Simultaneous Measurement of Lens Accommodation and Convergence

—Real objects, 2D vision and 3D vision—

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Introduction

Background

• Spread of 3D technology

3D Television

Head Mounted Display (HMD)

Stereoscopic Games, Nintendo 3DS
DVD, Photo, games, iPod, mobile phones, ... Stereoscopic Technology is widely and rapidly spread in our daily life.

But, This has some of harmful effects include eye fatigue, headache, 3D sickness, and so on.
The mechanisms remain incompletely understood.

In order to explain the causes,

It is often said that lens accommodation and convergence do not coincide. These are inconsistent!
It is said that lens accommodation is fixed at the display in viewing stereoscopic vision.
There is convergence at the location of the stereo image in gazing 3D images.
It is often said that this inconsistency caused by 3D.

But,

Experiments with 3D images on the CRT or LCD → Synchronized with the image of lens accommodation (Miyao et al, 1996~)

We argue that lens accommodation is not fixed at the display!
Our claim is described above, however our previous study had been measured accommodation and convergence, separately.

We need to measure these simultaneously.

We invented new measurement method using new instrument.
Aim

The purpose of this study was …

To confirm whether or not this new measurement method can be performed accurately to investigate measurement of 3D.

To verify that inconsistent between accommodation and convergence does not exist in viewing 3D vision.
WAM-5500 is an auto refractometer (Grand Seiko Co., Ltd.) that can measure accommodative power under natural conditions for the case in which both eyes are open.

By connecting with the computer and using dedicated software, it enables high speed mode in 0.2s step to measure accommodation.
Instruments for Measurement

**EMR - 9**

- EMR-9 is an eye mark recorder (NAC Image Technol. Inc.) that can measure the convergence distance using the pupillary/corneal reflex method.

- We combined both instruments.
Overview of the Experiment
Experiment I

Simultaneous measurement of lens accommodation and convergence to real objects

Experiment II

Simultaneous measurement of lens accommodation and convergence to 2D and 3D vision
Subjects

• The subjects in this study were 6 healthy young males (age: 20 ~ 37).

• One used his naked eyes and five used soft contact lenses.
Method

- We placed the spherical object facing the subjects at a distance of 1m from them.

- This spherical object was moved forward and backward with a cycle of 10s.

This is the object.
Method (2)

- This object was moved the range from 1m to 50cm.
- Subjects were asked to gaze at the center of this object for 40s. (4cycles)
- We developed an original machine by combining WAM-5500® and EMR-9® to perform the measurements.
- We simultaneously measured their lens accommodation and convergence distance during that time using this machine.
Results

Subject (age: 21, male, corrected)
Results: average
We simultaneously measured accommodation and convergence while subjects viewed real objects.

Accommodation and convergence were consistent with the position of the real object.

This new measurement method could be accurately performed and can apply to the case of 3D vision.
Experiment I

Simultaneous measurement of lens accommodation and convergence to real objects

Experiment II

Simultaneous measurement of lens accommodation and convergence to 2D and 3D vision
The subjects in this study were 6 healthy young males (age: 20 ~ 37).

One used his naked eyes and five used soft contact lenses.
We placed an LCD monitor facing the subjects at a distance of 1 m from them.

We presented either a 2D or a 3D video clip on the monitor; in both images, a spherical object moved forward and backward with a cycle of 10 s.

Video clip was presented using a liquid crystal shutter system.
Method (2)

- The spherical object appeared as a 3D video clip located on a display 1m apart from the subjects, and moved toward the subjects to a virtual distance of 0.35m.

- They were asked to gaze at the center of the spherical object for 40s. (4cycles)

- We measured their lens accommodation and convergence distance during that time.
## Table 1  Performance of the Monitor

<table>
<thead>
<tr>
<th>Target</th>
<th>FlexScanS1911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen resolution</td>
<td>1,280 × 1,024</td>
</tr>
<tr>
<td>Color usage</td>
<td>16,190,000</td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>Pixel Pitch</td>
<td>0.294 ×</td>
</tr>
</tbody>
</table>
## Table 2  Experimental Environment

<table>
<thead>
<tr>
<th></th>
<th>backward</th>
<th>forward</th>
</tr>
</thead>
<tbody>
<tr>
<td>brightness of spherical object (cd/m²)</td>
<td>3.6</td>
<td>3.0</td>
</tr>
<tr>
<td>illuminance (lx)</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>Size of spherical object (deg)</td>
<td>0.2</td>
<td>7.7</td>
</tr>
</tbody>
</table>
Results: 2D vision

Subject (age: 23, male, corrected)

![Graph showing dioptr and distance over time with lines labeled accommodation and convergence.](image-url)
Results: 3D vision

Subject (age: 23, male, corrected)

![Graph showing diopter vs. time and distance over various distances including infinity, with two lines representing convergence and accommodation.](image-url)
We simultaneously measured accommodation and convergence while subjects viewed 2D and 3D images.

Lens accommodation is consistent with convergence during 3D vision in young subjects.