Preschool Children Accuracy in Eye-Tracker Controlled Computer-Based Preferential Looking Test

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Abstract

Introduction & Objective:

Birth to the age of 3–5 y.o. is the critical period of visual acuity development in children. Preferential looking is an early eye examination to detect visual impairment in children and has been known as an objective test for children below 5 y.o. The purpose of this study was to examine the children's accuracy in answering the computer-based preferential looking test.

Methods

This research was conducted using a cross-sectional method. The subjects used were children aged 3–5 y.o. who were taken by convenience sampling technique in four urban kindergartens in Yogyakarta, Indonesia, and had met the inclusion and exclusion criteria. The visual acuity measurement technique used was a preferential looking with hemispatial Gabor patch written in Python application. The eye tracker was used as a control. The analytical method used was descriptive analysis to determine the characteristics of the subject and the average accuracy of both eyes followed by the one-way ANOVA method to see the significance of differences in overall eye accuracy.

Results

Mean Lea's Chart visual acuity (LogMAR) of the eye tracked group: 0.21 ± 0.14 and the no eye tracked group: 0.28 ± 0.13 . The accuracy of the eye tracked group ($n = 38$ eyes) for the 3, 4, and 5 y.o. groups were: 81.14 ± 14.75 , 75.98 ± 13.13 , 81.00 ± 10.71 , respectively ($p = 0.459$). Comparison between the eye tracked group and the no eye tracked group, the accuracy ($n = 38$ eyes) of eye tracked group: 78.90 ± 12.11 and no eye tracked group ($n = 38$ eyes): 86.21 ± 3.83 ($p = 0.001$).

Conclusions

The children's accuracy when performing the preferential looking test was remarkable considering their early age. Therefore, this method is applicable to a basic examination to get objective visual acuity in preschool children.

Introduction

From birth to the age of 3–5 y.o. is the critical period of visual acuity development in children.¹ During these periods, the child's visual acuity is relatively unstable and any disturbance might lead to amblyopia in the future.² It has resulted in an escalation of incidence of amblyopia in children with a prevalence

ranging from 0.2–6.2% worldwide.^{2,3} Visual problems can have a great impact on a child's development.⁴ Therefore, it is important to do early visual acuity examinations in children.

Preferential looking has been known to be an objective test for children below 5 y.o. Eye-tracking is very useful to examine vision in a nonverbal patient, namely children, neurologically impaired patients, and those with intellectual disabilities due to the difficulties in making a quantitative assessment in this group of patients. With an eye tracker, the quality of visual information processing can be assessed objectively without verbal communication.⁴ Here, we developed an eye-tracking-controlled automated preferential looking to make the test easy and objective to be used in a large population. This study aims to analyze the children 3–5 y.o accuracy in performing computer-based preferential looking test.

Material And Methods

Subject and Design

This is a cross-sectional study design. It was approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University (KE/FK/1265/EC on October 25, 2020). The population of this study was preschool children aged 3-5 y.o. from four Kindergartens in an urban area in Yogyakarta, Indonesia. The total subjects were 74 children and taken by using convenience sampling techniques. After met the inclusion and exclusion criteria, the total subjects who became the samples of this study were 38 children divided into 2 groups: eye-tracked vs no eye-tracked. The teachers were explained verbally about this study and the informed consent forms were given to the parents through the teachers.

Before the experiment, standard ophthalmic examinations (visual acuity using LEA's chart, anterior and posterior segment examination) were done to examine the eye conditions. The refraction status of the subjects was examined using a handheld auto refractometer and the last examination was the preferential looking test. The inclusion criteria for the subjects of this study were children aged 3-5 y.o., who did not suffer from eye disorders and were able to complete the preferential looking examination with a hemispatial Gabor patch. The exclusion criteria for the subjects of this study were incomplete data and uncooperative children.

Apparatus

Two Gabor patches ($10^\circ \times 10^\circ$ of visual angle) with 25% contrast were displayed on a LED color monitor on a laptop with a resolution of 1366x768 and a frame rate of 120 Hz. The trials started with a red fixation point at the center of the monitor, then a right or left positioned Gabor grating was played for 1s. The participants will then glance at the grating if they could see it and the observer will press one of two buttons using a two-alternative forced-choice staircase procedure. This response was controlled using an eye tracker (Tobiipro, Stockholm, Sweden) to make sure whether the subject sees the stimulus or just

guessed the target throughout the trials. The accuracy was shown in percentage with higher accuracy indicating better performance. The software was PsychoPy with hemispatial Gabor patch software written in Python. The room illumination was controlled at around 34-37 lux. The eye tracker is used to detect the eye movement of the subjects whether in the correct location of the preferential looking test or not. The examination finishes until it reached the threshold spatial frequency.

Data Analysis

The PsychoPy application will generate the accuracy of the child's eye while selecting a patch on a preferential looking examination with a hemispatial Gabor patch. The results of the accuracy were then collected and analyzed using Microsoft Excel and IBM SPSS Statistics 25 applications. The analytical method used was descriptive analysis to determine the characteristics of the subject and the average accuracy of both eyes followed by the one-way ANOVA method to see the significance of differences in overall eye accuracy.

Results

Characteristics of the Study Subjects

The subjects’ characteristics of the eye tracked group and the no eye tracked group were shown in Table 1.

Table 1
Subject characteristics (n = 38)

Variable		Group	
		Eye Tracked	No eye-tracked
Age group	3 y.o.	2 (10.53%)	2 (10.53%)
	4 y.o.	8 (42.10%)	8 (42.10%)
	5 y.o.	9 (47.37%)	9 (47.37%)
Lea’s visual acuity (LogMAR)		0.21 ± 0.14	0.28 ± 0.13
Spherical Equivalent		0.14 ± 0.46	0.07 ± 1.12
Note: LogMAR: Logarithm of the minimum angle of resolution; CPD: Cycle per degree			

The accuracy of the eye tracked group based on age group was shown in Fig. 2.

— Attach Fig. 2 here —

The accuracy of the eye tracked group compared to the no eye tracked group was shown in Fig. 3.

— Attach Fig. 3 here —

There was a significant accuracy difference between the eye tracked group and no eye tracked group ($p = 0.001$) with $p < 0.05$.

Discussion

The accuracy of the no eye tracker group was higher than the eye tracked group. Using an eye tracker is more difficult to apply because the subject needs to be more cooperative. Without an eye tracker is easier, more suitable for children, but maybe not that accurate.

The average eye accuracy shows the child's accuracy and ability in choosing the correct patch on the monitor screen. The results showed the average accuracy for each age group was above 75%. This is in line with the previous studies by Sturm *et al.*⁵, Massoni *et al.*⁶, Lewis *et al.*⁷, and Vabrie *et al.*⁸, which used 75% as a threshold cut-off point. These studies showed if the 75% responses in judging the location of the target with the gratings are correct, then it can be used as an infant visual acuity measurement.

Based on the signal detection theory, the subject will respond “yes” if a signal was presented, otherwise, the subject responds “no” if there was no signal presented. In this study, there was a bit of modification of the signal detection theory implementation, in which the subjects had to choose the “right” or “left” side. If the Gabor patch was on the right side and the subject chose the “right” side. Thus, the interpretation was “yes”. However, if the subject chose the “left” side, the answer was “no”. The subjects who were successfully collected in this study had a good signal detection and level of confidence in choosing the patch that was shown on the screen as a whole, as well as per age group.^{6,9-10}

The current gold standard infants' functional acuity test is the preferential looking acuity card test. The operator shows the infant with a sequence of cards, each card contains black and white gratings with gray background on the left or right side. Infants' preference for pattern over uniformity makes them tend to fixate on the grating pattern if they can resolve it. A well-trained operator judges whether the subject fixates the grating and determines the highest spatial frequency.¹¹

In this study, the examination was an eye-tracking-controlled automated preferential looking test. This study is in line with the previous study by Jones *et al.*¹¹ showing that a computer-based system in which stimuli are displayed on an LCD screen with a remote eye tracker to track infants' looking responses. It produced an ACTIVE procedure (Adaptive Computerized Test of Infant Vision using Eye Tracking), which is suitable for non-verbal users.¹¹ In this study, it is more appropriate if the term used is semi-automated rather than automated preferential looking test because the observer still needs to press the button after the subject glances at the grating.

The eye tracker provides several visual behavior measurements related for understanding the interpretive process; these are categorically referred to as movement measures, position measures, numerosity measures, and latency measures.¹² Eye tracking is controlling the oculomotor control of the eye to

observe the cooperativeness of the subjects.¹¹ Oculomotor control is affected by decreased sensitivity to multiple stimuli, emotional perception, cell degeneration, and eye muscle atrophy.¹³ The most likely thing is a decrease in the sensitivity of stimuli and emotional perceptions which may be related to the child's attention or visual attention.¹⁴

Study Limitations

This computer-based preferential looking demands a high load of cognitive process, therefore it needs very cooperative patients and longer practice sessions.

Conclusions

We reported a new method to replace the subjective conventional preferential looking test with a more objective test. In the present pilot study, we found that the subjects' accuracy of the automatic eye-tracking-controlled preferential looking was above 75% or surpassed the response bias threshold of diagnostic tools. Therefore, this method is promising and has a great potential to be used as a basic examination to get objective visual acuity in preschool children. The future direction and application of this study are to develop a fully automated preferential looking test using an electronic screen and eye tracker, thus children with immobility or cognitive impairment can also be assessed well.

Declarations

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Figures

Figure 1

Examination's apparatus and procedure. (A) The subject was seated on the parent's or examiner's lap with one eye closed using the parent's or examiner's hand in front of a laptop. The eye tracker was located in front of the laptop LED monitor and recorded the subject's eye movement. (B) At the screen, a single Gabor grating was presented either on the right side or left side.

Figure 2

The Accuracy results of eye tracker group based on age group (n=38 eyes). Note: The mean accuracy in 3, 4, and 5 y.o. age group ($p=0.459$)

Figure 3

Accuracy results of eye tracker group and non-eye tracker group (n=76 eyes)