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Original Article/นิพนธ์ต้นฉบับ

A Reliability and Validity of Thai Optotype Chart (SakThai Chart) on Visual Acuity Assessment

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Abstract

Objective: To examine the accuracy of the Thai Visual Acuity Test (SakThai Chart) for measuring visual performance.

Study Design: A cross-sectional study designed to test reliability and validity was conducted with 124 participants aged 20-65 years. These subjects voluntarily underwent visual acuity testing at the ophthalmology department of Thammasat University Hospital. The assessment involved reading both the numeric optotype chart and the Thai language visual acuity test (SakThai Chart) with the right eye, with subsequent result documentation. Data analysis was performed using SPSS version 25. The reliability of the instrument was evaluated using Pearson correlation, while validity was assessed through the Item-Objective Congruence (IOC) index and paired *t*-test.

Results: The Thai language visual acuity test (SakThai Chart) demonstrated a Pearson correlation coefficient of 0.992, indicating high reliability when compared to the Snellen Chart. Validity testing revealed IOC values exceeding 0.5 for all items. The paired t-test showed no statistically significant difference between the two instruments (*P*-value = 0.217).

Conclusion: The Thai language visual acuity test (SakThai Chart) exhibited high reliability with excellent correlation with numeric optotype chart. It demonstrated high content validity and can be considered a viable alternative to the numeric optotype chart for visual acuity assessment.

Keywords: Reliability, Validity, Visual Acuity, Snellen Chart, Thai Visual Acuity Test

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Introduction

Visual acuity assessment is a crucial component of comprehensive eye examinations, utilizing optotypes to evaluate visual resolution. This assessment plays a vital role in diagnosing, evaluating, and monitoring the treatment of various ophthalmic diseases. Since 1862, Herman Snellen developed a method for testing visual acuity using the principle of minimal legible visual angle.[1] This principle is then utilized in different forms of optotype charts including numerical Snellen chart, Tumbling E chart, ETDRS chart.[2] Additionally, various countries have also developed optotypes in their native languages, such as Chinese, Indian[4], Persian and including Thai language[5].

Although numerical optotypes are commonly used for visual acuity assessment in Thailand, there is no widely adopted Thai alphabet optotype. To address this issue, we have developed the SakThai Chart, a Thai alphabet visual acuity test chart that utilizes Thai alphabet instead of English letters or numbers. This chart adheres to principles of good optotype design, including uniformity in luminance, structural consistency, equality in difficulty level[3,] 5 arcminutes visual angle[2,3] and 5 × 5 grid design.

The development of this test chart aims to enhance convenience and accessibility for Thai patients. Additionally, it promotes the importance of the Thai language, stimulates learning, and fosters pride in Thai cultural identity. This study will present the development process, testing methodology, and performance comparison of the SakThai Chart with currently used numerical visual acuity test charts.

Material and Method

This study consists of two parts. The first part involves developing a visual acuity measurement tool (SakThai Chart), where the design incorporates the number of rows, gradual reduction in optotype size, and number of optotypes per row to correspond with the numeric Snellen VA chart. The second part examines the reliability and validity of the SakThai Chart and its correlation with the numeric Snellen chart through clinical testing with actual patients.

Objectives

Primary objectives: To develope a Thai acuity chart (SakThai Chart) and study the reliability of the Chart

Secondary objective: To study content validity and concurrent validity of a Thai acuity chart (SakThai Chart)

Study setting and population

The study was conducted among patients in outpatient ophthalmology department at Thammasat university hospital (TUH) from 1st May 2024 to 31st July 2024. TUH is a tertiary-care hospital serving the population in central Thailand. This study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the faculty of medicine, Thammasat university ethics committee. Participants were recruited based on inclusion and exclusion criteria. Investigators provided information, inquired about willingness to participate, and obtained signed written consent forms from all participants.

Inclusion Criteria

1. A Thai population presenting for examination at the outpatient ophthalmology department of Thammasat university hospital, capable of reading both Arabic numerals and Thai consonants. (without any concerns about educational level and visual threatening conditions)
2. Individuals aged between 20 and 65 years.
3. Ability to comprehend and follow examination

instructions.

Exclusion Criteria

1. Individuals with best corrected visual acuity (BCVA) worse than 20/200 ft.

2. Patients experiencing severe physiological conditions or severe psychiatric symptoms that significantly interfere with cognitive processes.

3. Patients with hearing impairments that preclude effective communication.

4. Individuals with intellectual disabilities.

Withdrawal or Termination Criteria

Participants who withdraw consent for continued participation or are unable to complete the visual acuity test in its entirety.

The Design of a Thai Language Visual Acuity Test Chart (SakThai Chart)

1. Selection of Thai characters that can be accommodated within a square frame grid size 5 × 5. A total of 16 characters were initially identified: ก ข ฃ ค ฅ ง จ ด ต ถ ธ ย ร ล ว อ. Subsequently, characters that are infrequently used or potentially confusing (ฃ and ฅ) were eliminated, resulting in a final set of 14 characters: "ก ข ค ง จ ด ต ถ ธ ย ร ล ว อ".

2. Random selection of 8 characters from the refined set, yielding: ก ค จ ย ร ล ว อ.

3. Incorporation of characters into the chart. The following design principles were adhered to when incorporating the characters into the Thai Optotype chart (Picture 1):

a) All optotypes in the set should exhibit similar levels of brightness (ease of luminance matching for all optotypes in the set).

b) The components of each optotype in the set should have the same structural uniformity.

c) Each optotype should have equal significance to prevent bias arising from familiarity or perceived difficulty, which could potentially influence the motivation of the examinee.

d) The optotypes should be easily generated, presented, and printed using computer technology

e) The optotypes should be designed within a 5 × 5 grid, with the stroke width of each optotype measuring one-fifth of its height.

f) The inter-optotype spacing within a row should be uniform, and the inter-row spacing should also be consistent.

g) Visual angle of each optotype subtends 5 arcminutes. The actual height of consonants in each row is calculated from tan α = a/b, where α is the visual angle equal to 5 arcminutes (5' or 0.08333°), a is the height of the optotype, and b is the distance between the reader and the optotype. For example, at a distance of 6 meters, the size of the optotype would be 8.7266 millimeters.

h) The red line at 7th row signifies normal visual acuity (20/20 ft) whereas, the yellow line signifies low vision visual acuity (20/70 ft).

i) Instructions are listed orderly below the chart.

Picture 1 Thai Optotype Chart (SakThai Chart)

Methodology and Data Collection Procedure

1. Sample size was calculated from this formula

$$n \geq \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{\frac{1}{2}\log_e \frac{1+r}{1-r}} \right)^2 + 3$$

Cohen's Kappa Sample size, estimated correlation coefficient(r) = 0.9, alpha = 0.05, beta = 0.2, Minimum sample size needed(n) ≥ 7.

By this formula, there are 8 distinct groups of possible reading results. Each group requires a minimum sample size of 7 participants. In practical implementation, data collection must continue until each reading result group attains a minimum of 7 samples. The minimum total sample size that satisfies the statistical testing requirements is 56 participants. If the number of participants exceed 56, the researcher will analyze all the available data.

2. Demographic Data: Participants completed a general information form, including age, gender, underlying medical conditions, and previous ocular history.

3. Visual Acuity Testing Environment: Participants stood 20 feet (6 meters) from the test chart in an adequately illuminated controlled environment. Visual acuity was assessed using both a Numeric Optotype Chart and a Thai Optotype chart.

4. Numeric Optotype Chart Testing: Participants read numbers with their right eye, progressing from top to bottom, one character at a time from left to right, until they could no longer discern the optotypes. Visual acuity was recorded as the lowest line where at least 50% of the optotypes were correctly identified. Results were documented in both fraction and logMAR formats. The Numeric Optotype Chart used in the study is The Novel Chart (SakChart) published in Journal of Medical Association of Thaialnd volume.100, 2017.

5. Thai Optotype Chart Testing: Visual acuity was then assessed using the Thai Optotype chart (SakThai chart). Participants read Thai consonants with their right eye, progressing from top to bottom, one character at a time from left to right, until they could no longer discern the optotypes. Visual acuity was recorded as the lowest line where at least 50% of the optotypes were correctly identified. Results were documented in both fraction and logMAR formats.

6. In this study, only one examiner performs the visual acuity testing for both Thai alphabet optotype chart and numeric optotype chart.

Statistical Analysis

The efficacy of the Thai consonant visual acuity chart was evaluated in comparison to the standard numeric chart used in clinical practice. Statistical analyses were performed using IBM SPSS Statistics version 25.

Reliability Assessment: The agreement between the Thai optotype chart (SakThai Chart) and the Numeric Optotype Chart was assessed using the test-retest reliability using Pearson correlation to evaluate the inter-rater correlation between two charts. The Pearson Correlation coefficient ranges from -1.0 to +1.0. If the value is close to -1.0, it means that the two variables have a strong negative relationship (inverse relationship). If the value is close to +1.0, it means that the two variables have a strong positive relationship. If the value is 0, it means that there is no linear relationship between the two variables.

Validity Assessment:

1. Content validity of the SakThai Chart was evaluated using the Item Objective Congruence (IOC) index. Each item comprises details used to assess the content validity of the SakThai Chart by several experts in clinical optics including ophthalmologists and optometrists.

2. Concurrent validity of the SakThai Chart was evaluated using paired *t*-test. A P value < 0.05 was

considered statistically significant.

Results

1. Demographic data

A total of 124 participants were included in this study. 7 participants was excluded due to their visual acuity is less than 20/200. The demographic characteristics of the study population are summarized in Table 1.

The age distribution was relatively even across the 31-40, 41-50, and 61-65 age groups, each comprising approximately 22-27% of the sample. The 51-60 age group made up 16.9% of participants, while those aged 20-30 represented 11.3% of the sample.

Regarding gender distribution, females constituted nearly two-thirds of the study population (65.3%, n = 81), while males accounted for 34.7% (n = 43).

Educational attainment varied among participants, with half (50.0%, n = 62) holding a Bachelor's degree. Secondary school graduates made up 37.9% (n = 47) of the sample, and 12.1% (n = 15) had completed primary school education.

Table 1 Demographic characteristics of study participants (n = 124)

Demographic and Characteristics	**n**	**%**
Age (years)		
20-30	14	11.3
31-40	28	22.6
41-50	28	22.6
51-60	21	16.9
61-65	33	26.6
Total	**124**	**100**
Gender		
Male	43	34.7
Female	81	65.3
Total	**124**	**100**
Educational Level		
Primary school	15	12.1
Secondary school	47	37.9
Bachelor's degree	62	50.0
Total	**124**	**100**
Underlying Diseases		
Yes	49	39.5
Diabetes Mellitus	20	16.1
Hypertension	18	14.5
Dyslipidemia	18	14.5
Other Conditions	**27**	**21.8**
No	75	60.5
Any Ocular Diseases		
Yes	69	55.6
Cataract	23	18.5
Glaucoma	14	11.3
Post-Cataract Surgery	11	8.9
Retinal vein occlusion/diabetic retinopathy/epiretinal membrane	11	8.9
Pterygium	7	5.6
Myopia	7	5.6
Nasolacrimal Duct Obstruction	5	4.0
Dry Eye Syndrome	5	4.0
No or N/A	**55**	**44.4**

For the prevalence of underlying diseases among the study, underlying diseases were presented in 39.5% (n = 49) of the study population. Among specific conditions, Diabetes Mellitus was the most prevalent, affecting 16.1% (n = 20) of participants. Hypertension and Dyslipidemia were equally common, each present in 14.5% (n = 18) of the sample. Other unspecified underlying diseases were reported in 21.8% (n = 27) of participants. Some participants had multiple underlying conditions, which explains why the sum of individual conditions exceeds the total number of participants with underlying diseases.

For the prevalence of ocular diseases among the study, over half of the participants (55.6%, n = 69) presented with at least one ocular disease. The most prevalent condition was cataract, affecting 18.5% (n = 23) of the study population. Glaucoma was the second most common ocular disease, present in 11.3% (n = 14) of participants.

Other ocular conditions were observed at lower frequencies:

- Post-cataract surgery status and retinal vein occlusion, diabetic retinopathy or epiretinal membrane were each present in 8.9% (n = 11) of participants.
- Pterygium was found in 5.6% (n = 7) of the participants.
- Myopia and nasolacrimal duct obstruction (NLDO) each affected 4.0% (n = 5) of participants.
- Dry eye syndrome was the least common among the reported conditions, present in 4.0% (n = 5) of the participants.

2. Reliability Assessment

The reliability of the SakThai Chart can be inferred from its correlation with the Numeric Optotype Chart. Pearson correlation = 0.992 ($p < 0.01$).

3. Validity Assessment

3.1 Content Validity:

The Item-Objective Congruence (IOC) index for the SakThai Chart demonstrates acceptable content validity among 3 experts including 1 ophthalmologist and 2 optometrists. An IOC value > 0.5 is considered acceptable, indicating that the items appropriately represent the intended content. The results for each item are shown in the Table 2.

Table 2 Item-Objective Congruence (IOC) index results for the SakThai Chart

Number	Item	IOC score	Interpretation
1	All optotypes in the set should exhibit similar levels of brightness (Ease of luminance matching for all optotypes in the set).	0.67	acceptable
2	The components of each optotype in the set should have the same structural uniformity	0.67	acceptable
3	Each symbol should have equal significance to prevent bias arising from familiarity or perceived difficulty, which could potentially influence the motivation of the examinee.	0.67	acceptable
4	The optotypes should be easily generated, presented, and printed using computer technology	1	acceptable
5	The optotypes should be designed within a 5x5 grid, with the stroke width of each optotype measuring one-fifth of its height.	0.67	acceptable
6	The inter-optotype spacing within a row should be uniform, and the inter-row spacing should also be consistent.	0.67	acceptable

3.2 Concurrent Validity:

A paired t-test was conducted to compare visual acuity measurements obtained from the SakThai Chart and the Numeric Optotype Chart. The mean difference in LogMAR scores between the Numeric Optotype Chart (M = 0.2800, SD = 0.32583) and the SakThai Chart (M = 0.2752, SD = 0.33342) was 0.00484 (95% CI: -0.00286 to 0.01254). This difference was not statistically significant (t = 1.244, p = 0.216, two-tailed).

Discussion

This study introduces and evaluates the SakThai Chart, a novel Thai language visual acuity test chart designed to enhance accessibility and cultural relevance for Thai patients. Our findings demonstrate that the SakThai Chart exhibits high validity and reliability, positioning it as a viable alternative to traditional numeric optotype chart for visual acuity assessment in Thai populations.

The content validity of the SakThai Chart was evaluated using the Item-Objective Congruence (IOC) index. All six assessed criteria, including luminance consistency, structural uniformity, equality of information content, digital versatility, grid-based design, and consistent spacing, achieved acceptable IOC scores (> 0.5). This indicates that the SakThai Chart adequately represents the intended construct and adheres to principles of good optotype design, as outlined by previous study[6,7].

Concurrent validity was established through a comparison with the widely used Numeric Optotype Chart. The paired t-test revealed no statistically significant difference between the LogMAR scores obtained from the SakThai Chart and the Numeric Optotype Chart (p = 0.216). This suggests that the SakThai Chart provides comparable visual acuity measurements to the Numeric Optotype Chart, supporting its use in clinical practice. Similar results have been observed in the development of other language-specific visual acuity charts[8,9].

The reliability of the SakThai Chart was assessed through Pearson's correlation analysis with the Numeric Optotype Chart. The high correlation coefficients obtained from Pearson correlation (0.992), statistically significant at $p < 0.01$, indicate excellent reliability. These positive correlations across different statistical methods reinforce the consistency and dependability of the SakThai Chart in visual acuity measurement, aligning with the reliability in currently used ophthalmic testing.[10,11]

Our study population represented a diverse range of age groups, educational backgrounds, and ocular conditions. The high prevalence of ocular diseases (55.6%) in our sample, particularly cataract (18.5%) and glaucoma (11.3%), underscores the importance of accurate and accessible visual acuity testing in clinical settings. These prevalence rates are consistent with previous epidemiological studies in Thailand and other Southeast Asian countries.[12,13]

The utilization of Thai alphabet optotype charts serves as a viable alternative for visual acuity measurement or confirmation, particularly in cases where patients may have memorized numeric optotypes. This innovative approach not only effectively addresses potential language barriers but also promotes cultural identity and may enhance patient engagement during eye examinations. Additionally, the implementation of Thai alphabet charts proves equally convenient and practical compared to conventional numeric charts, making it a seamless integration into standard clinical practice while maintaining testing efficiency and reliability.

This aligns with global efforts to develop culturally appropriate healthcare tools and supports the WHO's initiative for universal eye health.[14,15]

While this study provides evidence for the validity and reliability of the SakThai Chart, several limitations should be considered when interpreting the results:

1. Visual acuity assessment in this study was performed by ophthalmology residents. In clinical practice, the assessments are usually performed by assistants and technicians. Therefore, practical implementation necessitates a rigorous orientation process for personnel prior to actual application in the clinic.

2. Age range: Our study included participants aged 20-65 years. The performance of the SakThai Chart in pediatric populations and in adults over 65 years old remains to be evaluated. However, pediatric populations in verbal age and comprehension of Thai consonants could still be evaluated by Thai optotype chart.[16]

3. Examiner bias: Although efforts were made to standardize the testing procedure, the possibility of examiner bias cannot be completely ruled out.

4. The Snellen chart demonstrates several significant limitations compared to the ETDRS chart, including non-standardized progression of optotype sizes, inconsistent number of letters per line, and variable letter spacing that does not maintain proportional relationships with letter size. These design flaws, coupled with the non-logarithmic progression of the visual angle and lack of standardized testing distance flexibility, make the Snellen chart less reliable for research purposes and clinical trials where precise visual acuity measurements and statistical analyses are required.

Conclusion

The SakThai Chart demonstrates validity and reliability, comparable to the Snellen Numeric Optotype Chart, which is currently used in clinical practice for visual acuity assessment in Thai-speaking populations. Its implementation in clinical practice could enhance the accuracy and cultural appropriateness of visual acuity testing in Thailand, potentially improving patient care and outcomes in ophthalmology.

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การตรวจสอบความเชื่อมั่นและความเที่ยงตรงของแผ่นทดสอบความสามารถในการมองเห็นภาษาไทย (SakThai Chart) สำหรับการวัดสมรรถภาพการมองเห็น

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วัตถุประสงค์: เพื่อตรวจสอบความแม่นยำของแผ่นทดสอบความสามารถในการมองเห็นภาษาไทย (SakThai Chart) สำหรับการวัดสมรรถภาพการมองเห็น

แบบการศึกษา: A cross-sectional study, A test of reliability and validity โดยมีผู้เข้าร่วมวิจัยจำนวน 124 คน ที่มีอายุ 20-65 ปี ที่เข้ามาตรวจรักษาที่แผนกจักษุ โรงพยาบาลธรรมศาสตร์ฯ เข้าทดสอบสมรรถภาพการมองเห็นตามความสมัครใจโดยอ่านแผ่นทดสอบการมองเห็นแบบตัวเลข (numeric optotype chart) และแผ่นทดสอบการมองเห็นภาษาไทย (SakThai Chart) ด้วยตาข้างขวาและบันทึกผล จากนั้นวิเคราะห์ข้อมูลด้วยโปรแกรม SPSS เวอร์ชัน 25 โดยความเชื่อมั่นของเครื่องมือ ใช้สถิติทดสอบ Pearson correlation และความเที่ยงตรงของเครื่องมือใช้สถิติทดสอบ Item-objective Congruent (IOC) และ Paired *t*-test

ผลการศึกษา: แผ่นทดสอบความสามารถการมองเห็นภาษาไทย (SakThai chart) มีค่า Pearson corelation คือ 0.992 ซึ่งถือว่าเครื่องมือนี้มีความเชื่อมั่นสูงเมื่อเทียบกับการทดสอบความสามารถการมองเห็นแบบสเนลเลน และเมื่อทดสอบความเที่ยงตรงของเครื่องมือ พบว่า IOC มากกว่า 0.5 ในทุกหัวข้อ และ Paired *t*-test ไม่มีความแตกต่างอย่างมีนัยสำคัญของทั้งสองเครื่องมือ (*P*-value = 0.217)

สรุป: แผ่นทดสอบความสามารถในการมองเห็นภาษาไทย (SakThai Chart) มีค่าความเชื่อมั่นและมีความเที่ยงตรงของเนื้อหาสูง และสามารถใช้ทดแทนกับแผ่นทดสอบการมองเห็นแบบสเนลเลน (Snellen Chart) ได้

คำสำคัญ: ความเชื่อมั่น, ความเที่ยงตรง, สมรรถภาพการมองเห็น, แผ่นทดสอบความสามารถ, การมองเห็นสเนลเลน, แผ่นทดสอบการมองเห็นภาษาไทย

ภาควิชาจักษุวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

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