Making Reading from a Tablet Computer Easier for Older People in Thailand and the UK: Effects of Text and Background Colours

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Abstract: This study investigated the effects of text and background colour on tablet computers on reading performance and preferences for older and younger readers from two countries, Thailand and the UK. In the UK, 30 older (65 to 85 years) and 30 younger (18 to 23 years) participants took part; in Thailand 20 older (60 to 71 years) and 20 younger (20 to 23 years) participants. Participants skim read texts on a tablet computer presented in five combination of text and background colours (black text on white background, white on black, black on buff, sepia on buff and black on light blue) and answered multiple-choice questions about each text. Reading time and comprehension were measured and preferences for text/background colour combinations. Older participants in both countries took significantly longer to read the texts than younger participants and in Thailand older participants answered significantly fewer questions correctly than younger participants. However, the colour combinations had no significant effects on performance measures. On preferences for colour combinations, only the younger UK participants expressed significant trends, preferring and black/buff and black/light blue. Further research with larger samples of participants is needed to determine whether there are any clear preferences for text/background colour combinations in each country. In the meantime, black text on a pale background, either white, buff or pale blue can be recommended for presenting text on tablets to both older and younger readers in both countries.

1 INTRODUCTION

With the explosion of personal ICT devices, more and more information and services are being provided online. For example, in the United Kingdom (UK), the National Health Service (NHS) now provides an extensive website with information about medical conditions and medicines, where to access different services and even an online medical advice service (www.nhs.uk has over 500 pages of information). Similar services exist in many other countries. Increasingly this medium for providing information and services is the norm, with other channels such as paper leaflets, telephone helplines and face-to-face advice, becoming rarer.

Being able to access such information, particularly health and medical information, is very important for older people. However, to do so they need to be comfortable with the ICT devices and able to easily read the information provided. Older people are rapidly becoming more comfortable with using the Internet. For example, for the 65 to 74 age group

in the UK, Internet usage increased from 52% in 2011 to 80% in 2018 (Office for National Statistics, 2018b). Although Internet usage by older people may be lower in less developed countries, it is also increasing. In Thailand, Internet usage by people aged 50 and over increased from 6.2% in 2012 to 13.8% in 2016. In both countries older people are also now more likely to access the Internet using portable devices (i.e. smartphones, tablet computers) than by desktop computers. For example, in the UK, tablets are now the most popular device for accessing the Internet for people over 65 (Office for National Statistics, 2018a) Older people in Thailand are also more likely to access the internet using a mobile device (Electronic Transactions Development Agency, 2015; 2016).

However, little is known about how to best present text for older people to read it most easily on tablets. Some research has shown that older people do have some problems when using tablets, but little research has investigated how best to present text on tablets for older users. Therefore the research

presented in this paper investigated one aspect of the presentation of text on tablets for older users, that of the colour of text and background. As the effects of these variables may vary between languages using different orthographic systems and between user groups with different levels of experience with tablets, we conducted the research in two countries, Thailand and the UK.

2 RELATED WORK

There is a small body of research on older users' attitudes and performance with tablets from a range of countries. Jayroe and Wolfram (2012) compared interaction with an iPad tablet and a desktop computer for older Americans (67 to 87 years). Participants were interviewed after undertaking tasks on the Web such as finding a weather forecast and looking for information about glaucoma. Participants reported being more comfortable using the tablet than a desktop computer due to its portability, efficiency, ease of use and speed. However, participants encountered a number of problems, particularly with the iPad onscreen keyboard.

Werner et al. (2012) evaluated the usability and acceptance of an iPad for Austrians aged over 60 years (mean age 71). As in the Jayroe & Wolfram study, participants were asked to perform a number of tasks (only with an iPad), including a medical information task and were interviewed. All participants reported that the tablet was very easy to use, although only half would choose a tablet over a desktop computer. However, a number of problems were encountered, particularly with gesture controls such as the "pincer" movement for zooming in or out.

Barnard et al. (2013) studied the first use of tablets by older people in the UK (58 to 78 years). Participants undertook simple tasks such as sending an email and some encountered problems. For instance, the labelling of some controls was too small and the correct timing and right pressure of taps on the screen was difficult to achieve.

Findlater et al. (2013) compared the performance of older (61 to 86 years) and younger (19 to 51 years) American participants on typical actions (pointing, dragging, crossing and steering) on an iPad and desktop computer. Older participants were slower on both devices, but the performance gap, on both speed and errors, was smaller on the tablet. Older participants also rated the tablet as easier to use.

Chatrangsan and Petrie (2017) investigated the usability and acceptability of tablet for older participants in the UK (65 years and over) and in Thailand (60 years and over). Participants undertook two tasks with different websites on a tablet while producing a verbal protocol and were then interviewed. All participants were able to complete the tasks and had positive attitudes about using tablets. Some participants reported that they thought a tablet is easier, faster and also more convenient to use than a desktop computer. However, a number of problems were encountered such as text being too small and colour contrast between text and background being not sufficiently clear.

These studies show that while older people are generally positive about tablets, they do encounter a range of usability problems that clearly relate to their age: gesture control that requires good timing and pressure control, small labels and text, and insufficient colour contrast in labels and text.

Only three recent studies could be found that have investigated the issue of colour contrast in digital presentations for older users, although not necessarily in relation to tablet devices and two of those studies did not use a reading task. One source of information about colour combinations for digital presentations is guidelines about web design for older people. Numerous sets of guidelines have been developed, but they are now outdated as their recommendations probably relate to desktop computers whose screens lacked the colour palettes and fine resolution of current tablet screens.

Nine sets of such guidelines made recommendations on text and background colour (AARP, 2004; Agelight; 2001; Holt, 2000; NIA/NLM, 2002; SPRY, 1999; SilverWeb – Kurniawan and Zaphiris, 2005, Zaphiris et al. 2007, 2009; Webcredible, 2006; Zhao, 2001). Six sets of guidelines recommend using dark text on a light background (Agelight, Holt, NIA/NLM, SPRY, Webcredible, Zhao). Two sets of guidelines also mention that "reverse contrast" can be used, a light text on a dark background (Holt, NIA/NLM). Two set of guidelines mention only that strong contrast between text and background should be used (ARRP, SilverWeb). Two sets of guidelines also mention that off-white rather than pure white is a better background (SilverWeb, Webcredible). Kurniawan and Zaphiris (2005, see also Zaphiris et al., 2007, 2009) also made more detailed recommendations, proposing four guidelines including that blue and green tones should be avoided; background screens should not be pure white or change rapidly in brightness; and there should be high contrast between foreground and background, for example, coloured text on coloured backgrounds should be avoided.

A more recent set of guidelines has been produced by Loureiro and Rodrigues (2014) in this case for older users using multi-touch interfaces. They recommended that blue and yellow or red and green tones should be avoided and that high contrast between interface elements should be used.

Returning to the recent studies empirically investigating colour combinations, Huang et al. (2013) investigated the effect of colour for Chinese text displayed on an iPad with younger (20 to 30 years) and older (over 60 years) Taiwanese participants. The participants did not read the texts but made forced choice comparisons between two layouts with different text/background colours. Interestingly, the experiment took place in a dark room with only the light from the iPad, not a typical reading situation. In a first experiment, the text and background colours were presented in greyscale combinations from black to white. The older participants preferred stronger contrast combinations, while the younger participants preferred medium contrast. In a second experiment, text was presented in black, medium grey or white with a wide range of colours as background. Again, the older participants preferred strong contrast combinations while the younger participants preferred medium contrast.

Kamollimsakul (2014) investigated the effect of text and background colour on skim reading webpages from a laptop for younger and older participants in Thailand (19 to 29 years and 59 to 70 years) and in the UK (18 to 36 years and 66 to 79 years). Colours combinations were black text on white background, white on black, and sepia on off-white. Colour had no effect on either younger and older participants in either country on performance, however older participants preferred black on white and younger participants preferred that combination or sepia on off-white. Both groups liked white on black the least.

Yamazaki and Eto (2015) conducted an experiment on different background colours on tablet screens with Japanese participants over 65 years. Rather than reading, participants performed a circle counting task on a tablet with a white, blue and light blue background with the circle presented in black. The mean number of correct answers was higher with blue and light blue. Participants felt they were able to concentrate better and were least tired when counting black circles on a light blue background colour.

Given the sparse research on the effects of text and background colour combinations on reading from tablets for older people, this study investigated the effect of text and background colour on reading performance and preferences computer for both younger and older people in Thailand and the United Kingdom.

3 METHOD

3.1 Design

The study was undertaken in both Thailand and the United Kingdom. Data from each country was statistically analysed separately as the typefaces used in the two countries were not exactly the same (see section 3.3) and the readability of the texts may not be exactly the same in English and Thai (see section 5), although comparisons between the countries will be made. In each case, a Latin Square mixed experimental design was used with one key between participants variable and one key within participants variable. The between participants variable was Age Group (younger and older people). The within participants variable was Colour Combination (Black text on White background, White on Black, Black on Buff, Sepia on Buff and Black on Light Blue). The choice of combinations was made on the basis of two factors: that there be good contrast between text and background; and the colour combinations had been previously recommended or researched for older participants. Three dependent variables were measured: reading time (in seconds), the number of correct answers on comprehension questions and participants' preferred colour combination.

Each participant was asked to skim read five short texts presented on a tablet, one with each combination of text and background colours. The order of presentation of the texts and the colour combination were counterbalanced to avoid practice and fatigue effects. Skim reading was chosen as the task, as this is commonly what people do on websites and previous research has found this less tiring in experiments for older participants (Kamollimsakul, 2014).

3.2 Participants

100 participants took part in the study, 40 in Thailand and 60 in the UK. In Thailand, there were 20 older and 20 younger participants, all native Thai speakers. The older participants consisted of 5 men and 15 women, their ages range from 60 to 71 years (mean: 64.9 years). The younger participants consisted of 7 men and 13 women, their age ranged from 20 to 23 years (mean: 21.7 years). No participant had any colour vision deficiency problems.

In the UK, there were 30 older and 30 younger participants, all native English speakers. The older participants consisted of 13 men and 17 women, their ages ranged from 65 to 85 years (Mean: 71.2 years). The younger participants consisted of 13 men and 17 women, their ages ranged from 18 to 23 years (mean: 19.7 years). Two of the younger participants had mild red-green colour vision deficiency (this would not affect their perception of any of the colour combinations in the study).

Of the Thai participants, 17 (42.5%) had used a tablet before, 10 (50.0%) of the older and 7 (35.0%) of the younger participants. Of the UK participants, 43 (71.7%) had used a tablet before, 24 (80.0%) of the older and 19 (63.3%) of the younger participants. In terms of popularity of devices to access the Web (see Table 1), tablets are the most popular device for older UK participants, but were never chosen by the younger UK participants who strongly preferred smartphones or laptops. Thai participants, both younger and older, also preferred using their smartphones to access the web.

Table 1: Popular devices for accessing the web (% and number of participants, participants could choose more than one option).

Device	UK participants		Thai participants	
	Old	Young	Old	Young
Smart phone	33.3% (10)	70.0% (21)	70.0% (14)	95.0% (19)
Tablet computer	50.0 (15)	0.0 (0)	20.0 (4)	5.0 (1)
Laptop computer	26.6 (8)	53.3 (16)	15.0 (3)	60.0 (12)
Desktop computer	23.3 (7)	10.0 (3)	10.0 (2)	0.0 (0)

To thank them for their participation, a gift voucher value at £25 and 500 Baht was offered to older participants in the UK and Thailand, respectively. A gift voucher value at £10 and 100 Baht was offered to younger participants in the UK and Thailand, respectively. The difference in amount was due to the longer time required for the study with older participants.

3.3 Equipment and Materials

A 4th generation iPad tablet running iOS and Safari was used for the study.

An initial demographic and background questionnaire included three parts: (1) participants' use of websites (2) their use of tablets and (3) demographic information.

A website was created to present the texts, the comprehension questions, and the post reading questionnaire, with versions in English and Thai. The colours used for the text and background were white (#FFFFFF), black (#000000), buff (#F5EFDC), sepia (#5E2612) and light blue (#ADD8E6) (see examples in Figure 1). For the English version, each text had three paragraphs and comprised approximately 230 words (15-17 sentences). The text length was chosen to fit on a tablet screen without the need to scroll to read the text. The five texts were adapted from Wikipedia articles: Maple syrup, Taj Mahal, Peafowl, the Dead Sea and Brownies. The texts were adjusted to have the same readability level (Flesh-Kincaid and Gunning Fox Index: Grade 9 to 10) in English. Three multiple choice questions were created for each text from a larger initial set. The difficulty of the questions was assessed by a separate group of five participants and three questions were chosen with the same level of difficulty.

Figure 1: Examples of text and background colour combinations (black/buff, sepia/buff, black/light blue).

For the Thai versions of the texts, the first author translated the texts into Thai and then a back-translation method was used to check the translations. Another native speaker of Thai translated the texts back into English and any discrepancies were resolved. Each Thai text had three paragraphs and approximately 260 words.

The texts were presented on the tablet in Arial typeface for the English texts and in TH Sarabun New typeface for the Thai texts. The latter is the official typeface for documents in Thailand and is used on many Thai websites (see Figure 2). For both languages, texts were presented in 18 point with 1.5 line spacing and left justification, as recommended by a number of researchers for the text body of websites (Petrie et al., 2013; Kamollimsakul, 2014; Rello et al., 2015).

A post-study questionnaire asked participants to chose the colour combination they preferred. They could view examples of each of the combinations if they wished to remind them of the combinations.

The website was coded to record the time the participants took to read each text (i.e. the time they opened the page with the text to the time they moved on to the question page) and their answers to the questions into a database for later analysis.
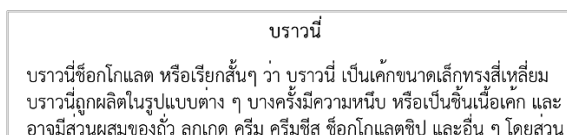

บราวนี่

บราวนี่ช็อกโกแลต หรือเรียกสั้นๆ ว่า บราวนี่ เป็นเค้กขนาดเล็กทรงสี่เหลี่ยม บราวนี่ถูกผลิตในรูปแบบตาง ๆ บางครั้งมีความหนืบ หรือเป็นชิ้นเนื้อเค้ก และ อาจมีส่วนผสมของถั่ว ลูกเกด ครีม ครีมชีส ช็อกโกแลตชิป และอื่น ๆ โดยส่วน

Figure 2: TH Sarabun New typeface (used for Thai texts).

3.4 Procedure

The same procedure has been used in the UK and Thailand. The study was conducted in a quiet room. Participants were briefed about the aims of study and the reading task. They completed an informed consent form and the initial questionnaire. Before reading the five texts, participants were given a practice skim reading task to get confident to doing the task and use of the tablet (important for the older participants).

The participants then read each of the five texts. They sat in any comfortable position for reading, but with the tablet resting on the table in front of them. When they had finished reading each text, they answered three multiple-choice questions about it. After reading all the texts, participants chose their preferred colour combination. At end of the session, participants were debriefed and encouraged to ask questions about the study. They were thanked for their participation and offered a gift voucher.

4 RESULTS

Shapiro-Wilk tests showed that the reading times were not normally distributed ($p < .05$). To reduce skew and the effect of outliers, a winsorizing process was applied to data from Thailand and the UK separately. Any times which were beyond standard deviations from the mean were adjusted to the mean +/- 2SD (Field, 2013). This resulted in normally distributed data.

The comprehension scores were also not normally distributed ($p < .05$), and the data were not suitable to be adjusted with winsorization (due to small number

of possible values). Thus, non-parametric statistical tests were used for analysis this variable.

4.1 Results from the UK

A mixed model ANOVA on reading times showed there was a significant main effect for age group ($F_{(1,40)} = 7.53$, $p < .05$, $\eta_P^2 = .16$) and for sequence of reading the texts ($F_{(4,224)} = 6.34$, $p < .05$, $\eta_P = .10$). Older participants took significantly longer to read the texts (*Mean*: 67.5 seconds, *Standard Deviation*: 24.57) than younger participants (*M*: 54.9, *SD*: 17.10). The sequence effect was that participants took longer to read the texts as the study progressed. This may have been due a fatigue effect, or it may have been that as participants realised they needed to answer comprehension questions about the texts, they read more carefully (in spite of the instruction to skim read) as the texts progressed. There was no significant effect of the text/background colour variable, nor any interaction between this variable and age group.

Friedman tests showed that there was no significant difference in comprehension scores between the different text/background combinations ($\chi^2 = 1.45$, *df*=4, *n.s*) nor on the sequence of reading the texts ($\chi^2 = 1.92$, *df*=4, *n.s*). A Mann-Whitney U test also found that there was no significant difference in comprehension scores between younger and older participants. (U=430.5, n.s.).

Table 2 shows the preferences for the different text and background colour combinations for younger and older participants. A χ^2 test showed that the distribution of preferences for text/background combinations between the two age groups and colour combinations was significantly different from random ($\chi^2=12.82$, df =4, $p < .05$). Taking older and younger participants separately, older participants most likely to choose either black on white or white on black, although the distribution of preferences was not significantly different from random ($\chi^2 =6.34$, df =4, n.s.). Younger participants were most likely to choose black on light blue or black on buff and their distribution of preferences was significantly different from random ($\chi^2=11.67$, df=4, p<.05). Most interestingly, only 10% of younger participants chose black on white, yet this is the most common presentation of text, both on screen and in print.

4.2 Results from Thailand

A mixed model ANOVA on reading times showed there was a significant main effect for age group ($F_{(1,21)} = 6.01$, $p < .05$, $\eta_P^2 = .222$). Older participants took significantly longer time to read the texts (*M*: 114.37,
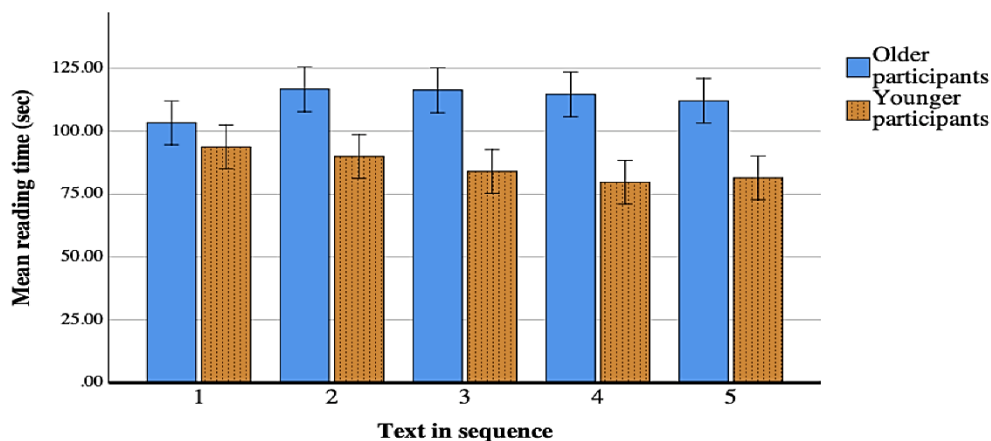
Figure 3: Mean reading time for each text in the sequence for younger and older Thai participants.

SD: 46.59) than younger participants (*M:* 85.79, *SD*: 31.82). However, there was no significant main effect for either for colour combination of text/background or sequence of reading the texts.

There was a significant interaction between age group and sequence of reading ($F_{(4,143)}$=2.58, *p*<.05, η_p^2=.07). Figure 3 shows that younger participants got progressively quicker at reading whereas older participants took longer after the first text. Again, older participants may have had a fatigue effect, or they may have realised that they needed to answer questions about the texts and began to read more carefully. In contrast, younger participants may be more used to skim reading as they do it frequently on the web, or as they are students, they might be very proficient at skim reading materials and being able to answer questions about that material.

Friedman tests showed that there was no significant difference in comprehension scores between the different text/background colour combinations (χ^2=2.24, *df*=4, *n.s*) nor on the sequence of reading the texts (χ^2 = 1.68, *df* = 4, *n.s*). However, a Mann-Whitney U test found that there was a significant difference in comprehension scores for age group (*U*=83.50, *p*<.05). The older participants answered significantly fewer questions correctly (*Median:* 1.00 correct out of 3) than younger participants (*Mdn*: 2.00).

Table 3 shows the preferences for the different text/background colour combinations for younger and older Thai participants. A χ^2 test showed that the distribution of preferences between the age groups and the colour combinations was not significantly different from random (χ^2=1.92, *df*=4, n.s). Nor was there a significant difference between preferences for the colour combinations when younger and older participants were considered together (χ^2=3.25, *df*=4,

Table 2: Preferences of UK participants for text and background colour combinations (% and number of participants).

Colour Combination (Text/background)	Older (N=30)	Younger (N=30)	All (N=60)
Black/White	9 (30.0%)	3 (10.0%)	12 (20.0%)
White/Black	9 (30.0%)	4 (13.3%)	13 (21.7%)
Black/Buff	6 (20.0%)	10 (33.3%)	16 (26.7%)
Sepia/Buff	4 (13.3%)	2 (6.7%)	6 (10.0%)
Black/Light blue	2 (6.7%)	11 (36.7%)	13 (21.7%)

Table 3: Preferences of Thai participants for text and background colour combinations (% and number of participants).

Colour combinations (Text/background)	Older (N=20)	Younger (N=20)	All (N=40)
Black/White	7 (35.0%)	5 (25.0%)	12 (30.0%)
White/Black	3 (15.0%)	4 (20.0%)	7 (17.5%)
Black/Buff	4 (20.0%)	5 (25.0%)	9 (22.5%)
Sepia/Buff	2 (10.0%)	4 (20.0%)	6 (15.0%)
Black/Light blue	4 (20.0%)	2 (10.0%)	6 (15.0%)

n.s). The most popular choice was black text on white background, chosen by 30.0% of participants.

5 DISCUSSION

This study investigated the effect of text and background colours on the reading performance and preferences of younger and older people in Thailand and the UK. Older participants read significantly more slowly than younger participants both countries,

and older Thai participants answered fewer multiple-choice questions about the texts correctly. However, the colour combinations of text and background had no effect on reading time for either age groups in either country. This result agrees with that of Kamollimsakul (2014) who also worked with younger and older participants in both Thailand and the UK and found that a range of text background colour combinations had no effect on reading performance, albeit on a laptop rather than on a tablet.

The main purpose of the comprehension scores as an independent variable was to ensure that participants would read the texts, the purpose of the study was not how accurately they answered the questions. However, as noted above, the older Thai participants answered significantly less questions correctly than younger Thai participants. In contrast, there was no significant difference on this variable between the older and younger UK participants. This difference may have been because older Thai participants were less familiar with the material in the texts. Although we attempted to find texts which would be of universal interest but unfamiliar to participants (so they could not answer questions from their general knowledge), this proved a challenge.

In terms of preferences, only younger UK participants showed a significant pattern of preferences, favouring black text on light blue background or black text on buff background. The black on light blue result agrees with Yamazaki and Eto's (2015) study which found that older Japanese participants performed better with black on light blue or blue. However, that study did not use a reading task, but a counting task and the participants were older people, whereas our result was for the younger UK participants, not the older ones. Only 6.7% of the older UK participants chose black on light blue, although 20.0% of the older Thai participants did so.

However, the numbers of participants in our studies are not large for a preference question, so the lack of significant results should be treated with caution. Further research is needed to establish whether there are clear preferences for these text background colour combinations for either age group. On the other hand these results to some extent contradict the guidelines from Kurniawan and Zaphiris (2005, see also Zaphiris et al., 2007, 2009) and Loureiro and Rodrigues (2014) that blue tones should be avoided (although it is not clear whether they are referring to text or background), although both sets of guidelines recommend strong contrast which all the combinations in the current study found. Kurniawan and Zaphiris (2005) also recommend avoiding white backgrounds, but this was the most

popular choice for older Thai participants (35.0%) and equal most popular for older UK participants (30.0%). It may well be that this combination was chosen frequently as participants are very familiar with it in both print and digital formats.

The preference results are also somewhat different from those of Kamollimsakul (2014). Like his results, this study found that older participants tended to prefer black text on white background (Thai: 35.0%, UK: 30.0%), but he found that the least prefered option in both countries was white on black, whereas in this study this was the equal most popular choice for older UK participants (30.0%), although not very popular with older Thai participants (15.0%).

The study had several limitations apart from the small sample size for the preference question, which need to be considered. We did not attempt to control the distance at which the participants viewed the tablet screen, as we wanted to create a reasonably ecologically valid scenario. We did ask participants to place the table on the desk, to create a similar viewing distance and for those who are regular users of a tablet, this may have actually been a little odd. The texts were originally created in English and the length and level of readability were very carefully matched across all five texts. However, there is no measure of readability for texts in Thai, so the texts could not be assessed for their readability once they had been translated into Thai. Thus, we cannot be sure that the texts were of equal readability in both languages. The participants in both countries were quite well educated and therefore not representative of the whole population. Different results may be found with less well educated participants with lower literacy levels.

Pending further research on this topic, it is reasonable at the moment to propose that black text on a light background, either white, buff or pale blue for presenting text on tablets to both older and younger readers in both countries. This would account for 67.5% of Thai preferences and 68.4% of UK preferences in the current study. We hope this will assist developers creating important information, such as medical and health information for older tablet users and will encourage other researchers to further investigate this interesting and important topic.

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