

ORIGINAL ARTICLE

Comparison of reading speed with 3 different log-scaled reading charts



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KEYWORDS

Reading chart;
Reading rate;
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Abstract

Background: A reading chart that resembles real reading conditions is important to evaluate the quality of life in terms of reading performance. The purpose of this study was to compare the reading speed of UiTM Malay related words (UiTM-Mrw) reading chart with MNread Acuity Chart and Colenbrander Reading Chart.

Materials and methods: Fifty subjects with normal sight were randomly recruited through randomized sampling in this study (mean age = 22.98 ± 1.65 years). Subjects were asked to read three different near charts aloud and as quickly as possible at random sequence. The charts were the UiTM-Mrw Reading Chart, MNread Acuity Chart and Colenbrander Reading Chart, respectively. The time taken to read each chart was recorded and any errors while reading were noted. Reading performance was quantified in terms of reading speed as words per minute (wpm).

Results: The mean reading speed for UiTM-Mrw Reading Chart, MNread Acuity Chart and Colenbrander Reading Chart was 200 ± 30 wpm, 196 ± 28 wpm and 194 ± 31 wpm, respectively. Comparison of reading speed between UiTM-Mrw Reading Chart and MNread Acuity Chart showed no significant difference ($t = -0.73$, $p = 0.72$). The same happened with the reading speed between UiTM-Mrw Reading Chart and Colenbrander Reading Chart ($t = -0.97$, $p = 0.55$). Bland and Altman plot showed good agreement between reading speed of UiTM-Mrw Reading Chart with MNread Acuity Chart with the Colenbrander Reading Chart.

Conclusion: UiTM-Mrw Reading Chart in Malay language is highly comparable with standardized charts and can be used for evaluating reading speed.

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PALABRAS CLAVE

Test de lectura;
Índice de lectura;
Rendimiento lector

Comparación de la velocidad lectora con tres tests de lectura con escala logarítmica

Resumen

Antecedentes: La disposición de un test de lectura que se asemeje a la situación real de lectura es importante para evaluar la calidad de vida en términos de rendimiento lector. El objetivo

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de este estudio fue la comparación de la velocidad lectora con el test de lectura con palabras afines de la UiTM de Malasia (UiTM-Mrw), el test de agudeza MNread y el test de lectura de Colenbrander.

Materiales y Métodos: En este estudio se seleccionó aleatoriamente a cincuenta sujetos con visión normal mediante muestreo aleatorio (edad media = $22,98 \pm 1,65$ años). Se solicitó a los sujetos que leyeran en voz alta tres tests diferentes de cerca, lo más rápidamente posible, siguiendo una secuencia aleatoria. Las tests fueron el test de lectura UiTM-Mrw, el test de agudeza MNRead y el test de lectura de Colenbrander, respectivamente. El tiempo empleado para leer cada test fue medido, anotándose cualquier error mientras se leía. Se cuantificó el rendimiento lector en términos de velocidad lectora en palabras por minuto (ppm).

Resultados: La velocidad lectora media con el test de lectura UiTM-Mrw, el test de agudeza MNread y el test de lectura de Colenbrander fue de 200 ± 30 ppm, 196 ± 28 ppm y 194 ± 31 ppm, respectivamente. La comparación de la velocidad lectora entre el test de lectura UiTM-Mrw y el test de agudeza MNread no reflejó una diferencia significativa ($t = -0,73$, $p = 0,72$). Lo mismo ocurrió con la velocidad lectora al comparar las medidas del test de lectura UiTM-Mrw y el test de lectura de Colenbrander ($t = -0,97$, $p = 0,55$). Los gráficos de Bland y Altman reflejaron una buena concordancia entre la velocidad lectora con el test de lectura UiTM-Mrw y con el test de agudeza MNRead, así como con la medida con el test de lectura de Colenbrander.

Conclusión: La el test de lectura UiTM-Mrw en lengua malaya es altamente comparable a las tests estándar, pudiéndose utilizar para evaluar la velocidad lectora.

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Introduction

Routine near visual acuity measurement using Snellen notation had shown low correlation and can only predict 10 percent of someone's reading speed because it only involves recognition of a single letter rather than giving real reading information.¹ This is because reading is a complex process that involves decoding and linguistic comprehension components in acquiring meaning from printed or written words.² The assessment of reading performance is very important and should be done as a routine clinical optometric examination. It can later provide more detailed information about visual impairment quitar esta frase, se repite.³

Reading performance can be evaluated in terms of reading acuity,⁴ reading rate,⁵ reading speed⁶ and critical print size⁷ using reading charts. Various standardized reading charts were studied in terms of design and validation testing in order to develop the Malay Reading Chart. The Practical near acuity chart (PNAC) was constructed using 3 related words for each print size ranging from N80 to N5.⁸ The words were extracted from internet English vocabulary of grade 4 and above. The PNAC was tested among visually impaired subjects and it showed that the chart was highly correlated with the Bailey-Lovie chart and had a good test-retest reliability. Since the lowest print size of PNAC was N5, the PNAC was mainly to be used among visually impaired patients or patients with almost normal eyesight.⁸ The Minnesota Reading Chart (MNRead) was developed using short sentences on computer screens.⁹ Each sentence has 3 lines and 60 characters but the number and length of the words chosen were varied. Later, the printed version of MNread Acuity Chart was designed to be used in the clinical setting.⁷ It comprised of 52 characters for each sentence and printed in 4 lines of text with 18 levels of print size ranging from 1.3 to -0.4 log-MAR, which is equivalent to 8.0M to 0.1M. The MNread Acuity Chart was one of the standardized reading charts that was available to test the reading performance of normal-sighted

and low vision patients. It has been constructed in different languages such as Turkish,¹⁰ Portuguese¹¹ and Greek¹² quitar esto!! The MNread Acuity Chart used sentences that were only similar in number of lines and number of characters, but not in length and position of words. The Radner Reading Chart not only controlled the number of words per sentence but also the position of the words and number of syllables which is an advantage over the MNRead.¹³ The PNAC, MNread Acuity Chart and the Radner Reading Chart met the requirements of a logarithmically progressing print size from one sentence to another and the possibility to acquire reading speed (in words/minute) and reading acuity simultaneously in the clinical setting.^{7,8,13}

Several reading charts are currently available to evaluate reading performance. However, not all reading charts are suitable to be used for all types of patient as it greatly depends on the patient's cooperation and ability to fluently read the chart. To develop a well-standardized reading chart, some factors and design including character size,¹⁴ font typeface,⁶ letter spacing,¹⁵ vertical spacing^{16,17} as well as contrast¹⁸ should be considered. Therefore, it would be beneficial to have a standardized reading chart to be used among native Malay language speakers in a clinical setting or in relevant scientific research.

Materials and methods

Fifty normal-sighted young university students (mean age: 22.98 ± 1.65 years) were recruited through randomized sampling with informed consent. A screening process was done prior to the reading performance assessment. Distant visual acuity using Lighthouse Distance Visual Acuity test (2nd Edition) was carried out binocularly at 4m with the chart illumination ranging between 550 lux and 580 lux. Remote near point of convergence and near point of accommodation using the Royal Air Force rule was also used to screen all subjects.

N log MAR	ht	snellen (mm) ratio	
N40 1.3	17.5	40/800	Setiap hari emak saya
			pergi ke pasar
N32 1.2	14.9	40/200	Cahaya bulan dan bintang
			amat terang
N25 1.1	11	40/500	Kerusi itu sangat cantik dan

Figure 1 The UiTM Malay related words reading chart.

The inclusion criteria were as stated below:

1. Able to read Malay and English fluently.
2. Corrected visual acuity of at least 6/9 binocularly.
3. No convergence and accommodation problems.
4. Absence of eye pathology which can affect reading performance.

This study followed the tenets of the Declaration of Helsinki and was approved by the Research Ethics Committee of Faculty of Health Sciences, Universiti Teknologi MARA (approval code: 600-FSK(P.T5/2)).

The UiTM-Mrw Reading Chart comprised of print sizes ranging from 1.3 LogMAR to 0.0 LogMAR, which was equivalent from N40 to N1 and 17.5mm to 0.9mm in 0.1 LogMAR steps. Each sentence had a maximum of 60 characters per sentence that consisted of 6–10 standard-length words. The chart consisted of fourteen sentences or sets of related words. Related words were used to make reading performance evaluation more practical and relevant. The sentences were extracted from Grade 3 to 6 Malay school textbooks used at school by the Malaysian Ministry of Education (MMOE). Several sentences were chosen to prevent learning effects. Font typeface used was "Times New Roman" as it was a print type commonly used in most of the reading materials.¹⁹ The chart was printed on matte surface white paper to avoid reflection with 100% contrast. Fig. 1 shows the UiTM-Mrw Reading Chart near chart.

The subjects were asked to read aloud the UiTM-Mrw Reading Chart, MNread Acuity Chart⁷ and Colenbrander Reading Chart at random order. Reading charts were placed on an inclined reading stand at 45° with a reading distance of 40cm. The chart was occluded with a blank card prior to each reading performance evaluation. This card was removed at the start of the evaluation and the subjects were required to read the sentence as quickly as possible. The subjects were asked to read from the largest sentence towards the smallest sentence until they could no longer manage to read any of the words on a line or read half of the words on that sentence wrongly. The time they completed reading each text was recorded to the nearest 0.1 s and any errors such as a reading mistake and omissions were noted. The reading acuity of the smallest print size that can be read was recorded in Snellen format and recalculated in geometric visual acuity with standard deviation.²⁰ Reading speed was quantified by dividing the number of words that could be read correctly with time taken to read the chart in words per minute (wpm).

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 20.0. Comparison of reading speed between UiTM-Mrw Reading Chart with MNread Acuity Chart

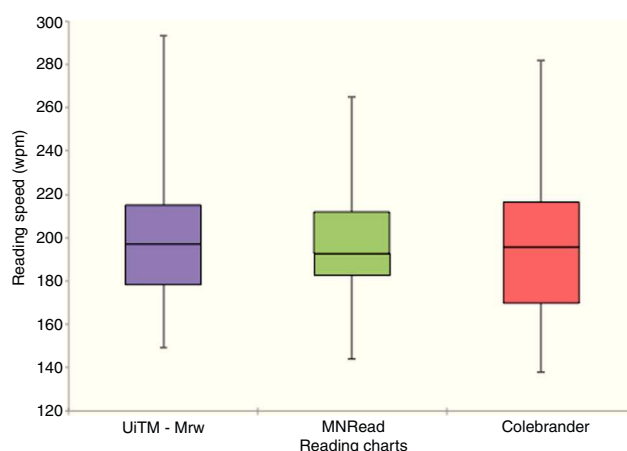


Figure 2 Box and whisker plot of reading speed for the UiTM-Mrw Reading Chart with the MNread Acuity Chart and the Colenbrander Reading Chart. The error bar shows the maximum and minimum values of the reading speed for each chart. The horizontal line in the middle of the box shows the median reading speed. The lower edge of the box represents the 1st quartile and upper edge of the box represents the 3rd quartile.

and Colenbrander Reading Chart was analyzed using independent sample *t*-test and agreement between charts was determined using Bland and Altman plot. A Bland–Altman plot is a graphical method to plot the different scores in analyzing the agreement of two measurements or instrument techniques against the mean for each participant.^{21,22} It calculates the mean difference between two methods of measurement and 95% limits of agreement as the mean difference of 1.96 standard deviation. The presentation of the 95% limits of agreement is for visual judgement of how well two methods of measurement agree.^{21,23,24}

Results

The reading speed with UiTM-Mrw Reading Chart, MNread Acuity Chart and Colenbrander Reading Chart was summarized in Fig. 2. The mean reading speed for UiTM-Mrw Reading Chart, MNread Acuity Chart and Colenbrander Reading Chart was 200 ± 30 wpm, 196 ± 28 wpm and 194 ± 31 wpm, respectively. The UiTM-Mrw Reading Chart showed the highest reading speed with the range between 149 wpm to 293 wpm. The minimum reading speed of MNRead reading chart was 144 wpm while the maximum reading speed was 266 wpm. The Colenbrander Reading Chart showed the range of reading speed between 138 wpm to 282 wpm. Independent sample *t*-test showed that there was no significant difference ($t = -0.73$, $p = 0.72$) in reading speeds between the UiTM-Mrw Reading Chart and the MNread Acuity Chart. Comparison of reading speeds of the UiTM-Mrw Reading Chart and the Colenbrander Reading Chart also showed no significant difference ($t = -0.97$, $p = 0.55$) between both charts. The reading errors made by the participants while reading the UiTM-Mrw Reading Chart, MNread Acuity Chart and Colenbrander Reading Chart were described in Fig. 3.

Bland and Altman plot (Fig. 4) showed a good agreement of reading speed between the UiTM-Mrw Reading Chart

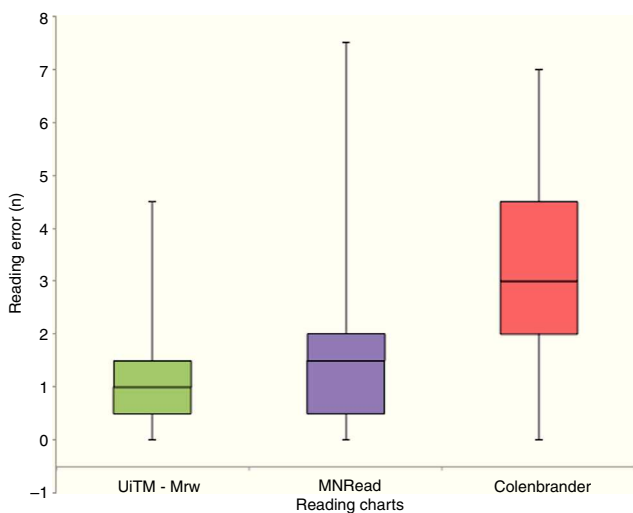


Figure 3 Box and whisker plot of reading error for the UiTM-Mrw Reading Chart with the MNread Acuity Chart and the Colenbrander Reading Chart. The error bar shows the maximum and minimum values of the reading speed for each chart. The horizontal line in the middle of the box shows the median reading speed.

and the MNread Acuity Chart (Fig. 4a). The mean difference, standard deviation of the differences and the 95% limits of agreement were 4.2 wpm, 23.6 wpm, +51.4 wpm and -43.0 wpm, respectively. The reading speed of the UiTM-Mrw Reading Chart also strongly agreed with the Colenbrander Reading Chart as shown in the Bland and Altman plot (Fig. 4b). The mean difference of reading speed was 5.9 wpm and standard deviation of the differences was 26.2 wpm. The 95% limits of agreement were +58.3 wpm and -46.5 wpm, respectively.

Discussion

Comparison of the UiTM-Mrw Reading Chart with the MNread Acuity Chart and Colenbrander Reading Chart confirmed that the reading speed of the UiTM-Mrw Reading Chart was not significantly different than those values obtained with the other two charts. This might suggest that the new UiTM-Mrw Reading Chart could be used in evaluating reading performance in terms of reading speed among young adults in Malay language.

Normal-sighted reading speed was found to be in the range of 169 wpm to 273 wpm with a mean of 215 wpm.²⁵ The mean reading speed of the UiTM-Mrw Reading Chart among normal-sighted young adults in this study was 200 wpm with range of 149–293 wpm while the reading speed of MNread Acuity Chart was within 144–266 wpm. The reading speed measurement using the UiTM-Mrw Reading Chart in the current study was similar to the one reported by Legge et al.²⁵ using the MNread Acuity Chart. Therefore, the UiTM-Mrw Reading Chart could be considered as comparable with the MNread Acuity Chart despite a difference in language (Malay language).

The reading speed among Malay speakers was reported to be 102 ± 33 wpm.²⁶ This is lower than the result of this study, which is 200 ± 30 wpm. The differences in both

reading speeds might be because the Malay reading text used in Mohammed and Omar's study was constructed using unrelated words instead of related words used in the UiTM-Mrw Reading Chart. When reading the related words in the form of sentences, readers were able to read faster compared to reading unrelated words because of contextual cues in that sentence.¹⁴ Furthermore, related words or sentences were chosen to represent real reading conditions in evaluating the reading performance in the clinical setting.

The mean difference of the reading speed between the UiTM-Mrw Reading Chart and the MNread Acuity Chart was 4.2 wpm (95% Confidence Interval (CI): -2.6 wpm to 11.1 wpm). Lower limit and upper limit were -43.0 wpm (95% CI: -54.8 wpm to -31.2 wpm) and 51.4 wpm (95% CI: 39.6 wpm to 63.2 wpm), respectively. The mean difference of the reading speed between UiTM-Mrw near chart and Colenbrander Reading Chart was 5.9 wpm (95% CI: -1.7 wpm to 13.5 wpm). The lower limit was -46.5 wpm (95% CI: -59.6 wpm to -33.4 wpm), whereby the upper limit was 58.3 wpm (95% CI: 45.2 wpm to 71.3 wpm). The Bland-Altman plot (Fig. 4) charts the difference in reading speed measurement (UiTM-Mrw minus MNRead) on the vertical axis against the average of the two measurements. It is expected that the 95% limits ($\pm 1.96SD$) includes 95% of differences between two measurements.²¹ The smaller the range between these two limits the better the agreement.²¹ The 95% CI for the mean difference between the UiTM-Mrw and MNRead as well as between the UiTM-Mrw and Colenbrander were relatively small and clinically negligible. The difference reported here was similar to the previous study for the evaluation of the test-retest of Radner Reading Chart where the mean difference was 8.03 ± 12.32 wpm, and 95% CI: 4.87 wpm to 11.19 wpm and was concluded as clinically interchangeable.²⁷ Hence, good agreement between the UiTM-Mrw Reading Chart with the MNread Acuity Chart as well as the UiTM-Mrw Reading Chart with the Colenbrander Reading Chart were shown in the Bland-Altman plot and indicated that the UiTM-Mrw Reading Chart was highly comparable with standardized English reading charts.

The reading speed of young university students was compared between two charts with different languages. Comparison of reading test between newly developed reading charts with standardized reading charts of a different language could be carried out as long as the participants are fluent in both languages. The Dutch version of Radner Reading Chart showed high inter-chart reliability of reading performance with the German version of Radner Reading Chart among older population affected by macular disease.²⁸ A set of standardized, homogeneous, and comparable texts in four European languages, which were English, Finnish, French and German was developed to evaluate the reading performance.²⁹ There were 10 texts constructed by linguistic experts of those particular languages. It showed that the reading speed was not significantly different between reading texts of different languages that resulted in recommendations for inter-language comparisons in the evaluation of the reading performance.

Reading can be influenced by many factors including font typeface.⁶ Times New Roman font typeface was used in developing the UiTM-Mrw Reading Chart because it is commonly used in most reading materials.¹⁹ Previous studies have debated usage of serif and sans serif font typeface

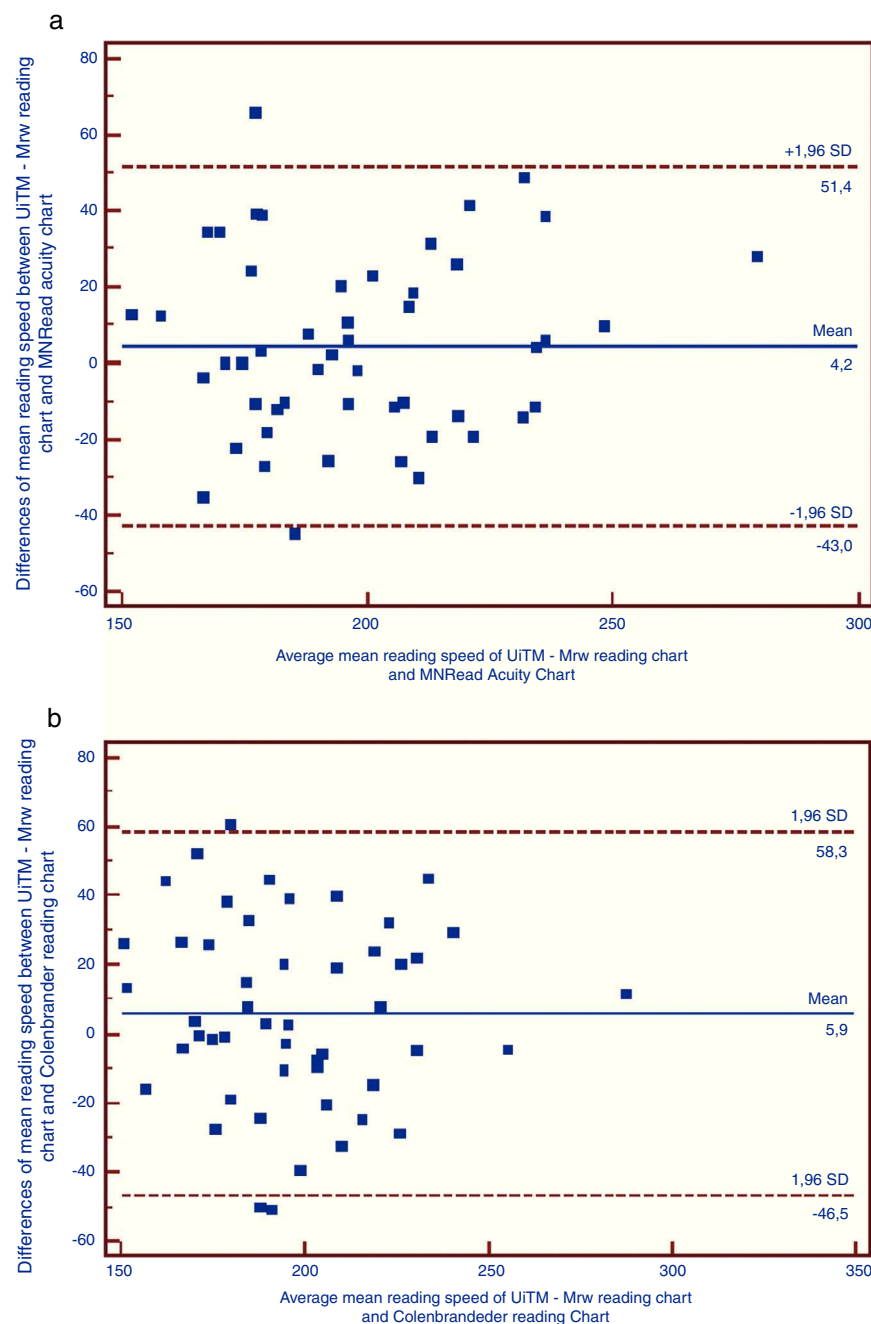


Figure 4 (a) Bland and Altman plot of reading speed between the UiTM-Mrw Reading Chart and the MNread Acuity Chart. (b) Bland and Altman plot of mean reading speed between the UiTM-Mrw Reading Chart and the Colenbrander Reading Chart. Three lines are displayed on the Bland–Altman plot. The thick blue line represents the mean difference of reading speed between two charts, the upper and lower red dash lines represent the 95% limit of agreement (± 1.96 SD).

in affecting the reading performance evaluation. A serif, which is a letter with an end stroke (e.g. Times New Roman), reported increased reading acuity among low vision subjects compared to san serif font typeface.⁶ At lower illumination using rapid serial visual presentation on monitor among normal readers, san serif font typeface seemed to be faster compared to serif font typeface.³⁰ This was because compared to san serif font typeface, the end stroke at the serif letter acted as visual noise when the readers attempted to detect the letter or words and letter spacing

between serif fonts.³¹ This would lead to the increase in crowding effect in word identification especially among dyslexic children.³² Even though some studies showed that the font doesn't affect the reading speed among either normal or low vision subjects,^{17,33–35} choices of san serif font typeface may be taken into consideration when designing a reading chart to enable reading performance evaluation for those who experience problems in reading due to crowding effect. Number of words per acuity size was varied in the UiTM-Mrw reading chart. The maximum was 10

words and the minimum was 6 words. This showed that the number of words for every acuity size was not controlled compared to the Radner reading chart^{13,28,36} where the number of words, syllables per word and location of words in every acuity size was the same and fully controlled. This would be beneficial in recording the precise reading acuity and reading speed during the evaluation because every syllable represents a specific log unit. Repeatability, validation of reading performance using the UiTM-Mrw Reading chart among low vision patients, children as well as geriatric subjects would be recommended for future research.

In conclusion, the UiTM-Mrw Reading Chart was found to be highly comparable and has good agreement with standardized reading charts (MNread Acuity Chart and Colenbrander Reading Chart). Therefore, the UiTM-Mrw Reading Chart can be used in evaluating reading performance such as reading speed in Malay language among young adults in clinical settings or for research purposes.

Conflicts of interest

The authors have no conflict of interest to declare.

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