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Buari-Chen Malay Reading Chart (BCMRC): Contextual Sentence and Random Words 2-in-1 Design in Malay Language

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ABSTRACT

A full description of a new reading chart in Malay language, the Buari-Chen Malay Reading Chart (BCMRC) is described. Internal and external comparisons of BCMRC are also reported. BCMRC comprised four reading sets with contextual sentence (CS1 and CS2) and random words (RW1 and RW2) designs. A total of 14 prints, ranging from 1.3LogMAR to 0.0LogMAR in 0.1LogMAR steps (equivalent to 8 M to 0.4 M) were printed in high contrast Arial font. CS1, CS2, RW1 and RW2 were presented in random order to the participants for internal comparison. The reading was evaluated aloud with clear pronunciation (errors were recorded). Maximum reading speed (MRS) was reported in words per minute. The external comparison involved two standard English reading charts [MNread acuity chart (MNread) and Bailey-Lovie words reading chart (Bailey-Lovie)]. The internal and external comparisons were analysed using the intra-class correlation coefficient (ICC) and Cronbach's alpha (α) respectively. Contextual sentence set (ICC=0.82) and random word set (ICC=0.85) exhibited good reliability in our internal comparison. The external comparison showed acceptable reliability for both MNread (α=0.76) and Bailey-Lovie (α=0.80). BCMRC sets with similar features could be used interchangeably to monitor clinical progress in visual rehabilitation. BCMRC was comparable with MNread and Bailey-Lovie reading charts.

Keywords: Malay reading chart, reading, reading chart, reading speed

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INTRODUCTION

The reading assessment in an eye examination was evaluated using reading charts. Standardized reading charts are usually equipped with its validity and reliability. Contextual sentences and random words are the options for text design. The contextual sentence comprises continuous and meaningful text. The random words design uses string of words that are independent of semantic and syntactic cues. The contextual sentence reading charts available are MNread acuity chart (MNread)(Mansfield, Ahn, Legge, & Luebker, 1993), Radner reading chart (Radner) (Radner et al., 1998) and International reading speed test (IReST) (Hahn et al., 2006). The random words reading charts include Bailey-Lovie word acuity chart (Bailey-Lovie) (Bailey & Lovie, 1980), practical near acuity chart (PNAC) (Wolffsohn & Cochrane, 2000), Pepper Visual Skill for Reading Test (VSRT) (Watson, Whittaker, & Steciw, 2010) and Rate of Reading Test (RRT) (Wilkins, Jeanes, Pumfrey, & Laskier, 1996). The majority of random words reading charts contain string of words that are arranged to mimic sentences. Some are translated into different languages for the clinical evaluation of reading (Alio et al., 2008; Buari, Azizan, & Chen, 2015; Buari, Chen, & Musa, 2014; Calossi, Boccardo, Fossetti, & Radner, 2014; Castro, Kallie, & Salomao, 2005; Hahn et al., 2006; İdİl et al., 2011; Maaijwee, Mulder, Radner, Van Meurs, & Meurs, 2008; Mataftsi et al., 2013; Trauzettel-Klosinski & Dietz, 2012).

The need for standardised reading charts in local language is undisputable. Language barrier should be eliminated during reading assessment by adapting to native language. Factors that should be considered in developing and designing the reading chart include the notation, number of words for every print size, number of lines for every print size, font type and the arrangement on the chart. The majority employed LogMAR notation for reading acuity scoring because it gives similar geometric progression (Bailey, 2006). Other notations are “M” notation and “N” notation (Colenbrander, 2001). The number of words and lines for every print size vary for different reading charts. Some charts have a constant number of words throughout the print sizes (Radner et al., 1998; Wilkins et al., 1996; Wolffsohn & Cochrane, 2000) while others have different number of words for each print size (Bailey & Lovie, 1980; Buari et al., 2015; Buariet al., 2014; Hahn et al., 2006; Mansfield et al., 1993). The variations in the number of words per print size might affect the duration of reading for each print size (Jufri, Buari, & Chen, 2016). The number of lines may vary according to different charts ranging from a single line up to 13 lines. The alignment is either centre alignment or left alignment in the reading chart. *Times New Roman* is the most common font typeface used in reading charts to relate to the common print size used for newspapers and books (Wolffsohn & Cochrane, 2000). Font choice is crucial to reduce the visual noise and crowding effect especially among people with special needs (Spinelli, De Luca, Judica, & Zoccolotti, 2002).

Most reading charts establish its reliability before being used in the clinical setting or as a research tool. The MNread displays good reliability on normal vision (adults: r = 0.82; children: r = 0.95 to 0.94) (Castro et al., 2005; İdİl et al., 2011; Legge, Pelli, Rubin, & Schleske, 1985; Legge, Rubin, Pelli, & Schleske, 1985; Mansfield et al., 1993; Mansfield, Legge, & Bane, 1996; Virgili et al., 2004) and low vision (Subramanian & Pardhan, 2006, 2009). The PNAC is highly correlated with Bailey-Lovie (r = 0.99) (Wolffsohn & Cochrane, 2000), Radner had has good inter-chart reliability (reliability = 0.88 – 0.98) (Burggraaff, van Nispen, Hoek, Knol, & van Rens, 2010; Maaijwee et al., 2008; Radner et al., 1998; Stifter et al., 2004), UiTM-Mrw and UiTM-Muw had has good reliability (0.85) in repeated measurement of the reading speed (Buari, Yusof, Mohd-Satali, & Chen, 2014). Contextual sentence design reflects daily reading activities, but random word design dedicates visual aspect in reading (Lüdtke & Kaup, 2006; Van Petten & Kutas, 1990). Having both designs in a single reading chart might be an advantage. Internal and external comparisons of Buari-Chen Malay Reading Chart are reported in our study.

MATERIALS AND METHODS

Buari-Chen Malay Reading Chart (BCMRC)

The chart in this study is referred as Carta Membaca Bahasa Melayu Buari-Chen (in Malay) or Buari-Chen Malay Reading Chart (in English). BCMRC comprises four reading sets with contextual sentences (CS1 and CS2) and random words (RW1 and RW2) designs (Figure 1). The fundamental characteristics and features in each set design are identical except for the text itself (sentences and words). Contextual sentences and random words are organised to form the reading text. Both the materials used are approved under the Ministry of Education, Malaysia. The contextual sentences are selected from Malay language primary school textbooks from Grade 3 to Grade 6. The random words consist of a string of words that do not represent any contextual meaning. The words are selected randomly from Word Registry of Primary School (Daftar Kata Bahasa Melayu Sekolah Kebangsaan) for primary school students from Grade 1 to Grade 6. A total of 28 sets of contextual sentences and 28 sets of random words are constructed to develop the BCMRC. The appropriateness of the Malay contextual sentences were examined, finalised, and confirmed through formal consultation with experienced Malay language school educators. It was done manually within the scope of grammar, composition and arrangement of contextual sentences. Subsequently, 14 print sizes ranging from 1.3LogMAR to 0.0LogMAR in 0.1LogMAR steps were printed in high contrast Arial font. Each print size comprise six Malay words and is arranged into two lines. Four notations are incorporated in the design namely the M notation, N notation, Snellen ratio and LogMAR. The M notation and Snellen ratio range from 8 M to 0.4 M and 20/400 to 20/20, respectively. The N notation is from N64 to N3. The sentences are set at left alignment. The BCMRC is printed on A4 size white matte surface material, double sided with high contrast of black print on white background.

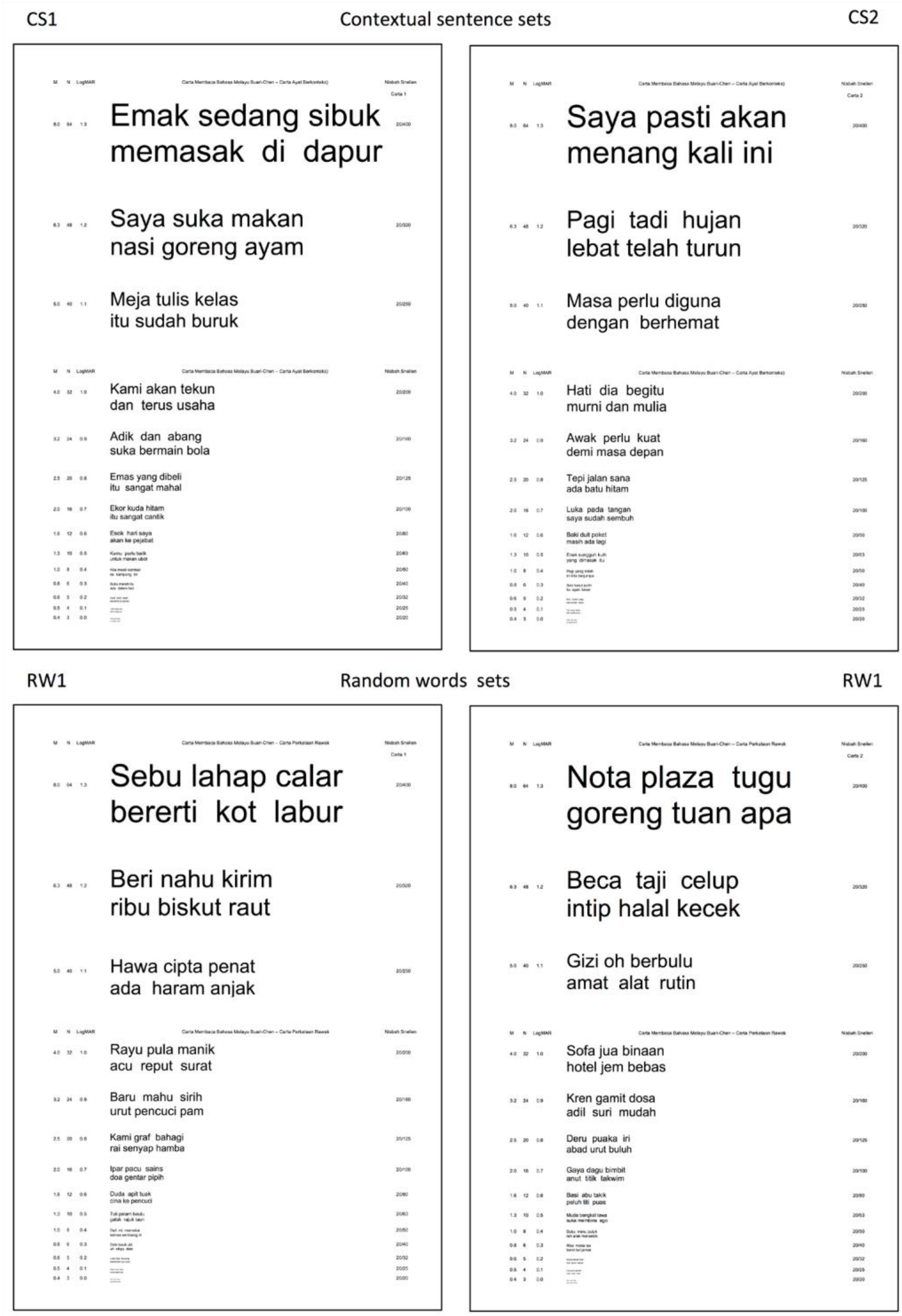


Figure 1. Buari-Chen Malay reading chart

Internal Comparison of BCMRC

The internal comparison between sets was evaluated by comparing the maximum reading speed (MRS) for both BCMRC contextual sentence sets (CS1 vs CS2) and BCMRC random words sets (RW1 vs RW2). The reading speed of each sentence was calculated as number of correct words read in a minute (wpm). The reading speed was plotted against the print sizes to obtain the critical print size (CPS). The CPS was the smallest print size that gave the maximum reading speed before it plateaued within 1.96 standard deviation of the mean reading speed (Stifter et al., 2004). The maximum reading speed (MRS) was then determined as the maximum number of words that could be read by the participants in a minute, that is, the words per minute. The MRS was calculated as the mean reading speed from the print size of 1.1LogMAR (5M) to the critical print size (Maaijwee et al., 2008). The two largest and smallest print sizes were excluded as the reading speed was deviated from the constant rate (Legge, et al., 1985). Ethical approval and informed consent was obtained to examine 31 young adults with normal vision (mean age: 22.17±1.71 years). The sample size was calculated using G power version 3.1.9.2 based on reading outcome from previous findings (Alio et al., 2008). The alpha error of probability was set at 0.05; the effect size (d) was 0.71 and this gave the power of study of 0.87.

The inclusion criteria: habitual distance visual acuity (6/9 binocularly or better), remote near point of convergence (5±2.5cm) and amplitude of accommodation (18–1/3(age)±2D). The participants were asked to read from the largest to smallest prints of the sets. The testing distance was set at 40 cm. The sets were read binocularly under the illumination of 80-90 cd/m² with their habitual refractive error correction at random order. An inclined reading stand with a 45-degree angle was used to hold the chart. A blank card was used to cover before the reading speed evaluation to avoid pre-reading. The participants were asked to read the charts at normal speed aloud, with clear and precise pronunciation. The time taken to read until the smallest print size was recorded. The end point was more than 50% incorrect words of the smallest print size. Errors such as incorrect, substitution, reversal and omission were noted. The reading evaluation was recorded on audio tape.

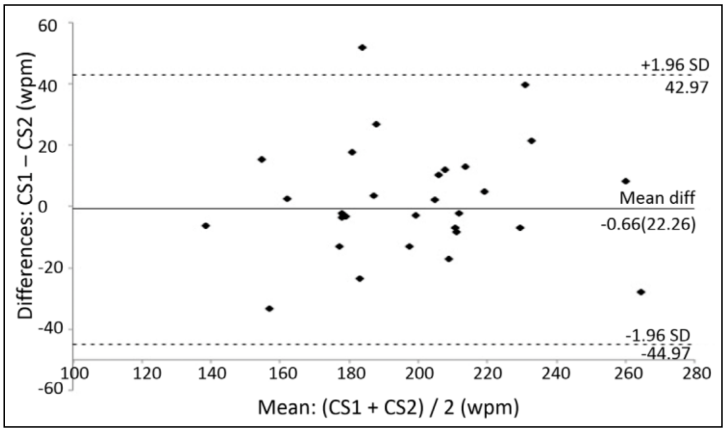
External Comparison of BCMRC

The external comparison involved two standard English reading charts [MNread acuity chart (MNread) and Bailey-Lovie words reading chart (Bailey-Lovie)]. The reliability test was performed between the contextual sentence set of BCMRC and MNread. The MNread was chosen because the contextual sentence reading chart was widely used in clinical setting and in research (Subramanian & Pardhan, 2006, 2009). The random words set of BCMRC was compared with Bailey-Lovie because the Bailey-Lovie was the standardised random word chart. Similar participants from the previous section continued reading the MNread and Bailey-Lovie at random. The testing distance was at 40 cm except for Bailey-Lovie, which was set at 25 cm as to comply with the recommended testing distance of each reading chart.

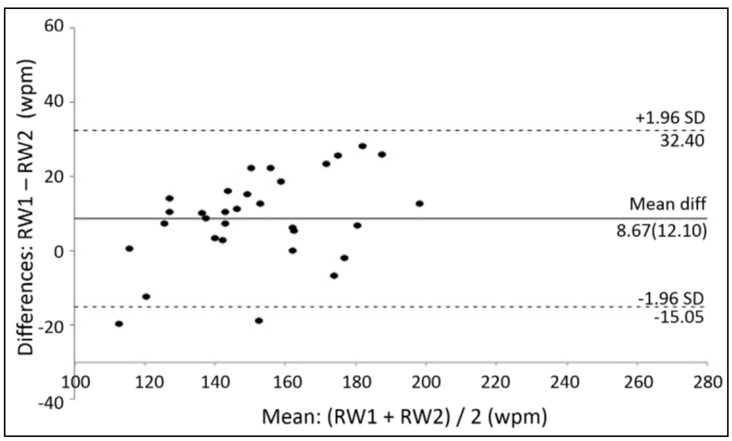
RESULTS

Internal Comparison of BCMRC

The internal comparison of MRS was examined between CS1 vs CS2 and RW1 vs RW2 using the independent sample t-test and intra class correlation coefficient (ICC). The significant level was set at 0.05(Kottner et al., 2011). ICC ranged between 0 and 1. The following rules of thumb were used in the interpretation of ICC values: > 0.9 – Excellent, > 0.8 – Good, > 0.7 – Acceptable, > 0.6 – Questionable, > 0.5 – Poor, and < 0.5 – Unacceptable (Gliem & Gliem, 2003). The agreements between charts were plotted using Bland and Altman plot (Bland & Altman, 1986; Bland & Altman, 1995). The mean difference between two variables and 95% limits of agreement as the mean difference of 1.96 standard deviation were calculated. The presentation of the 95% limits of agreement was for the visual judgement of how well the two variables agreed (Sedgwick, 2013). The reading speed for each print size was charted against the print size to obtain the critical print size (CPS) and maximum reading speed (MRS) of every set. MRS was 201.64±32.95 wpm for CS1 and 202.29±34.71 wpm for CS2. The difference in MRS was not statistically significant [t(60) = -0.08, p>0.05]. CPS was 0.3LogMAR (0.8M) for both CS1 and CS2. The agreement between CS1 and CS2 was well distributed within the lines of lower and upper limits of agreement in Bland and Altman plot [Figure 2(a)]. The mean difference was -0.66±22.26 wpm (95% CI: -17.85 to 16.54 wpm). The lower and upper limits of agreement ranged from -44.97 wpm (95% CI: -30.61 to -59.33 wpm) to 42.97wpm (95% CI: 57.33 – 28.61 wpm). The intra class correlation coefficient between CS1 and CS2 was found to be good (ICC=0.88). Good agreement and intra class correlation coefficient suggested that the two contextual sentence sets of BCMRC were homogeneous in evaluating the reading speed among young adults. The CPS for random words set of BCMRC was at 0.3LogMAR, which was equivalent to 0.8M or N6. The MRS for RW1 and RW2 were 156.30±24.92wpm and 147.63±20.08wpm respectively. The difference was not significant [t(60) = 1.51, p>0.05]. The agreement between RW1 and RW2 was also good with the mean difference of 8.67±12.10 wpm and 95% of confident interval range between -2.83 to 20.17 wpm [Figure 2(b)]. The lower limit of agreement was at -15.05 wpm (95% CI: -7.24 to -22.86 wpm) while the upper limit of agreement fell at 32.40 wpm (95% CI: 40.21 to 24.59 wpm). RW1 and RW2 showed good intra class correlation coefficient (ICC = 0.92).



(a)



(b)

Figure 2. The Bland and Altman plot for internal comparison of BCMRC: (a) CS1 versus CS2; and (b) RW1 versus RW2

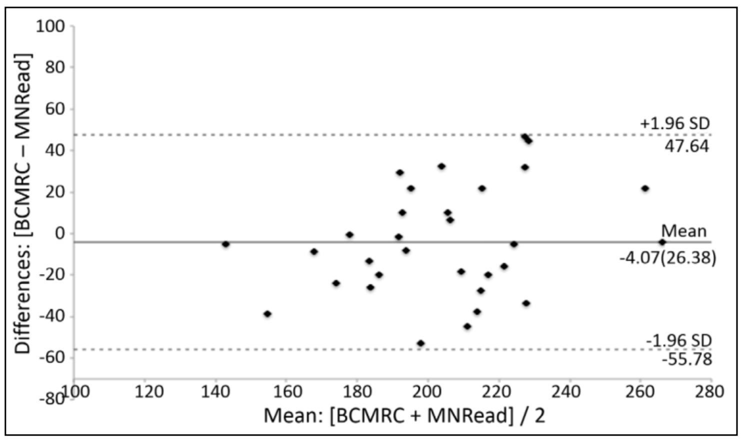
Figure 2. The Bland and Altman plot for internal comparison of BCMRC: (a) CS1 versus CS2; and (b) RW1 versus RW2

The differences of MRS were charted against the mean of MRS between two sets of BCMRC. The middle black line represent the mean difference in measurement of MRS between the two charts. The dashed-lines illustrated the upper limit of agreement (+1.96 SD) and lower limit of agreement (-1.96 SD).

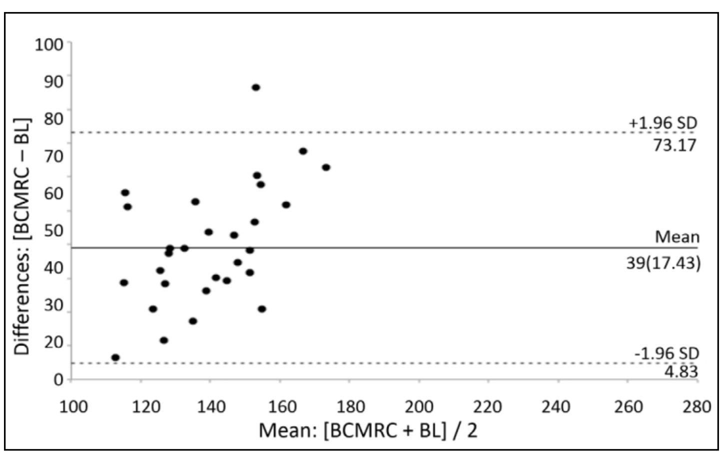
The differences of MRS were charted against the mean of MRS between two sets of BCMRC. The middle black line represent the mean difference in measurement of MRS between the two

External Comparison of BCMRC

The external comparison of BCMRC was tested with Cronbach's alpha (α). The MRS for BCMRC and MNread were 201.64±32.95wpm and 205.71±26.41wpm, respectively. Most of the data in Bland and Altman agreement plot between BCMRC and MNRead was fell within the lower limit of agreement and upper limit of agreement that ranged from -55.78 (95% CI: -38.77 to -72.79 wpm) wpm to 47.64 wpm (95% CI: 30.63 to 64.65 wpm) with a narrow mean difference, -4.07 wpm and 95% of CI ranged between -19.25 to 11.10 wpm [Figure 3(A)]. This indicated a good agreement between BCMRC and MNread. BCMRC had a good reliability with MNread (α= 0.76). Good reliability (α= 0.80) and good agreement [Figure 3(B)] between BCMRC and Bailey-Lovie was also demonstrated. The MRS was 156.30±24.92 wpm and 117.30±16.89 wpm for BCMRC and Bailey-Lovie respectively. The lower limit of agreement was 4.83 wpm (95% CI: -6.41 to 16.07 wpm) and upper limit of agreement was 73.17 wpm (95% CI: 61.93 to 84.41 wpm).



(a)



(b)

Figure 3. The Bland and Altman plot for external comparison of BCMRC: (a) BCMRC versus MNread; and (b) BCMRC versus Bailey-Lovie

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Figure 3. The Bland and Altman plot for external comparison of BCMRC: (a) BCMRC versus MNread; and (b) BCMRC versus Bailey-Lovie

The differences of MRS were plotted against the mean of MRS between two charts. The middle black line presents the mean of differences of measurement of MRS between two charts. The dashed-lines indicate the upper limit of agreement (+1.96 SD) and lower limit of agreement (-1.96 SD).

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DISCUSSIONS

Internal Comparison of BCMRC

The internal comparison of contextual sentence sets of BCMRC found that the CS1 and CS2 provided similar agreement between each other with a good ICC. The contextual sets of BCMRC used meaningful sentence to test the reading acuity and reading speed simultaneously. Reading charts that employed meaningful or contextual sentence were the MNread, Radner, IReST and UiTM-Mrw (Buari et al., 2014; Hahn et al., 2006; Mansfield et al., 1993; Radner et al., 1998). Among the mentioned contextual reading charts, MNread, Radner and IReST had more than one set of charts. Similar with internal comparison of CS1 and C2 in our study, MNread, Radner and IReST also showed good reliability between sets. Excellent reliability score was obtained in both MNread and Radner with Cronbach Alpha of 0.95 (Virgili et al., 2004) and 0.98 (Burggraaff et al., 2010; Maaijwee et al., 2008; Radner et al., 1998) respectively. Apart from reliability test, some other charts tested its inter-chart comparison with Pearson's correlation coefficient. Highly significant correlation coefficient was found in MNread (r=0.86 to 0.88) (Ahn et al., 1995; İdİl et al., 2011; Legge et al., 1989), Radner (r=0.98) (Burggraaff et al., 2010; Maaijwee et al., 2008; Radner et al., 1998) and also between sets in IReST texts (0.77 to 0.93) (Trauzettel-Klosinski & Dietz, 2012). Similar with BCMRC, MNread also had two sets of chart (İdİl et al., 2011; Mataftsi et al., 2013; Subramanian & Pardhan, 2006) and Radner had three sets of chart (Burggraaff et al., 2010). The earlier version of IReST had 10 sets of text for each of the four European languages and it was found that seven out of 10 texts were comparable (Hahn et al., 2006). The second version of IReST also consisted of 10 sets of text, but the choice of language was expanded up to 17 languages (Trauzettel-Klosinski & Dietz, 2012). Usually more than one set is available in the existing reading charts, so that they can be used interchangeably. The multiple sets are beneficial for the repeated measurements and rehabilitation sessions. Therefore, learning bias could be ruled out in the clinical setting.

The MRS outcome of CS1 and CS2 were 201 wpm and 202 wpm respectively. In comparison to the same construction of text design, that is, the contextual sentence, the MNread, Radner, IReST and UiTM-Mrw gave approximately similar outcome of MRS. The MRS was found to be 215 wpm in MNread (Legge et al., 1985), 211 wpm for Radner (Radner et al., 1998), 228 wpm for English IReST (Trauzettel-Klosinski & Dietz, 2012) and 200 wpm for UiTM-Mrw (Buari et al., 2014). Similar finding might be due to similar text choices, that is, contextual sentence. The construction of designs of BCMRC and UiTM-Mrw are different in the number of lines per print size despite using the same Malay language. UiTM-Mrw has varied number of lines. There are two lines of sentence for six print sizes (1.4LogMAR to 0.8LogMAR) and single line for the rest of the print sizes. In comparison, BCMRC has two lines for every print size available in the set. The varied number of lines in UiTM-Mrw is because it has varied number of words, that is, maximum of 10 words and minimum of six words for some of the print sizes. Standardisation has been made in BCMRC as in other established English reading charts (Mansfield et al., 1993; Radner et al., 1998) where a similar number word for every print size is chosen.

The random word sets of BCMRC also show no significant difference in MRS between RW1 and RW2. The sets are in agreement and have good intra-class correlation coefficient. The random words set available reading charts are the Bailey-Lovie (Bailey & Lovie, 1980), PNAC (Wolffsohn & Cochrane, 2000), UiTM-Muw (Buari et al., 2015), VSRT (Watson et al., 2010) and RRT (Wilkins et al., 1996). Among the published random words reading charts, only Bailey-Lovie, VSRT and RRT have more than one set. The Bailey-Lovie is among the pioneer random words set of progressive log-scale reading chart that is designed in five sets. The comparison between sets is not published elsewhere, but the features have been described in a previous study (Bailey & Lovie, 1980). The VSRT has three sets, which contain five print sizes from 4M to 1M. The VSRT is a combination of single letter, short word (two to three letters per word) and compound words for every print sizes (Watson et al., 2010). The RRT has two sets with the highest number of words, which is, 150 words in comparison with other types of charts. It is a non-progressive logarithmic random words chart that contains single print size. The correlation coefficient is good between these 2 sets (r=0.83) (Wilkins et al., 1996). As comparison in our random words sets of BCMRC, it is designed as a progressive logarithmic chart from largest print size to the near acuity threshold print size. The BCMRC in this study controlled the number of words and the number of lines to make it similar between every print size. The outcome of MRS by RW1 and RW2 of BCMRC were 156 WPM and 147 wpm respectively. These outcomes are a bit higher than RRT as they found the reading speed of 99 wpm (Wilkins et al., 1996). The differences might be due to different sample size, which this study investigated among normally sighted young adults, but Wilkins et al. (1996) tested the RRT among school children of grade 4 to 6. The reading speed of children was proven to be lower than young adults. Furthermore, BCMRC was is short sentence reading chart while the RRT is a long passage reading chart. The reading speed for random words was found to be within 69 to 135 wpm among Malay native speakers (Buari et al., 2015; Omar & Mohammed, 2005).

Having more than one chart would be an advantage to minimise the learning effect during repeated measurements. However, both charts should offer similar outcomes, thus, the evaluation of reading speed is reliable.

External Comparison of BCMRC

The MRS of BCMRC was compared with the standardised English version of reading charts. Each contextual sentence and random words set of BCMRC was selected in this external comparison. The contextual sentence of BCMRC was compared with contextual sentence reading chart (MNread). The BCMRC had a good reliability and agreed with MNread. The random words of BCMRC was also reliable and was in agreement with Bailey-Lovie. A comparison between newly developed reading charts with published reading charts was done in several previous studies (Buari et al., 2015; Buari et al., 2014; Wolffsohn & Cochrane, 2000). The limits of the agreement were calculated based on d± 1.96s, whereby, d was the mean difference and s was the standard deviation of the mean difference. From the calculation, the limits of the agreement were between 1.96 of ±26.38 wpm and ±17.43 wpm for contextual sentence set and random words set respectively. Previous study recommended calculating the CI of both limits of agreement, as the limit was only estimation (McAlinden et al., 2011). When the limit is wide, it may be due to small sample size (McAlinden et al., 2015). The confident interval for mean difference, lower limit of agreement and upper limit of agreement indicated a possible error in estimation (Giavarina, 2015). However, 95% of confidence interval that was calculated from standard error and t value for degree of freedom was found to be ±17.01 wpm for contextual sentence set and ±11.24 wpm for random word set in the study. Inter-chart comparison of MNread for young adults and low vision patient showed the mean difference of 8.6 wpm and 2 wpm respectively (Patel et al., 2011; Subramanian & Pardhan, 2006). Both studies did not mention the 95% of CI for upper and lower limits of agreement. However, it was stated that when the bias falls within the limit of the agreement, then a good agreement is achieved (Subramanian & Pardhan, 2006). Other studies that measured the agreement between two charts showed the limits of agreement ranged between -46.5 wpm to 58.3 wpm (Buari et al., 2014). The agreement of 3 Radner charts were ranged between -16.11 wpm to 32.17 wpm (Stifter et al., 2004). Although the mean difference is not zero, the 95% confidence interval contains zero, thus no practice effect exists.

The PNAC was compared with Bailey-Lovie (Wolffsohn & Cochrane, 2000), the UiTM-Mrw and UiTM-Muw were compared with MNread and Colenbrander reading chart (Buari et al., 2015; Buari et al., 2014). The PNAC was found to be highly correlated with Bailey-Lovie. However, the time to measure the near acuity was found faster with PNAC as compared with Bailey-Lovie. This might be because PNAC employs short words which contain three words per print size. In comparison, Bailey-Lovie, comprises two words (1.6 LogMAR to 1.4LogMAR), three words (1.3LogMAR to 1.1LogMAR) and six words (1.0LogMAR toward 0.00LogMAR) (Bailey & Lovie, 1980). The UiTM-Mrw was found to be comparable and highly agreeable with MNread and Colenbrander because all tested charts use contextual sentence reading charts.

The reading speed of UiTM-Mrw differ and have weak agreement with MNread and also Colenbrander (Buari et al., 2015). The differences in reading speed could be due to different text construction; the UiTM-Mrw is designed with low syntactic and semantic cues, but both MNread and Colenbrander use contextual sentences. Comparing the reading speed between the contextual sentences and random words reading chart might give different outcomes of the reading speed. A different brain processing image pattern is shown in reading poor lexico-semantic fit words in both strong and weak constraint sentences (Hoeks et al., 2004). The message-level and lexico-semantic information is the main component of the reading process to understand the meaning of sentences that may lead to an increase in the reading time and comprehension. Increased reading time might be due to the increase of preview duration that happen in low contextual constraints of target words (Li et al., 2017).

External comparison of the newly developed and established reading chart might give an overview of design and its application in relation to established reading charts. It might be beneficial to have a standardised and good construction of reading chart with the language that can be used among the native speakers of that language. The fluency of reading with different languages might be biased in the evaluation of the reading speed. Several established reading charts have also been constructed with different languages to serve patients with different preferable speaking or reading language.

In conclusion, the Buari-Chen Malay reading charts display good internal and external comparisons and is recommended for the clinical evaluation of reading performance for Malay language native speakers.

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