Measuring Visual Abilities in an Engaging Manner

Kazushi Maruya, Kenchi Hosokawa, and Shin'ya Nishida

Abstract

The human visual system differs considerably from person to person, and its ability varies with the context, task, and circumstances. To grasp the variability of visual ability in daily circumstances, we created two test batteries to easily measure visual abilities.

One is a simple visual test called a Tablet Test, which can be performed using conventional measurement methods. The other is a visual test battery called Shikaku no Mori that involves short video games. The gamification improves the enjoyability of the test compared with the conventional experimental method. The measurement time is approximately three minutes, and the accuracy of the test is comparable to that obtained in laboratory experiments, in which it often takes several hours to acquire data. The proposed test batteries would be useful for research in vision sciences as a method to investigate the diversity of visual ability and early detection of eye disease.

Keywords: vision test, self-check, gamification

1. Introduction

The incidence rate of eye disease increases with age. It can therefore safely be said that in an aging society, the number of people suffering from eye disease will increase. In addition to the aging problem, there are problems associated with display devices. We are surrounded by various display devices in our daily lives, and the effects of these devices on our visual functions are not yet clear. The types of devices have rapidly increased in number, and the range of choices has broadened. It is therefore important that we understand our own visual characteristics in advance when choosing a device.

In addition, on the device design side, knowledge of the variability of visual functions among individuals—referred to as visual diversity—is often required. However, people often forgo tests at a hospital or clinic in their busy daily lives, especially when they do not notice any abnormalities in their vision. If there were a way to self-check visual functions and skills more easily, more people would be able to better ascertain the characteristics of their own visual functions.

However, there are various problems in applying the methods used in eye examinations at hospitals, clinics, or in vision science experiments to self-check scenarios. For example, conventional vision tests require high measurement accuracy and take a considerable amount of time to complete. In addition, the equipment and measurement kits require professional operators. Furthermore, the tasks in those kits are usually not very enjoyable and are unsuitable for use by people who do not have any concerns about their eye functions.

Researchers at NTT Communication Science Laboratories have conducted various experiments in visual science over many years and acquired the know-how for appropriate data acquisition. In this research project, we considered ways to make use of our accumulated know-how and tried to create test batteries that could be used easily.

2. Two test batteries for measuring visual functions

We propose two new test batteries for visual function measurement (**Fig. 1**). One is a simple visual test

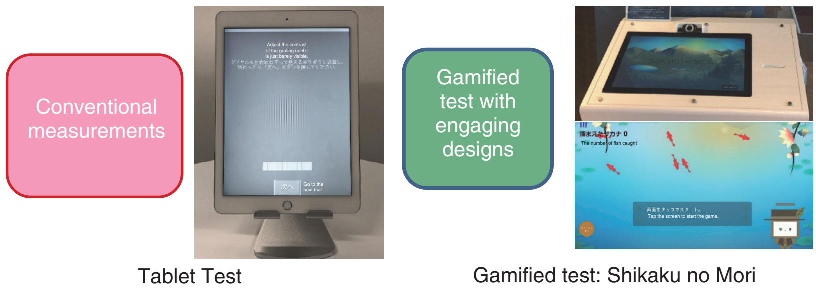

Fig. 1. Images of screens used in test batteries.

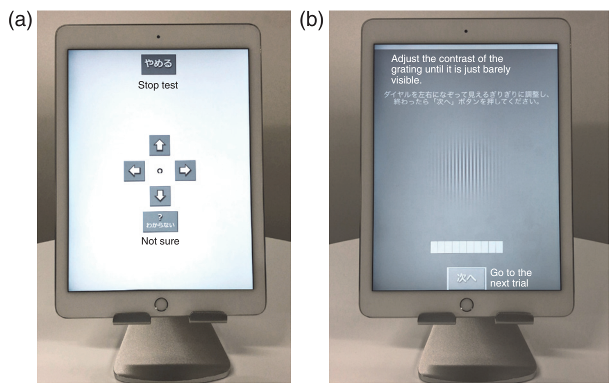

Fig. 2. Screen images from Tablet Test.

called a Tablet Test, which can be performed using conventional measurement methods. The other is a visual test battery called Shikaku no Mori that involves short video games. The test battery employs graphics, directions, and task settings designed to motivate users and promote repeated use in everyday life [1].

2.1 Tablet Test

In developing the Tablet Test, we considered the possibility of using it for the early detection of serious eye diseases such as cataracts, glaucoma, and age-related macular degeneration. With the cooperation of Dr. Satoshi Nakadomari from the Kobe Eye Center, we selected several test items for the test (**Fig. 2**). We started with the development of a test that can measure vision and contrast sensitivity, which can reveal the basic characteristics of the user's visual functions.

One common test used in measuring vision is performed by having the testee report the direction of the gap in a figure with the form of a "C," which is called a Landolt ring (or Landolt C) (Fig. 2(a)). For determining contrast sensitivity, the ability to see subtle differences in the color (or luminance) of black and white stripes of various widths is measured (Fig. 2(b) and **Fig. 3(a)**). Various eye diseases can reduce contrast sensitivity [2], so its measurement can be used to check for them. Moreover, contrast sensitivity data provide important information about a person's basic visual ability. In the Tablet Test, the user measures the contrast sensitivity curve by adjusting the stimulus's contrast to almost invisible levels with stripes of various widths (**Fig. 3(b)**). One can also use the Tablet Test to check if there is a field of view that is significantly reduced in sensitivity near the center of the visual field.

2.2 Gamified test: Shikaku no Mori

The other test set introduces a video game format that includes well-designed graphics and test methods that differ significantly from conventional ones in measuring visual functions (**Fig. 4**). In this test set, it is assumed that even people who do not notice anything

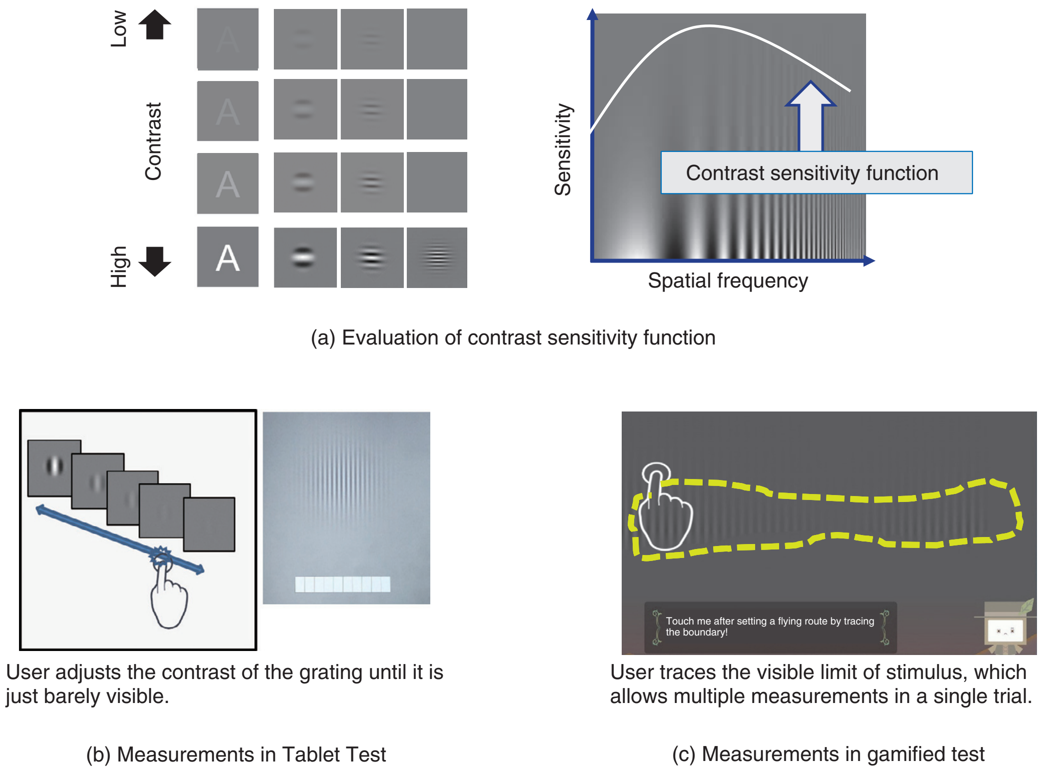

Fig. 3. Measuring contrast sensitivity.

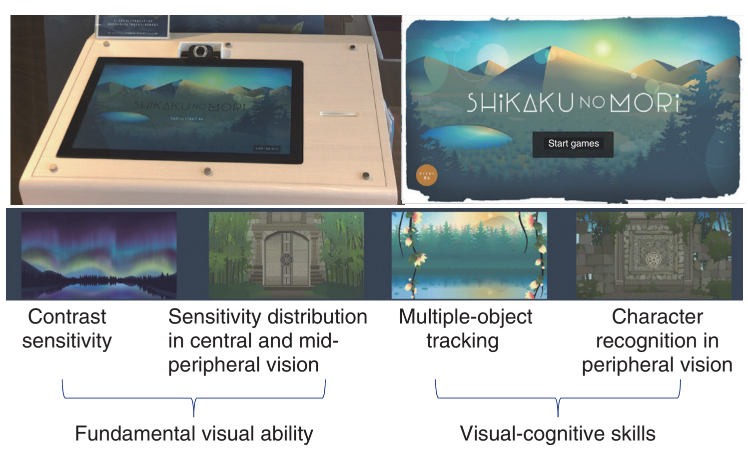

Fig. 4. Gamified test: Shikaku no Mori.

unusual in their own visual functions will use their spare time to assess them. When game elements and forms are incorporated into tasks that originally are not intended for entertainment, various positive effects can sometimes be observed in the behavior of persons who perform them. These include improved motivation, a better understanding of the issues, and a sharper focus on the issues.

In fact, in the field of vision research, games have been developed that are designed to improve the visual functions of low-vision patients, especially children [3]. It follows then that it would be effective to introduce game elements into other visual function measurements. This test set consists of four short video games. Each can easily measure the level of contrast sensitivity, sensitivity distribution in central and mid-peripheral vision, character recognition ability in the peripheral visual field, and the ability to track multiple moving objects. The former two items are also included in the Tablet Test and can be used to check basic vision functions. The latter two items can be used to check functions that include visual cognition processing at higher levels in the visual system.

For the three items other than contrast sensitivity, we measure the functions that have already been recognized as being important in research on the relationship between video games and visual functions. When these are combined with the measurement of contrast sensitivity (**Fig. 3(c)**), which is considered important in the field of visual science, it is possible to check visual functions within a wider range of the processing stream in the visual system. After they have finished playing, the players can view the measurement results in a graph on the display screen. In addition to this graph, detailed results are recorded in a QR (Quick Response) code that is also displayed on the screen. The QR code is encrypted, and special data decryption software is provided to read the data and display the data graphically.

2.3 Test performance

The tests we created were implemented as applications that run on a web browser, under the assumption that the browser is used on a general-purpose device. The measurements use simplified methods. However, we included several technical functions to make the measurements as accurate as possible. One is a capability of accurate graphic drawing, which we developed by using JavaScript and WebGL (Web Graphics Library) with precise time control [4]. For example, the color control in general equipment is genuinely 8-bit, 256 steps. In the proposed software, color control of pseudo-12-bit, 4096 steps is achieved by utilizing a method called space-time dithering. This contributes to enhancing the accuracy of contrast sensitivity measurements and visual field examinations [5].

In addition, the proposed tests preserve the essence of measurement obtained using conventional methods. However, procedures and measurement conditions that do not critically influence the results are omitted. Furthermore, we implemented a relatively new measurement method that utilizes the characteristics of tablet computers and reduced the measurement time. We have devised these approaches to improve the performance of the test as much as possible, even with short measurement times.

We conducted experiments to examine whether these ideas were actually reflected in the performance of the test. The results showed that gamification improved the enjoyability of the test compared with the conventional experimental method. The measurement time was approximately three minutes, and the accuracy of the test was comparable to that in laboratory experiments, in which it often takes several hours to acquire data [1]. We have also confirmed that other tests can be performed with the expected accuracy.

3. Possibilities and tasks for future development of our simple vision test batteries

The circumstances under which the two test batteries are expected to be used are different (**Fig. 5**). For example, we assume that the proposed gamified tests will be used repeatedly for short durations in everyday situations, including at home. Through repetitive use, users will naturally come to know the range of game scores based on their visual ability. A continual decrease in the scores would indicate that something may have happened to the user's eyes. In that case, the user can be directed to perform measurements with the Tablet Test, which uses a task similar to conventional examinations. If the user senses any abnormality during the Tablet Tests, he or she would then go to a hospital or clinic to have a detailed examination done by an ophthalmologist. Thus, the proposed test batteries would be useful for early detection and treatment of eye disease and rehabilitation outside the hospital.

Furthermore, the test set proposed here may be useful for research in visual science as a method to investigate the diversity of visual ability. The gamified test could provide data on many healthy people or people with mild abnormalities because it offers a way to check visual ability with a general-purpose device repeatedly in daily life. The Tablet Test might provide data from various groups, including patients with eye disease, when utilized by specialists in hospitals. By combining the large amount of diverse data with deep data accumulated from precise experiments in previous visual science research, we can elucidate the diversity of visual ability and the factors behind it.

To realize this possibility, it is necessary to make the proposed test batteries accessible to many people. We are now conducting trial experiments at the Kobe Eye Center and at various events. In addition to these

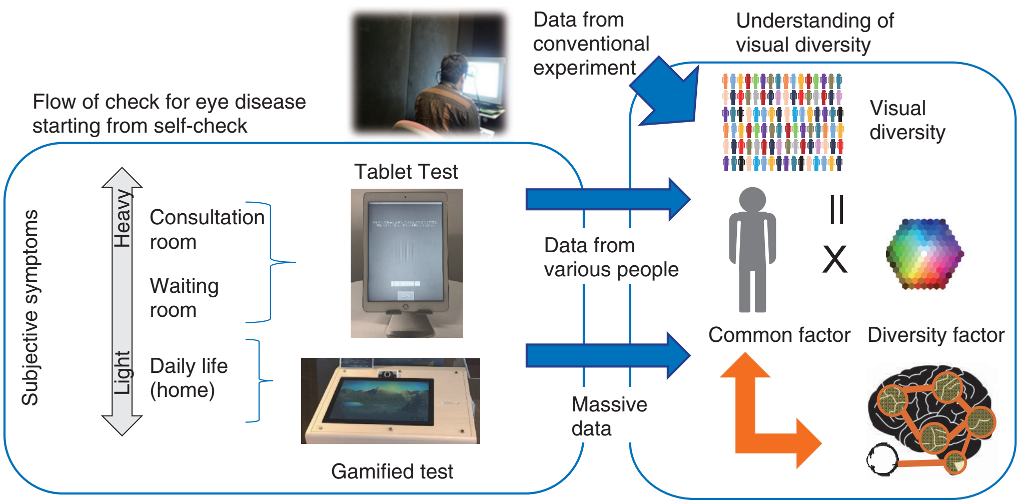

Fig. 5. Diagram outlining future use of the proposed vision test batteries.

trial experiments, we are preparing to have more people try our test batteries through the Internet.

Acknowledgments

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Trademark notes

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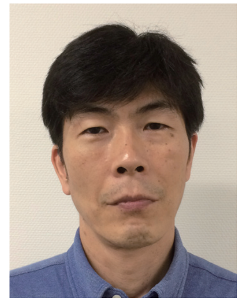

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