



Fig. 3. Auto Ref/Keratometer WAM-5500 (Grand Seiko Co. Ltd., Hiroshima, Japan).



Fig. 4. EMR-9 (NAC Image Technology Inc., Tokyo, Japan).

preserved on an SD card, they are read into a personal computer (Sakaki, 2009; Egami *et al.*, 2009).

These two devices were combined as in Fig. 3, and we simultaneously measured focus distances of accommodation and convergence when subjects were gazing at objects (Fig. 4).

The following experimental procedure was used. Subjects' accommodation and convergence were measured

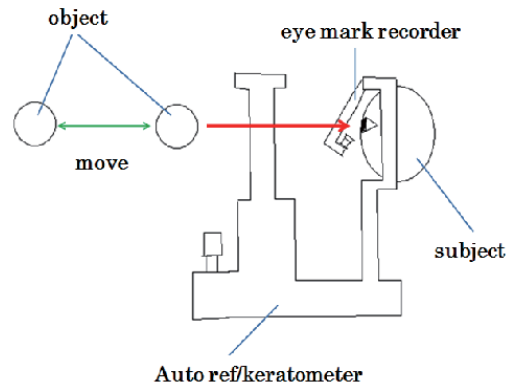


Fig. 5. Pattern diagram of measurements.

when they were gazing with binocular vision at an object (tennis ball, diameter 7 cm) presented in front of them. The object moved in a range of 0.5 m to 1 m, with a cycle of 10 seconds. Measurements were made four times every 40 seconds. The illuminance of the experimental environment was about 103 (lx), and the brightness of the object in this environment was 46.9 (cd/m²).

3. Results

In this study, we simultaneously measured subjects' accommodation and convergence while they were gazing at an object with binocular vision. The results of these measurements were comparable in all subjects. The results of this experiment for two representative subjects are shown in Figs. 5 and 6.

In Figs. 5 and 6, “accommodation” stands for focal length of lens accommodation, and “convergence” stands for convergence focal length. From these figures, it is found that the accommodation and convergence of both subject A and B are in agreement and have changed. Moreover, the change in the diopter value occurred with a cycle of about ten seconds. Maximum diopter values of accommodation and convergence of A and B were both about 2 D, which is equal to 0.5 m. This was consistent with the distance from the subject to the object.

On the other hand, their minimum values were accommodation distance of 1 D, equal to 1 m, and convergence distance of 0.7 D, equal to 1.43 m. Convergence was consistent with the distance to the object, but accommodation was focused a little beyond the object (about 0.3 D).

4. Discussion

In this experiment, we used the WAM-5500 and the EMR-9.

As an experiment using the WAM-5500, the result that there was a research that examined the performance, and it was possible to measure it by the accuracy of $-0.01 \text{ D} \pm 0.38 \text{ D}$ by examining the result of a measurement of the WAM-5500 from the agreement with subjective findings within the range from -6.38 to $+4.88 \text{ D}$ was obtained (Sheppard and Davies, 2010). There was also a research that investigated eyestrain and transient myopia using the WAM-5500 (Tosha *et al.*, 2009; Borsting *et al.*, 2010). Moreover, the experiment that examined the accuracy of