

## Trialing Time Resolution Evaluation in Visual Function Tests

Takashi Yuki<sup>1</sup> and Tomoya Handa<sup>1,2\*</sup>

<sup>1</sup>Master's Program of Medical Science, Kitasato University Graduate School, Sagamihara, Japan

<sup>2</sup>Department of Rehabilitation, Orthoptics and visual Science Course, School of Allied Health Sciences, Kitasato University, Sagamihara, Japan

\*Corresponding Author: Tomoya Handa, Master's Program of Medical Science, Kitasato University Graduate School, Sagamihara, Japan.

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### Abstract

Clinical ophthalmology mainly uses spatial resolution evaluation for assessing visual function. However, evaluation of temporal resolution is also important when considering the visual function required for everyday vision, for example, while driving a car or playing sports. This investigation focused on visual acuity response speed (time until response to visual target). The subjects were 22 healthy youths with no ophthalmic diseases other than mild ametropia, with a mean age of  $21.4 \pm 2.2$  years. Individuals with manifest refraction (spherical equivalent) of  $-3.18 \pm 2.40D$  and visual acuity of  $\geq 1.2$  with complete refractive correction were selected as subjects. The method was as follows. The test distance was set at 70 cm, Landolt rings with logarithm of the minimal angle of resolution (logMAR) values of 1.0, 0.4, and 0.1 (decimal visual acuity: 0.1, 0.4 and 0.8, respectively) were each displayed on a liquid crystal display monitor under complete refractive correction. The "X" key was pressed in the direction of the visual target where the break was perceived in the Landolt ring, and visual acuity response speed was evaluated based on the time from display of the visual target to pressing the button. The results were investigated comparing 3 different conditions: binocular vision and monocular vision (dominant and non-dominant eye). There was no significant difference in the visual acuity response speed for binocular vision ( $1.08 \pm 0.20s$ ) and for the dominant eye under logMAR 1.0 visual target conditions ( $1.09 \pm 0.14s$ ). On the other hand, the visual acuity response speed for the non-dominant eye ( $1.17 \pm 0.14s$ ) was significantly more than that for binocular vision. The visual acuity response speed for monocular vision (non-dominant eye) was significantly more than that for binocular vision. These results suggest that temporal resolution-based evaluation of visual function may lead to more detailed visual function assessment.

**Keywords:** Visual Acuity Tests; Visual Acuity Response Speed; Ocular Dominance; Quality Of Vision; Time Resolution Evaluation

### Introduction

Visual acuity tests are important for ascertaining and diagnosing pathologies and during the treatment process. They are also extremely important for monitoring the progress and treatment of amblyopia in children. It can be difficult for an individual to be aware of a reduction in the quality of vision (QOV) during daily activities after treatment of a pathology and refractive surgery. Thus, a visual function test which can sensitively evaluate such reductions in QOV, which are difficult to perceive, is essential.

Many visual function tests, including the visual acuity test, center around spatial resolution evaluation. Temporal resolution capability, which determines how quickly an object can be recognized, is required for vision during sports and while driving a car, but it is rarely evaluated during clinical testing. Therefore, we investigated the assessment of response speed in visual acuity tests, by adding temporal resolution evaluation (time until response to a displayed visual target).

### Methods

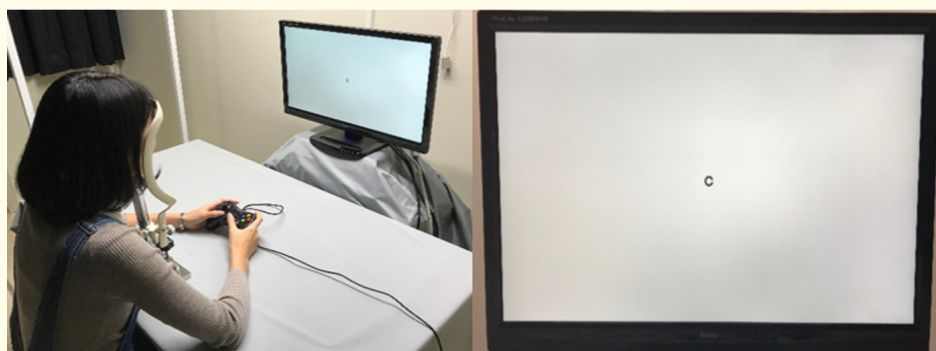
#### Subjects

The subjects were 22 healthy youths (men,  $n = 4$ ; women,  $n = 18$ ) with no ophthalmic diseases other than mild ametropia, with a mean age of  $21.4 \pm 2.2$  years. All subjects had a visual acuity (decimal) of  $\geq 1.2$  with complete refractive correction, and their stereoscopic

response was confirmed to be less than 60s. Manifest refraction (spherical equivalent) was  $-3.18 \pm 2.40D$  in the dominant eye and  $-3.07 \pm 2.32D$  in the non-dominant eye. The manifest refraction for the dominant eye was determined using the hole-in-card test.

**Experimental designs**

Visual acuity response speed was measured using an independently developed control program where Landolt rings with logarithm of the minimal angle of resolution (logMAR) values of 1.0, 0.4, and 0.1 (decimal visual acuity: 0.1, 0.4, and 0.8, respectively) and 95%, 25%, and 6% contrast were displayed on a computer monitor (26-inch, Iiyama). The subjects viewed the images under complete refractive correction, seated 70 cm away from the monitor, with their head fixed in a chin rest (Figure 1).



**Figure 1:** Visual acuity response speed evaluation. Right: Visual target for visual acuity test. Left: Schematic representation of the test.

The time until the cross key was pressed in the perceived direction of the visual target of the break in the Landolt ring was measured, with the image displayed 5 times for each visual acuity. The visual acuity was obtained based on 3 or more correct responses out of 5, and the response speed (mean) at that time was evaluated as the visual acuity response speed. The test items examined visual acuity response speed (both eyes) at each visual acuity and comparatively examined it under 3 conditions: binocular vision and monocular vision (dominant and non-dominant eye), with changes in contrast.

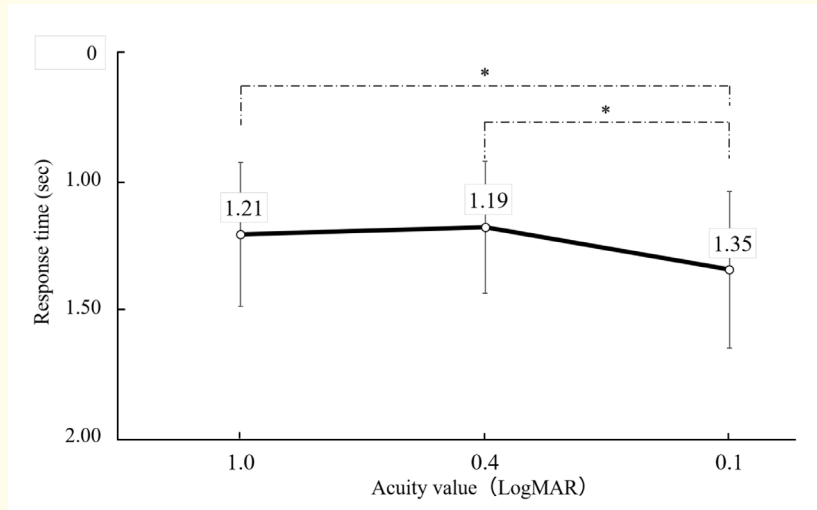
The Steel-Dwass test was used to compare the visual acuity and the visual acuity response speed for binocular and monocular vision with changing contrast, and a level of significance of less than 5% was set as the threshold for statistically significant differences. This study was implemented with the approval of the ethics committee of the School of Allied Health Sciences, Kitasato University (2017-033).

**Results**

Visual acuity response speed was evaluated under all conditions for all subjects. Table 1 and Figure 2 shows the visual acuity response speed (both eyes) for logMAR values of 1.0, 0.4, and 0.1 under complete refractive correction. The visual acuity response speed significantly decreased with reduction in the size of the visual target. The visual acuity response speed (both eyes) at 95% contrast was  $1.08 \pm 0.20s$  at logMAR 1.0,  $1.09 \pm 0.14s$  at logMAR 0.4, and  $1.17 \pm 0.14s$  at logMAR 0.1. The stereoscopic response speed at logMAR 0.1 was significantly reduced compared with the visual acuity response speed at logMAR 1.0 and 0.4 (Steel-Dwass test,  $p < 0.05$ ).

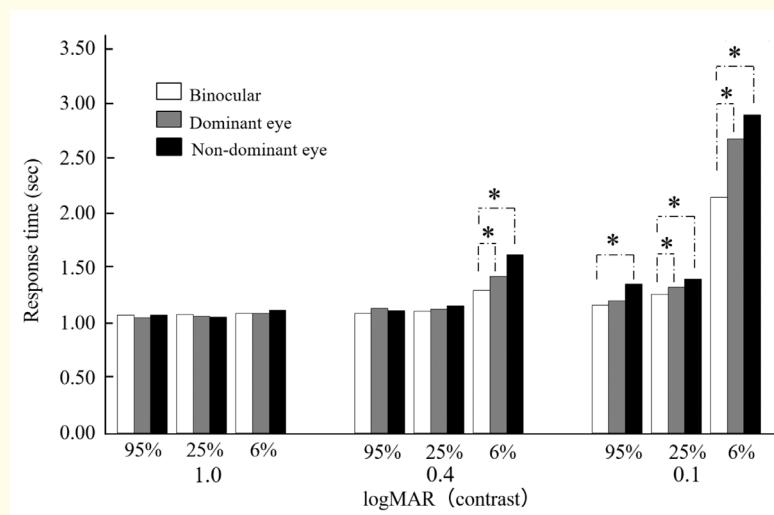
	Acuity value (logMar)		
	1.0	0.4	0.1
Both Eyes	$1.08 \pm 0.20s$	$1.09 \pm 0.14s$	$1.17 \pm 0.14s$

**Table 1:** Visual acuity response speed (both eyes) under complete refractive correction.



**Figure 2:** Visual acuity response speed (both eyes) under complete refractive correction. Response speed declined with reduction in the size of the visual target. \*:  $p < 0.05$ .

Figure 3 show the visual acuity response speed for each visual acuity (contrast) for both eyes (dominant and non-dominant). The monocular (dominant and non-dominant eye) visual acuity response speed was significantly reduced compared with that for both eyes, as the contrast was decreased. Visual acuity response speed for both eyes at logMAR 0.4 and 6% contrast was  $1.30 \pm 0.21s$ , while it was  $1.43 \pm 0.35s$  for the dominant eye and  $1.63 \pm 0.64s$  for the non-dominant eye, indicating a significant reduction (Steel-Dwass test,  $p < 0.05$ ). The visual acuity response speed for both eyes at logMAR 0.1 and 95% contrast was  $1.17 \pm 0.14s$  and  $1.36 \pm 0.64s$  for the non-dominant eye, while at 25% and 6% contrast, the visual acuity response speeds for both eyes, the dominant eye, and the non-dominant eye were  $1.26 \pm 0.19s$  and  $2.15 \pm 0.96s$ ,  $1.33 \pm 0.26s$  and  $2.68 \pm 1.07 s$ , and  $1.40 \pm 0.40s$  and  $2.90 \pm 1.45s$ , respectively, indicating a significant reduction (Steel-Dwass test,  $p < 0.05$ ).



**Figure 3:** Comparison of visual acuity response speed at each visual acuity.

## Discussion

In this study, we evaluated visual acuity using temporal resolution scales. Various visual acuity tests are used in clinical practice. Practical visual acuity tests that measure temporal changes in visual acuity within a set timespan for a particular contrast are used to evaluate visual function in patients with cataracts or dry eye [1-3]. In addition to static visual acuity, kinetic visual acuity, which is defined as the ability to clearly see an object approaching in a straight line [4] and dynamic visual acuity, which measures the minimum viewing angle of a visual target moving laterally [5], are also known; both of these play extremely important roles in the evaluation of visual function for driving cars and playing sports. The results obtained in this study suggest that addition of temporal resolution evaluation to visual acuity tests may be applicable for clinical ophthalmology in the assessment of amblyopia treatment and ascertainment of pathology.

In this study, the visual acuity response speed was found to decrease with the low contrasts of 25% and 6%, compared with the high contrast of 95%. Even if good visual acuity can be easily achieved with high-contrast visual acuity in patients with cataracts or after refractive surgery, these patients may also experience visual problems that are difficult to evaluate. The use of low-contrast visual acuity to conduct evaluations may enable evaluation of such visual problems, and further addition of a temporal scale may enable even more detailed evaluation.

The visual acuity response speed was found to be lower in the non-dominant eye than in the dominant eye. Ocular dominance plays an extremely important role in binocular vision. Using temporal resolution evaluation may not only enable assessment of spatial quantification, but may also be closer to the vision used in daily life. This suggests that further beneficial evaluation may be possible using the monovision technique, which is one of the presbyopia correction methods where ocular dominance becomes important [6].

## Conclusion

These results suggest the possibility that addition of a temporal resolution evaluation scale to subjective tests, including the visual acuity test, may lead to the development of new evaluation methods for visual function during sports and driving, and allow evaluation of reduced visual function and QOV, which is not possible with the conventional evaluation methods.

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