAT subjects' averaged age are statistically equal (both 79 years old) and their dementia severity are examined by Hasegawa Dementia Scale Revised (HDS-R) before the measurement. The averaged

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HDS-R points are 30(Full mark) in YC, 27.9±3.4 in NC and 11.3±7.7 in DAT, which are statistically significant

Some parameters are measured during every tracking. We are interested in initial time and changing time (Fig.2)

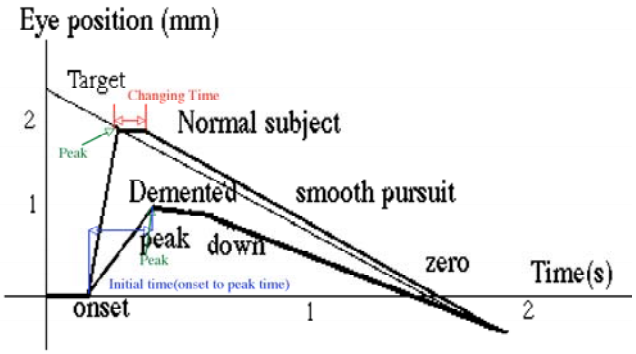

Fig.2 Oculogyration parameters

The initial time is the time from the onset of oculogyration to the time of peak eye position after the tracking movement. Both parameters are longer in the demented subject than the normal.

RESULTS

The Eye Tracking Curves show that tracking ability of EC and DAT are significantly decreased comparing NC (Fig.3)

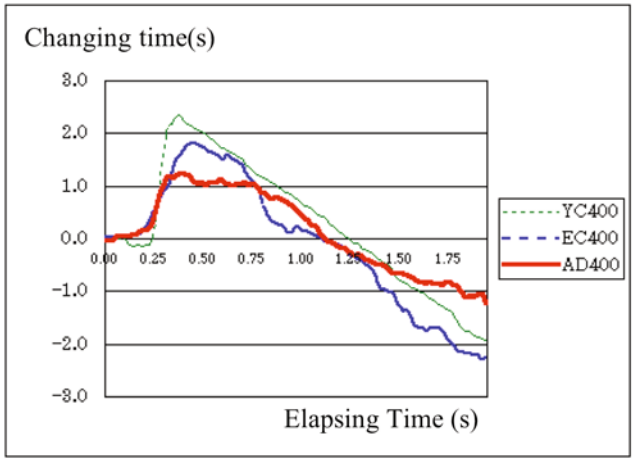

Fig.3 Eye Tracking Curves at target velocity 400 pixel/s

Although the delay time was increased, the peak position and the gain were diminished in the DAT patients.

The initial time (=latency time) of the DAT patients is significantly longer than the time of NC and NY (Fig.4).

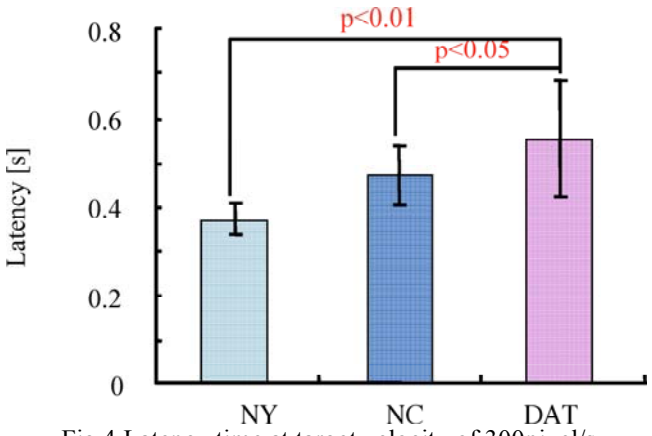

Fig.4 Latency time at target velocity of 300pixel/s

The Averaged pursuit velocity of the DAT is significantly slower comparing NC and NY (Fig.5).

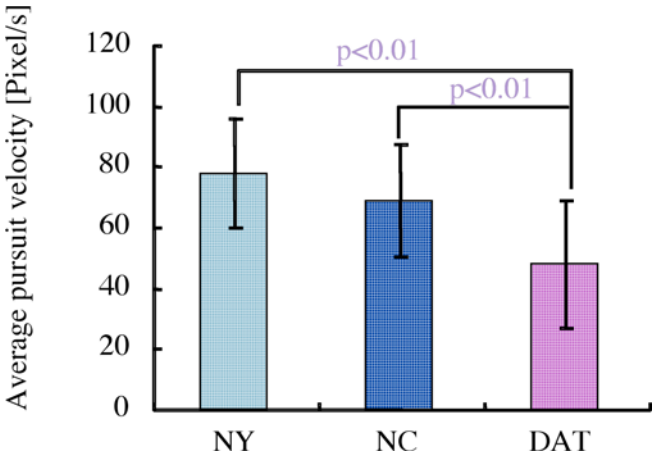

Fig. 5 Averaged pursuit velocity at 300pixel/s

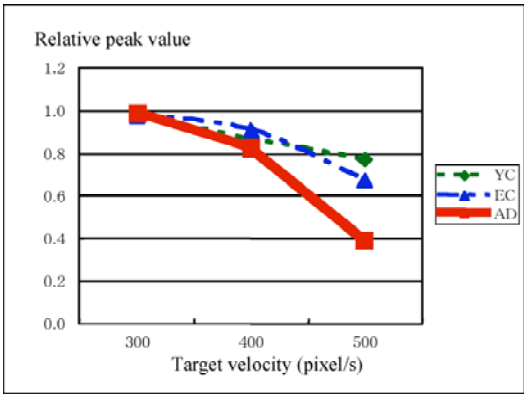

Fig.6 Relative peak value by target velocity

The relative peak value is decreased rapidly in DAT according to the increase of target velocity from 300 pixel/s to 400 and 500 pixels/s (Fig.6).

The changing time of DAT patients has negative relationship (r=-0.56) with MMSE point, which shows the severity of dementia (Fig.7).

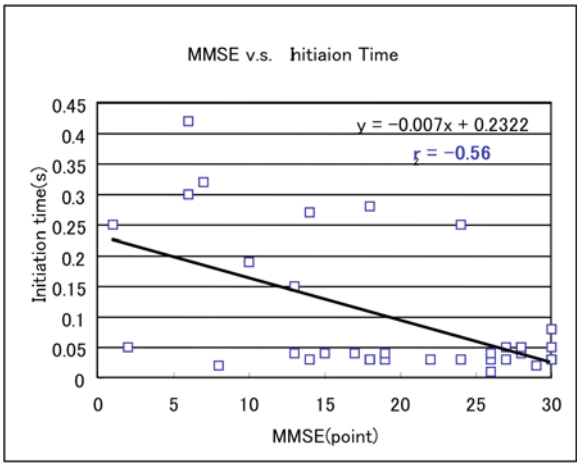

Fig.7 The Changing Time of DAT Patients against MMSE

The initial time has a negative relationship (r=-0.77) with the changing time (Fig.8).

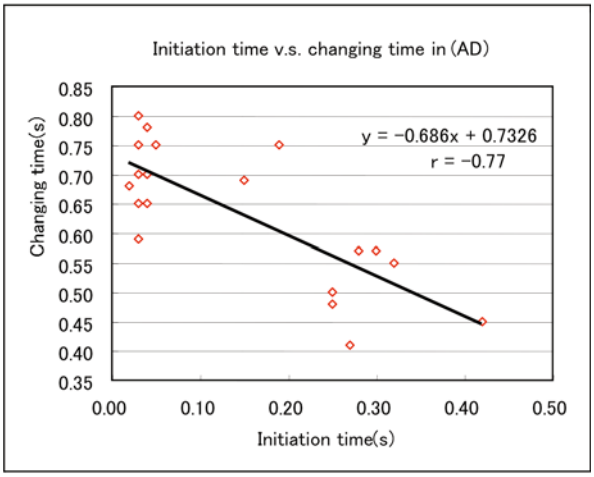

Fig.8 Relationship between Changing time & Initial time

The changing times of NC and of AD are significantly longer than YC (young control). There is a remarkable difference between NC and AD at the target velocity 400 pixels/s (Fig.9).

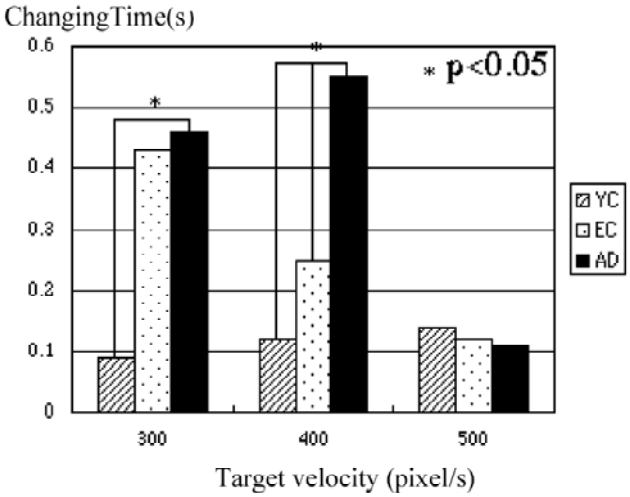

Fig.9 The changing time variation by target velocity

When the individual patients' changing time data are plotted with MMSE points, we can find clear threshold in the changing time of 0.35s (Fig.10).

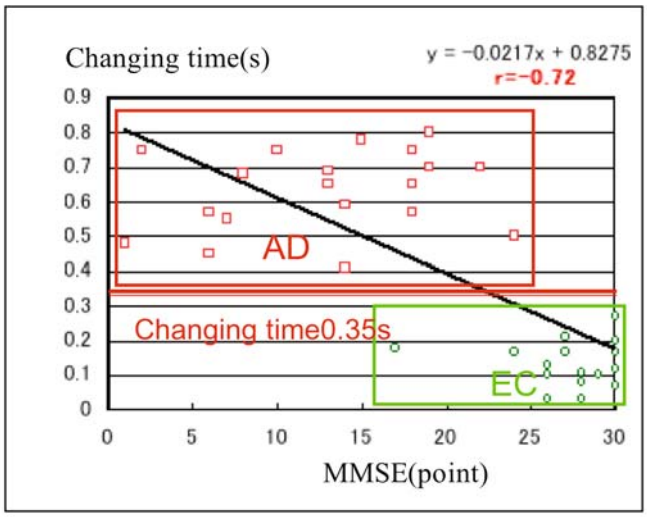

Fig.10 Relationship between MMSE & Changing time.

Negative relationship between MMSE & Changing time (r=-0.72) All AD patients show Changing time over 0.35s.

A neural model of eye tracking is composed in order to explain the connection between eye movement and higher neural functions relevant to dementia (Fig.11).

The frontal lobe is considered to be a saccade center, and the occipital lobe may be a smooth pursuit center in the neural model. Both center have control to collicullus supe-

rior that realize the alternative changing mechanism of the internal and external straight muscles.

It is widely admitted that frontal and occipital lobes as well as hippocampus are affected in the demented patients.

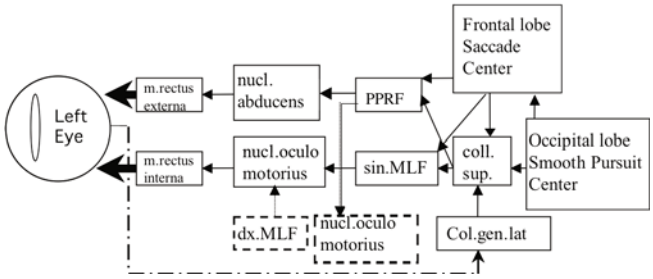

Fig.11 A Neuron Model of Eye Tracking
Example of the left eye. The real line shows moving signals and the dotted chain line means target position signals from retina.

DISCUSSIONS

The number of neuron is drastically reduced in Alzheimer type dementia, and the neuro-transmitters such as acetyl – choline (Ach) also decreases its amount as well as receptors. Consequently the whole brain function will gradually lose its activity and response. The all obtained result in this oculogyration study may be explained from the dysfunction of the patients' brain.

Of course the diagnosis of the dementia must be executed by clinical, psychological, pathological as well as medical imaging examinations. As the number of the demented patients is increasing rapidly, it will be difficult to do screening only by dementia specialists. Our method is harmless, fast and cheap. Moreover the examined result can be evaluated numerically and objectively, so we hope that the method should become standard arsenals for the dementia screening.

CONCLUSIONS

Alzheimer type dementia patients show the following features comparing the elder and the young controls.

1) Increasing of the Initial time and Latency.
2) Elongation of changing time between mm.rectus interna and externa.
3) Decreasing of the peak value and pursuit velocity.
4) Rapid falling of the relative peak value according the increase of target velocity.

1)3)4) may mean the delay of visual recognition time and 2) may indicate the retardation of information processing time in AD patients' brain.

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