Estimating the reading time of Familiar and Non-Familiar words

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Abstract

Reading time is worth estimate in many contexts of engineering design such as the directional sign presented on narrow space, the design of technology interface in car for user to read while driving, or process simulation of people evacuate from any disaster that need to read some word sign. While the majority of researches in this area have been focusing on the development of reading skills, where traditional study were relied on reading speed to apply on word reading time. Thus, the purpose of this study was to estimate the reading time of familiar and non-familiar words concerning individual differences in term of IQ level. A total of 59 Thai natives participated in this study. Results provided reading time estimating equations and pattern of reading time. Implications for designers are discussed.

Keywords
Familiar word, Non-Familiar word, Reading speed, Normal reading, Information design

1. INTRODUCTION

Reading is the process of searching for meaning from written characters as presented on technology, sign, or media for understanding both intellectual, emotional, and social information. Especially in public communication, text message or keywords are greatly used as a main communication channel (Lyxell et al., 2008).

Reading time is worth estimate in many contexts of engineering design such as the directional sign presented on narrow space, the design of technology interface in car for user to read while driving, or process simulation of people evacuate from any disaster that need to read some word sign (Vorst, 2010). Research showed that people spend long periods reading the words from the disaster sign due to non-familiar word or long difficult word, which could lead to slow evacuation from hazardous areas (Oskamp, 1995), etc. If the word reading time could be accurately estimated, this would imply for more practical and realistic design of the space of venue that match with the flow rate of people when reading or the improvement of information design that make people effectively read the information.

Majority of reading studies are focusing on developing reading skills (Aghababian & Nazir, 2000; Grellet, 1986) and measuring reading time in context of paragraph base (Cirilo & Foss, 1980; Kintsch & Keenan, 1973) which was resulting in unit of number of words per minute. While the reading time estimation from people reading speed calculated from paragraph base may differ to single word reading speed due to different level of semantic processing (Jackson & McClelland, 1979). Moreover, the effect from level of familiarity may play a big role on single word reading time.

Familiar words refer to words that most people have seen or encountered, heard through reading or listening (Patterson & Hodges, 1992). While, non-familiar words refer to words that most people are not Familiar with, or have not seen or read before (Graesser, Hoffman, & Clark, 1980). Previous study reported that subjects took longer time reading non-familiar word than familiar word significantly (Stanovich, 1984). While the estimation of reading time of familiar and non-familiar words remains underdeveloped.

Beside from level of familiarity, literature also revealed that IQ effects on individual reading speed. People with high IQ could process and respond faster than those with lower IQ (Postlethwaite & Ross, 1992). Thus, the objective of present study is to estimate the reading time of familiar and non-familiar words concerning individual differences in term of IQ level. The result from this study would provide benefit for engineers who need reading time estimation of words for conducting simulation or support any process design when people encounter with word reading scenario such as warning sign, directional sign.

2. METHODOLOGY

2.1 Participants

Participants in the study were 59 Thai natives from Bangkok metropolitan area. Their age ranged from 20 to 55 years old (M = 31.14, SD = 9.66). All participants have normal vision. 49.15% were male and 50.85% were female.

2.2 Stimulus material

2.2.1 IQ Intelligence test

IQ intelligence test used in this study is the standard intelligence test for adults consists of twenty-five items. Score ranged from 0 to 25, which has a score of 1 point per question item as shown in Figure 1 (Carpenter, Just, & Shell, 1990; Raven, 2003).

2.2.2 Reading speed test

Reading speed test were conducted by providing 2 general topic articles which is about history of the Olympic games, and symbol of the Olympic games, presented with black 20 TH Sarabun New font. These two articles have 363, and 354 words, respectively. Participants were asked to read as fast as possible since time was recorded, and were asked to answer 3 questions regarding to the paragraph to confirm their understanding. Average reading time were calculated from 2 articles and convert to reading speed as second per word (Kershner, 1964).

2.2.3 Familiar and non-familiar word

Fifty Thai words for each familiar and non-familiar words for used in the experiment to assess participants reading time. Familiar were selected from questionnaire and interview. Non-familiar word were selected from questionnaire and interview. Each group of familiar word and non-familiar word were classified into 3, 5, 7 syllables for testing.

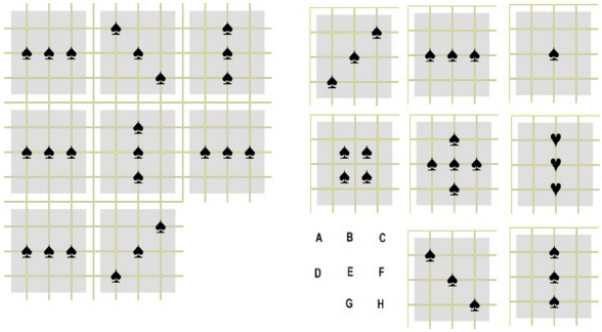

Figure 1. IQ Intelligence Test (Carpenter, Just, & Shell, 1990; Raven, 2003)

2.3 Apparatus

A private closed room was set with the facilities and without noise. Familiar word and non-familiar word was presented by software on a laptop with monitor screen 4K Ultra HD, 65 inches for testing.

2.4 Measurement

2.4.1 Reading Time

Reaction time were used to record reading time of each word in this study. Time were start counting when word was presented on the screen and stop when participant press stop button on keyboard, then word was disappeared after the stop button was pressed. After stop the time, participant were asked to write down reading word such as star is sa-tar.

2.5 Procedure

Prior to begin the experiment, participants were given a brief explanation of the purpose of research and were asked to read and sign a consent form for their participation. Demographic questionnaires were then completed. Participants were asked to complete intelligence tests and reading speed tests.

After completed all IQ intelligence test and reading speed test, participants were explained the instruction of the experiment that there would be a word randomly presented on the monitor screen which the time is start recording. Participant have to read a word as fast as possible and press stop button on keyboard to stop the time recording which will make the word on screen disappear. Then, participants were ask to write down reading word such as star is sa-tar. Once participant complete each word press next button for the next word showing up on screen. This process was repeated until participants finished all 100 words. They were thanked, received gifted, and dismissed

3. RESULTS

3.1 IQ intelligence test score

Participants in this study showed significant differences in their IQ intelligent scores which can be used to separate participants into 2 groups based on their scores as shown in Figure 2 ($t(47.327) = 18.033$, $p < .001$). The high IQ score group ($N = 30$, $M = 17.83$, $SD = 2.614$) had significantly higher IQ score than those in low IQ score group ($N = 29$, $M = 7.79$, $SD = 1.544$).

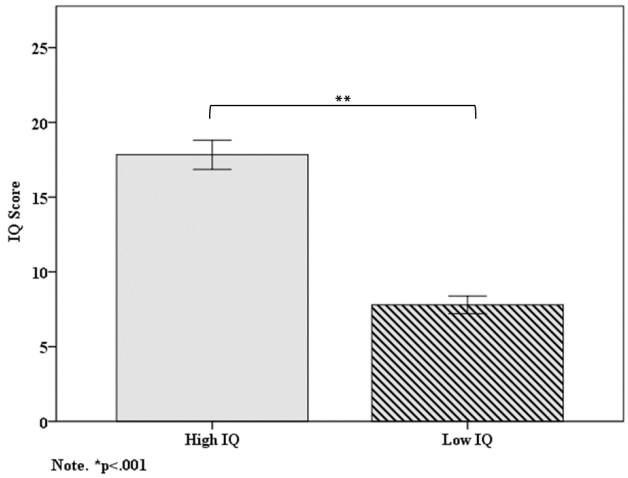

Figure 2. Means and Standard deviation of participants IQ intelligence test scores in high IQ score group and Low IQ score group

3.2 Reading speed test

The descriptive statistics of reading speed of each article and groups of IQ score was shown in Table 1. A two-way ANOVA of article and groups of IQ score was conducted on reading speed. The results showed that there were no significant main effect of articles and group of IQ score and its interaction.

3.3 Reading Word Test

The descriptive statistics of word type, syllables, and groups of IQ score on word reading time were presented in Table 2. A three-way ANOVA was conducted with word types, syllables, and groups of IQ score on word reading time.

There was significant main effects of word type ($F(1,5888) = 857.675$, $p < 0.001$), showing that participants spent significant longer time for reading non-familiar word than familiar word. There was also significant main effect of syllable ($F(2,5888) = 466.870$, $p < 0.001$), showing that participants spent significant longer time for reading word of 7 syllables than 5 syllables and 3 syllables ($p < .001$), and spent longer reading time for 5 syllables than 3 syllables ($p < 0.001$). Moreover, the main effect of groups of IQ score also showed significant differences ($F(1,5888) = 619.218$, $p < 0.001$) that participants in high IQ score group took shorter reading time than those from low IQ score group.

The results of interaction effect of IQ group × word types showed significance on reading time ($F(1, 5888) = 15.928$, $p < 0.001$). Post hoc analysis (LSD) of IQ group × word type interaction effect showed that participants in high IQ group took significantly shorter reading time than those in low IQ group on familiar words ($p < .000$) and non-familiar words ($p < .000$). Also, participants from both low IQ group and high IQ group took significantly shorter reading time on familiar words than non-familiar words ($p < .000$).

Table 1: Descriptive statistics of reading speed (second) of each article by groups of IQ score.

Group	Type of article			
	Article 1		Article 2	
	N	Mean (SD)	N	Mean (SD)
High IQ	30	4.64 (0.67)	30	4.32 (0.59)
Low IQ	29	4.68 (0.76)	29	4.78 (0.89)

Table 2 : Descriptive statistics of word types, syllables, and groups of IQ score on word reading time (ms).

Time of Reading Words of High IQ				
Word Type	Number of Syllables	N	Mean	SD
Familiar	3	540	810.59	513.91
	5	450	996.18	944.32
	7	510	1387.16	980.79
Non-Familiar	3	480	1182.47	1154.55
	5	540	2239.06	1531.04
	7	480	3325.63	2308.11
Time of Reading Words of Low IQ				
Word Type	Number of Syllables	N	Mean	SD
Familiar	3	522	1618.20	1000.47
	5	435	1894.92	1216.27
	7	493	2615.69	1248.03
Non-Familiar	3	464	2054.59	1242.31
	5	522	3451.59	2013.29
	7	464	5297.09	4337.02

The results of interaction effect of IQ group × number of syllables showed significance on reading time (F (2, 5888) = 23.391, p < 0.001). Post hoc analysis (LSD) of IQ group × number of syllables interaction effect showed that participants in high IQ group took significantly shorter reading time than those in low IQ group for reading word of 3 syllables (p < .001), 5 syllables (p < .001) and 7 syllables (p < .001), respectively. Also, participants in low IQ group took significantly longer reading word of 7 syllables than 5 syllables and 3 syllables (p < 0.001), and spent longer reading time for 5 syllables than 3 syllables (p < .001), and high IQ group took significantly longer reading word of 7 syllables than 5 syllables and 3 syllables (p < .001), and spent longer reading time for 5 syllables than 3 syllables (p < .001).

The results of interaction effect of word types × number of syllables showed significance on reading time (F (2, 5888) = 139.183, p < 0.001). Post hoc analysis (LSD) of word types × number of syllables interaction effect showed that participants spent significantly longer time for reading non-familiar word than familiar word for reading word of 3 syllables (p < .001), 5 syllables (p < .001) and 7 syllables (p < .001). Participants reading familiar word spent significantly longer time for reading word of 7 syllables than 5 syllables and 3 syllables (p < 0.001), and spent longer reading time for 5 syllables than 3 syllables (p < .001), and non-familiar spent significantly longer time for reading word of 7 syllables than 5 syllables and 3 syllables (p < 0.001), and spent longer reading time for 5 syllables than 3 syllables (p < .001).

The results of interaction effect of IQ group × word types × number of syllables showed significance on reading time as presented in Figure 3 (F (2, 5888) = 4.496, p < 0.001). Post hoc analysis (LSD) of IQ group × word type × number of syllables interaction effect revealed that participants in high IQ group spent significantly longer time for reading non-familiar word than familiar word for reading word of 5 syllables (p < .001), and 7 syllables (p < .001), while reading word of 3 syllables was not significant differences, and participants in low IQ group spent significant longer time for reading non-familiar word than familiar word for reading word of 5 syllables (p < .001), and 7 syllables (p < .001), while reading word of 3 syllables was not significant differences.

Also, participants in high IQ group spent significantly longer time for reading word of 7 syllables than 5 syllables and 3 syllables (p < 0.001), and spent longer reading time for 5 syllables than 3 syllables (p < .001) for both familiar and non-familiar words, as well as participants from low IQ group spent significant longer time for reading word of 7 syllables than 5 syllables and 3 syllables (p < 0.001), and spent longer reading time for 5 syllables than 3 syllables (p < .001) for both familiar and non-familiar words.

The correlation analysis of familiar and non-familiar word reported that there was little correlation between the independent variables with an r value less than 0.7, which did not cause problems of multicollinearity. The results of correlation analysis were reported in Table 3 and Table 4, respectively.

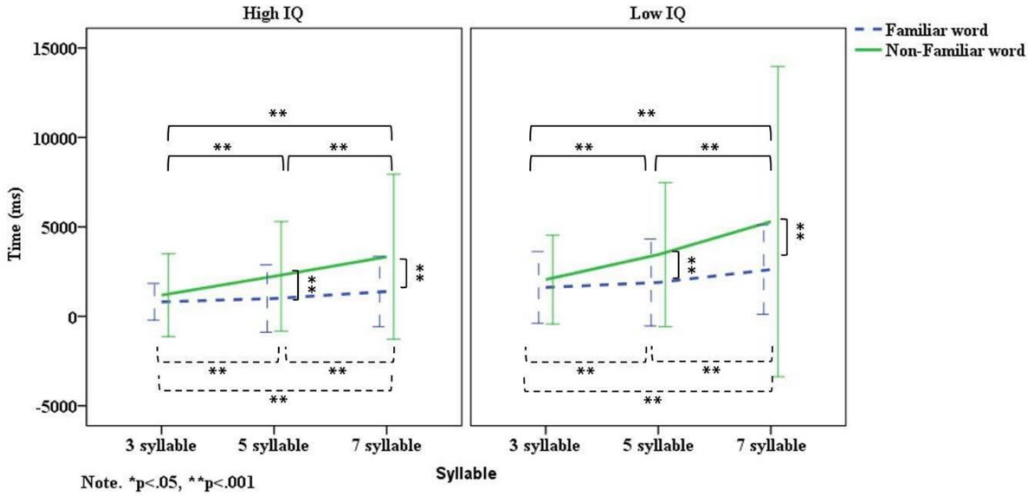

Figure 3. Interaction effect of Word type × Number of syllables × IQ group on reading time

Table 3: Correlation analysis of independent variable on familiar word reading time

Variable	Mean	SD	1	2
Time (ms)	1543.04	1167.97	.280**	-.448**
Predictor variable				
1. Number of syllables	4.96	1.67	-	0.00
2. IQ Score	12.90	5.45		-

*p<.05; **p<.01

Table 4: Correlation analysis of independent variable on non-familiar word reading time

Variable	Mean	SD	1	2
Time (ms)	2910.47	2661.16	.403**	-.258**
Predictor variable				
1. Number of syllables	5.00	1.60	-	0.00
2. IQ Score	12.90	5.45		-

*p<.05; **p<.01

The multiple regression analysis revealed that two independent variables focused in this study, IQ scores and number of syllables, together explained the speed of reading familiar word and non-familiar by 28 and 23 percent, respectively as reported in Table 5 and Table 6 respectively.

The equation for predicting familiar word reading time is shown as follows. Where $Y_{familiar}$ represents the predicting reading time of familiar words (ms), X_1 represents IQ score of reader, and X_2 represents numbers of syllable of target familiar word.

$$Y_{familiar} = 1812.435 - 95.939X_1 + 195.173X_2 \quad (1)$$

The equation for predicting non-familiar word reading time is shown as follows. Where $Y_{non\text{-}familiar}$ represents the predicting reading time of non-familiar words (ms), X_1 represents IQ score of reader, and X_2 represents numbers of syllable of target non-familiar word.

$$Y_{non\text{-}familiar} = 1182.429 - 126.09X_1 + 670.878X_2 \quad (2)$$

Table 5: Multiple regression analysis of independent variable versus reading time of familiar word.

Variable	B	SEB	Beta
Constant	1812.435	71.694	
IQ Score	-95.939	3.354	-.448**
Number of Syllables	195.173	10.923	.280**

Note. R^2 = .28; F (2,2947) = 568.841, p<.001

*p<.05; **p<.001

Table 6: Multiple regression analysis of independent variable versus reading time of non-familiar word.

Variable	B	SEB	Beta
Constant	1182.429	174.077	
IQ Score	-126.090	7.897	-.258**
Number of Syllables	670.878	26.890	.403**

Note. R^2 = .23; F (2,2947) = 438.695, p<.001

*p<.05; **p<.001

Comparative graph between predicting word reading time from equations, actual reading time from experiment, and participant's reading speed were plotted in Figure 4. The results revealed that estimated reading time of 3 syllables (short word) by equation were much more differences from using reading speed, while the time estimate of familiar and non-familiar word were approximately similar. People with lower IQ scores took longer time to response on reading word. The effect of familiar and non-familiar word on reading time were getting higher on 5 syllables and 7 syllables.

The estimate reading time for 5 syllables started to show some differences on reading time of familiar and non-familiar word. People with lower IQ scores took longer time to response on reading word. However, both predicted reading time by equations were still lower than the time we calculated from the reading speed.

The results of reading time for 7 syllables showed a difference in word reading time of familiar and non-familiar words. In the same tendency, people with lower IQ scores took longer time to response on reading word. While the estimate non-familiar word reading time of people with low IQ scores (range 6-10) were close to the time obtained from the reading speed.

4. DISCUSSIONS & CONCLUSIONS

This study aimed to estimate the reading time of familiar and non-familiar words concerning individual differences in term of IQ level. Results provided the estimate reading time equations that showed more accurate results to the time obtained from the experiment than using traditional reading speed. The results revealed that people reading time have an effect from both medium, such as word familiarity and number of syllables of word, as well as an individual differences in term of IQ level.

The results from reading speed test showed contradictory to the literatures that IQ have effect on people reading speed (Whitaker & Stacey, 1981). This might be explained that the article used to assess reading speed in this study are general topic article, while IQ showed effect on reading word test that participants from high IQ group took shorter time in reading word than those from low IQ group.

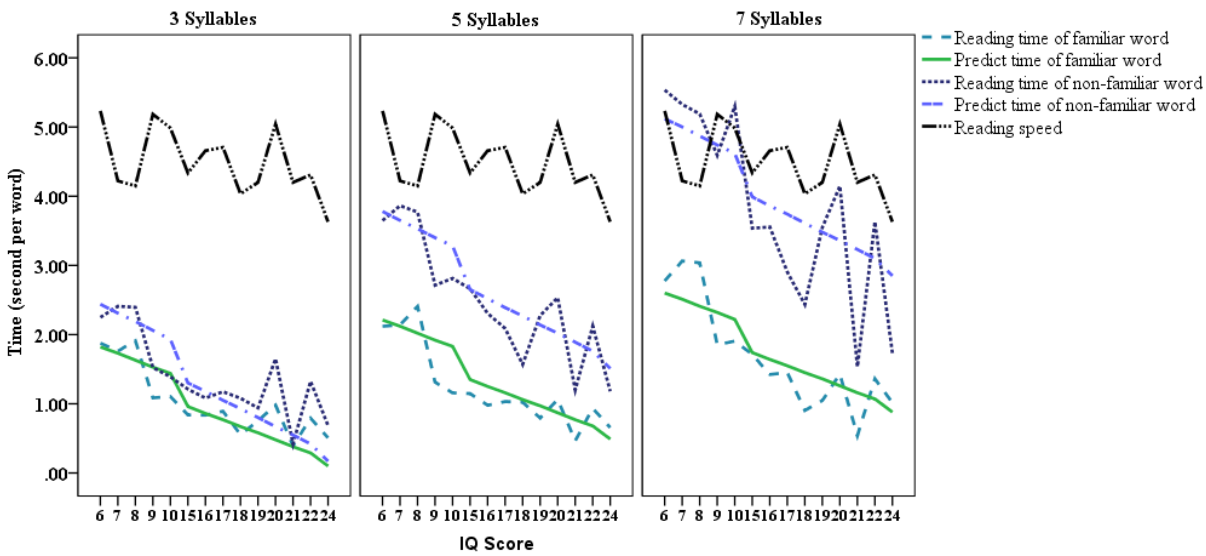

Figure 3. Comparative graph between predicting word reading time from equations, actual reading time from experiment, and participant's reading speed in dimensions of word syllables and IQ scores

There were some patterns in the results as showed in figure 3. Firstly, the pattern of word reading time between low IQ group and high IQ group are same pattern. The time used for 3, 5, and 7 syllables of familiar words were slow rising, respectively, which mean there were low effect of syllable of familiar word on word reading time, while the time spent for 3, 5, and 7 syllable of non-familiar words showed much greater slope. Participants used reading time even longer time for long non-familiar word which imply difficulty in reading.

Although the R^2 of predicting equation of word reading time were not much high, the time estimates by equations provide approximately word reading time that are closer to actual time that participants used to read words in the experiment than the traditional way of using people reading speed as showed in figure 4 in this study. This could be used in engineering design to be more accurate to what actual people spend time reading word such as public space simulation. However, since the results showed that people with low IQ may take longer time in reading word, the design that used in public should take this issue in concern and apply the longer time condition to simulation so that everyone in society could achieve with design goal. As well as an implication to designer who design the word sign for people to read to be concern the size of short-long word that may have an effect on people reading time that are measurable.

There were limitations regarding the scope of this study. Participants were limited to people in Bangkok metropolis only and the number of familiar and non-familiar words that are limited. Further studies should include a more diverse group of people related to age, gender, education, and cultures, including the number of words and syllables for more accurate estimating word reading time

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Biographies

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