Tablet computers for older people in Thailand and the UK: usability and effects of different text presentations

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Abstract

As there is a sharp increase in the older population in Thailand, the UK and worldwide and the older population will continue to grow worldwide in the next two decades. The use of personal technologies such as tablet computers has also rapidly increased in both Thailand and the UK. Although the number of older people using tablet computers has increased, some older people still have issues in using tablet computers. Thus the usability and acceptability of tablet computers for older people is still an issue and there is little research about how to best present text on tablet computers on tablets for older people in English and none for the Thai language.

Therefore this programme of research investigated usability issues in using tablet computers and attitudes toward tablet computers for older people in Thailand and the United Kingdom. In addition, it investigated a number of aspects of text presentation for tablet computers in Thai and English with both younger and older people. Study 1 focused on older people's attitudes to and use of the tablet computers and another three studies focused on the effects of text presentation on tablets. Study 2 investigated font types and font sizes, Study 3 investigated text and background colours, and Study 4 investigated column format and text justification.

Key findings included that Thai and UK older people had positive attitudes toward tablets, although some encountered usability problems such as text which was too small and not resizable. In addition, tapping and zooming on the tablet were generally easy for older people, but tapping is still a problem for some of them. On text presentation, on the basis of the findings in these studies, 18 point text in a Sans Serif typeface for English and a Serif typeface for Thai are recommended for text presentation on tablets. Black text on a white background is the best for readers in both countries. Finally, a format of two columns with left justification is recommended for both English and Thai, when tablets are used in landscape orientation.

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Author's Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been submitted for an award at this, or any other, university. All sources are acknowledged as references.

Some parts of work contained in this thesis have been published in the following papers and posters as below:

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Chatrangsan, M. and Petrie, H. (2017). The Usability and Acceptability of Tablet Computers for Older People in Thailand and the United Kingdom[1]. In M. Antona & C. Stephanidis (Eds.), Universal Access in Human–Computer Interaction. Human and Technological Environments: 11th International Conference, UAHCI 2017, as Part of HCI International 2017, Vancouver, BC, Canada, 9-14 July 2017, Springer International Publishing, Proceedings, Part I, 156-170.

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Chatrangsan, M. and Petrie, H. (2019). The effect of typeface and font size on reading text on a tablet computer for older and younger people. In proceeding of the 16th International Web for All Conference: Addressing Information Barriers as held in San Francisco, the United states, 13-14 May 2019.

[1] The results of usability problems in this paper and in this programme of research were a little difference because the researcher re-analysed them in more detail after the publication.

Chapter 1 Introduction

Worldwide, the older population is increasing rapidly and will continue to grow in the next decades. According to the latest United Nation estimates, the number of older people across the world is projected to be 1.4 billion by 2030 and could rise to 2.1 billion in 2050 (United Nations, 2017d; 2019). This is affecting not only the highly industrialized countries, but countries across the world. For example, countries as diverse as Thailand and the United Kingdom (UK) are amongst the ten most populous countries with below replacement fertility rates, so their proportions of older people will grow rapidly over the next decades (United Nations, 2017d). In addition, the ratio of the older population aged 65 years or above per 100 persons working age population aged 15 to 64 years in the UK will be raised from 28.2 percent in 2015 to 43.6 percent in 2050 while those in Thailand will be raised from 14.8 percent in 2015 to 50.0 percent in 2050 (United Nations, 2017c). Moreover, within the next few years, the number of persons aged 60 and over will outnumber children under the age of 15 for the first time in Thai history (Knodel et al., 2015) while older persons in the UK have already outnumbered the number of children under the age of 16 for the first time in 2008 (Guardian.com, 2008).

As the older population increases, older adults are becoming increasingly involved in the use of technology. For example, the generation gap is narrowing in recent internet use in the UK: internet use for the 65 to 74 age group increased from 52 percent in 2011 to 80 percent in 2018 (Office for National Statistics, 2018b). This trend is similar in Thailand, albeit at a lower level, with internet use for the over 50 age group increasing from 6.2 percent in 2012 to 21.2 percent in 2018 (National Statistical office, 2017; 2018).

Tablet computers are now a very popular device for accessing the internet for older people in both the UK and Thailand (Electronic Transactions Development Agency (ETDA), 2015; 2016; Office for National Statistics, 2018a). In the UK, the usage of portable devices such as laptop or tablet computers amongst older people is growing rapidly. In 2018, 42% of people 65 years and above now use a tablet computer, 37% use a mobile or smartphone, and 37% use a laptop and netbook.

Surveys about internet use in Thailand (Thai Electronic Transactions Development Agency, (2015; 2016)) conducted found that Thai people were more likely to access the internet via portable devices such as smartphones and tablet computers than via desktop computers. In 2016, 77.3 % of people aged 55 to 73 years used a smartphone, 39.5% used laptop and 33.6% used a tablet computer. In addition, in 2016 33.6% of people in this age group used tablet computers to surf the internet, a higher proportion than those in the 39 to 54 year age group, and the 19 to 38 year age group (see Figure 1.1). Furthermore, the number of people aged 55 to 73 years who used the internet rose from 29.6 to 31.8 hours per week between

2015 and 2016. Although, the Thai Electronic Transactions Development Agency (2017) have not presented information for 2017, the data from 2015 and 2016 show that Thai older age group spend more time online than previously reported. Thus, portable devices are now becoming more widely used by older people in both the UK and Thailand.

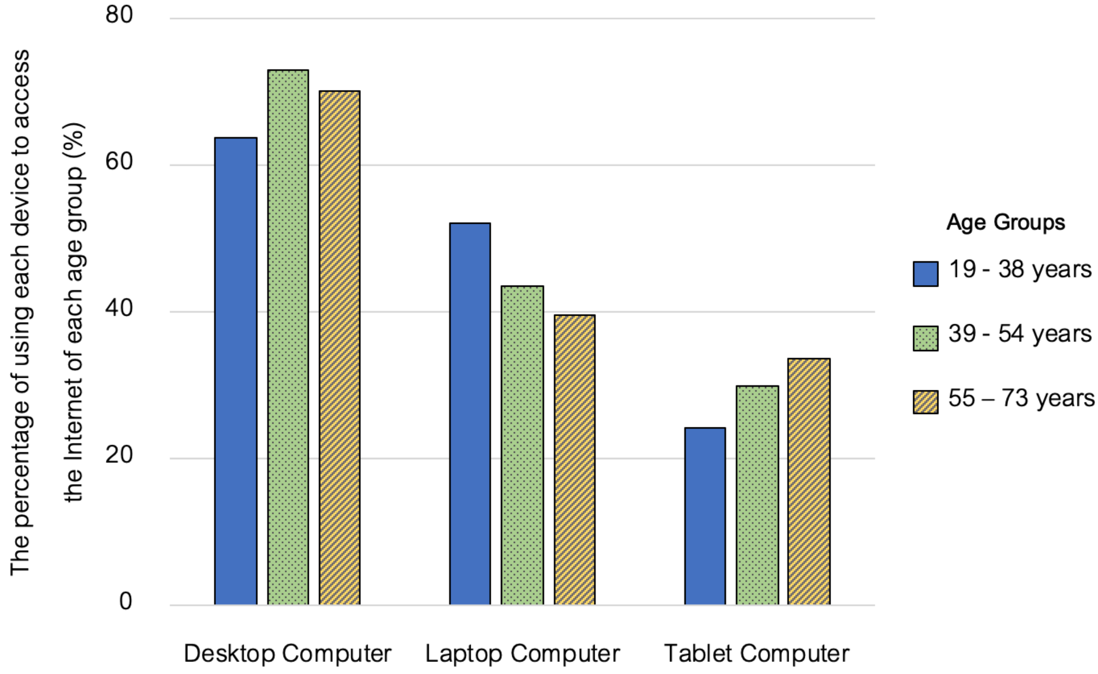


Figure 1.1 Devices used to access the internet by generation in Thailand (source: Electronic Transactions Development Agency (ETDA), 2016)

In Thai society, older people enjoy more status and seniority than younger ones and thus many Thai older adults may find their skills more sought after than in western societies (Utakrit and Utakrit, 2015). In addition, Utakrit (2006) and Loipha (2014) noted that older people in Thailand are still reluctant to use new technologies because they are unfamiliar with these technologies. However, Utakrit and Utakrit (2015) investigated the attitudes of Thai older people about using social networks and found that the older generation of Thais tend to be positive in their attitudes and agree that computers and the internet now play large roles in everyday life and that technologies should not just be for younger people. However, there has been no specific research yet on the usability and acceptability of tablet computers for older people in Thailand.

Tablet computers, in particular, have been proposed as an appropriate personal technology for older people, due to their light weight, portability and apparently easy to use interfaces and interaction styles (see Chapter 2, section 2.7). However, there are arguments both for and against the usability and acceptability of tablet computers for older people. Thus, this programme of research started by investigating the usability and acceptability of tablet computers for older people both in the UK and Thailand to provide empirical evidence about the performance and attitudes of older people to the use of tablet computers.

One area of particular interest about the usability of tablet computers for older adults is the presentation of text of the tablet: how large the text should be and what fonts, font size, font and background colours, column formats and justifications should be used. There is much research about text presentation on personal computers (see Chapter 2, section 2.9), some research on text presentations for older adults (see Chapter 2, section 2.9) and several studies on text presentations on tablet computers (see Chapter 2, section 2.9) but no research on text presentation for Thai older people on tablet computers has been found. Therefore, this programme of research will investigate text presentations for older adults on tablets in both English (with UK participants) and Thai (with Thai participants).

1.1 Research aims

The aims of this programmes of research are to investigate the usability and acceptance of tablet computers in Thailand and the United Kingdom. In particular, the thesis reports the investigation of the presentation of text for reading on tablet computers for older people in both English and Thai. The programmes of research also developed recommendations for the presentation of text for older people on tablet computers for both English and Thai.

After an exploratory study investigating general usability and accessibility of tablets for older people (see Chapter 3), a series of three studies were conducted investigating text presentation for both younger and older people in both English and Thai.

The independent variables in these studies are:

- Font type
- Font size
- Text colour
- Background colour
- Column format
- Text justification

The dependent variables in these studies are reading time and reading comprehension, reading ratings as well as participants preferences for different text presentations. Reading time and reading comprehension are typical measures of “readability”. Readability is normally concerned with both reader proficiencies in the language and different typographic variables (Mills and Weldon, 1987). In addition, reading comprehension is an important skill for older adults to employ in maintaining functional independence and quality of life (Birren and Schaie, 2006).

1.2 Thesis structure

The thesis consists of seven chapters and this section outlines each chapter:

Chapter 2 presents a review of literature on areas relevant to programme of research. This includes definitions and characteristics of older people, demographics of aging, characteristics of older people, definition of tablet computers, the use of tablet computers by older people, and finally research about text presentation on computer screens, including tablet computers.

Chapter 3 presents an investigation the usability and acceptability of tablet computers for older people both in the United Kingdom and Thailand. Eight UK older participants aged 65 to 81 years and ten Thai older participants aged 61 to 71 years were asked to undertake a series of tasks on a mini iPad tablet with think aloud protocols. Then the participants were interviewed about the task. This chapter presents the problems and attitude of older people when using a tablet computer which lead to the investigation on readability of tablet computers to be conducted in next chapters.

Chapter 4 presents an investigation of the effect of font types and font sizes on readability on tablet computers for younger and older people in English and Thai. Fifty-four UK and thirty-six Thai participants were asked to read the six texts of different combination of fonts type and font sizes with an iPad tablet. In addition, the participants were asked to choose their preference of the font type and font size combination. This chapter presents the effect of font type and font size on reading for younger and older people, and recommendations on the combination of font types and font sizes for tablet computers.

Chapter 5 presents an investigation of the effect of text and background colours on readability of tablet computers for younger and older people in English and Thai. Sixty UK and forty Thai participants were asked to read five texts of different combination of text and background colours with an iPad tablet. In addition, the participants were asked to choose their preference of the text and background colour combination. This chapter presents the effect of text colour and background colour, and recommendations on the combination of text and background colours for tablet computers.

Chapter 6 presents an investigation of the effect of column formats and text justifications on readability of tablet computers for younger and older people in English and Thai. Seventy-two UK and seventy-two Thai participants were asked to read six texts of different combination of column formats and text justifications. In addition, the participants were asked to choose their preference of the column formats and text justifications. This chapter presents the effect of column format and text justification, and recommendations on the combination of column format and text justification for tablet computers.

Chapter 7 presents the overall discussion and conclusions of this research programme. Including a discussion of how the studies compare with previous research, limitations of the studies, and recommendations for future research.

Chapter 2 Literature Review

2.1 Introduction

This chapter presents a review of literature relevant to my programme of research. It includes definitions of older and younger people, demographics of aging, characteristics of older people, definition of tablet computers, the use of tablet computers for older people, research on the use of tablet computers by older people, web design guidelines for older people and research on text presentation on computer screens, particularly on tablet computer screens and by older people.

2.2 Definitions of older people

There are many different definitions of the threshold of old age from different organizations and in different countries. For example, according to the World Health Organization (2012) and the United Nations (UN) 60 years is the threshold for old age. However, the WHO (2012) stated that most developed world countries use the age of 65 years as the threshold. The problem of different definitions relates to the differing aging contexts of people in different parts of the world. Kowal and Peachey (2001) noted that the 2000 Harare Minimum Data Set Workshop used the age of 60 years as the minimum of old age while at the 2001 Dar es Salaam Minimum Data Set Meeting the minimum of old age was changed to 50 years, because using this age represents the real situation of older people in developing countries.

In the context of research, Nichols et al. (2001) analysed information from 131 papers in the Human Factors Journal published between 1998 to 2000. They found that only 18 papers listed a mean/median age, standard deviation and age range data for participants (these are the data which they recommend all papers report). There were also only 15 papers defined the age categories of participants. Eleven studies used participants they termed “older”, with mean age range of 57.5 (SD: 8.1) to 76.1 (SD: 11.6) years. Similarly, they analysed information in 202 papers published in the Psychology and Aging Journal between 1995 and 1999. In these papers, older participants had mean age range of 62.2 (SD: 4.2) to 82.3 (SD: 7.1) years.

In addition, Sweiry and Willitts (2012) examined data from the Office for National Statistics Opinions Survey about age categorisation and identification in the UK. In 2010, younger respondents (under the age of 50 themselves) estimated old age to start on average at 56 years. Older respondents (aged 50 year and over themselves) estimated it to start on average at 64.44 years. Figure 2.1 shows mean age at which old age is perceived to start for respondents of different age groups and for four survey years.

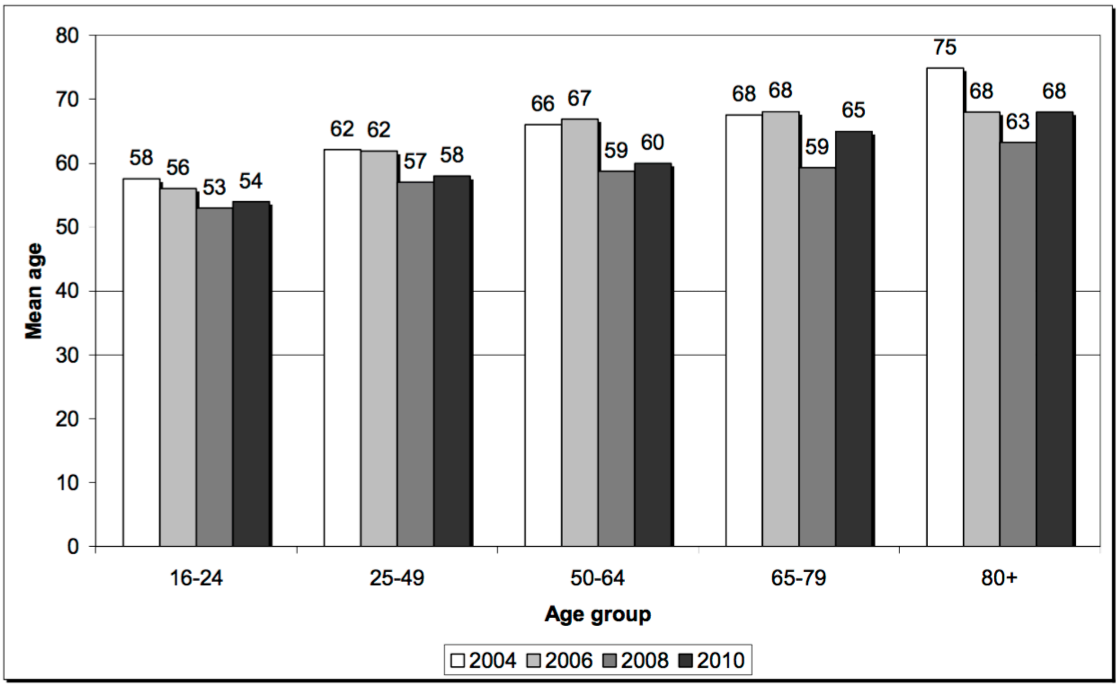


Figure 2.1 Mean age at which people are perceived to start old age by respondents of different age groups and for four survey years (source: Sweiry and Willitts, 2012)

I have analysed 24 papers from my literature review on older people and technology for their definitions of old age, and the age range of their participants, these are summarized in Table 2.1. This can be seen that most studies set the threshold for old age at 60 years for their participants, while a few studies set the threshold under 60 years. However, some studies did not mention which definition of old age they used.

Table 2.1 The range of age of older participants in 24 studies about technology

Definition of old age (years)	Actual age range or mean (years)	Country	Reference
Not given	Range: 62 – 83 Mean: not given	USA	Bernard et al. (2001)
Over 60	Range: 61 – 78 Mean: not given	UK	Darroch et al (2005)
Over 50	Range: 55 – over 85 Mean: not given	UK	Dickinson et al. (2005)
Over 60	Range: Not given Mean: 59.2	UK	Zaphiris et al (2006)

Definition of old age (years)	Actual age range or mean (years)	Country	Reference
60 and over	Range: 60 and over Mean: 66.9	Korea	Kong et al. (2011)
Not given	Range: 67 – 87 Mean: not given	USA	Jayroe and Wolfram (2012)
55 and over	Range: 55 – 78 Mean: 62 (study 1)	Malaysia	Malik (2011)
55 and over	Range: 58 – 81 Mean: 66 (study 2)	Malaysia	
65 and over	Range: 65 – 90 Mean: 72 (study 1)	UK	
65 and over	Range: 66 – 91 Mean: 75 (study 2)	UK	
Not given	Range: 63 – 89 Mean: 77.58	France	Lepicard and Vogouroux (2012)
Not given	Range: 71 – 92 Mean: not given	Australia	Waycott et al. (2012)
Over 60	Range: Over 60 Mean: 71	Austria	Werner et al. (2012)
Not given	Range: Over 60 Mean: not given	Taiwan	Huang et al. (2013)
Over 65	Range: over 65 Mean: 68 (study1)	UK	Barnard et al (2013)
Over 65	Range: 58 – 78 Mean: not given (study2)	UK	
Not given	Range: 61 – 86 Mean: 74.3	France	Findlater et al. (2013)

Definition of old age (years)	Actual age range or mean (years)	Country	Reference
Not given	Range: 60 – 89 Mean: 70.3	Japan	Lege et al. (2013)
Over 65	65 and over Mean: not given	USA	Gitlow (2014)
55 and over	Range: 60 – 76 Mean 63.37 (study 1)	Thailand	Kamollimsakul (2014)
55 and over	Range: 60 – 76 Mean: 73.75 (study 2)		
55 and over	Range 59 – 70 Mean: 61.33 (study 3)		
65 and over	Range: 65 – 78 Mean: 72.17 (study1)	UK	
65 and over	Range: 65 – 87 Mean: 73.75 (study 2)		
65 and over	Range: 66 – 79 Mean: 73.56 (study 3)		
Over 65	Range: 66 – 88 Mean: not given	UK	Page (2014)
Not given	Not given	UK	Wright (2014)
60 and over	Range: 70 – 76 Mean: not given	Brazil	de Almeida et al. (2015)
Not given	Range: 69 – 91 Mean: 79.5	USA	Tsai et al. (2015)
60 and over	Range: 60 and over Mean: not given	Thailand	Utakrit and Utakrit (2015)
65 and over	Range: 64 – 104 Mean: 76	USA	Vroman et al. (2015)

Definition of old age (years)	Actual age range or mean (years)	Country	Reference
Over 65	Range: 65 – 83 Mean: not given	Japan	Yamazaki and Eto (2015)
65 and over	Range: 65 – 76 Mean: 71.1	UK	Vaportzis and Clausen and Gow (2017)

Thus can be seen that there is no agreed definition of old people even in research on older people and technology, as this concept has different meanings for different organizations, research fields and countries.

Kamonlimsakul (2014) noted that "healthy life expectancy" should be considered as a factor for deciding the minimum age of older participants in different countries, as different countries have different healthy life expectancies. Healthy life expectancy (HLE) is the average number of years that a person can expect to live in full health (World Health Organization, 2006). Malik (2011) and Kamollimsakul (2014) both investigated appropriate definitions of older people in different countries where the retirement age, life expectancy and health life expectancy vary. For example, as shown in Table 2.2, in Thailand, retirement is typically at 60 years, life expectancy is 75.5 years and healthy life expectancy is 66.8 years (World Health Organization, 2018). Whereas in the UK, 65 is the typical retirement age (Thomas and Pascall-Calitz, 2010), 81.4 years is the life expectancy and 71.9 year is the healthy life expectancy (World Health Organization, 2018). Obviously, people in the UK can live with full health longer than people in Thailand. Both researchers (Malik, 2011; Kamollimsakul, 2014) used this information to calculate the appropriate minimum age for the older participants for their countries for accuracy and reliable data. The current research will be conducted in the UK and Thailand, as was the research by Kamollimsakul (2014).

Table 2.2 Retirement age, healthy life expectancy and life expectancy in the United Kingdom and Thailand (2018)

Country	Retirement Age (years)	Healthy life expectancy (years)	Life expectancy (years)
United Kingdom (UK)	65	71.9	81.4
Thailand	60	66.8	75.5

Kamonlimsakul (2014) used the formula below to calculate the appropriate minimum age of older participants for Thailand (defined as the second country) by using the minimum age of older participants in the UK (defined as the first country) which was set at 65 years, because this has been the typical age of retirement in the UK and this is the commonly used minimum age for older adults in research related to this research programme. Healthy life expectancy of Thai people has now increased from the 60 years used by Kamonlimsakul to 66.8 years.

$$\text{Appropriate minimum age for the second country} = \text{HLE2} - \left(\left(\frac{\text{HLE1} - \text{RA1}}{\text{LE1}}\right) \times \text{LE2}\right)$$

RA1: The minimum age of participants for first country (the UK)

LE1: Life Expectancy in the first country

HLE1: Health Life Expectancy in the first country

LE2: Life Expectancy in the second country (Thailand)

HLE2: Health Life Expectancy in the second country

Table 2.3 results from calculation of the minimum age for the UK and Thailand older participants for this programme of research

Country	Healthy Life Expectancy (years)	Appropriate minimum age for older participants (years)
The United Kingdom	71.9	65 (set)
Thailand	66.8	60.40 (calculated)

Table 2.3 presents the results of calculations for the minimum age of older participants which shows that the equivalent of 65 years in the UK is 60 years in Thailand. In addition, 60 years of age is one of the commonly used minimum age for older people in literature reviews about older people and technology. In addition, the retirement age is typically at 60 years in Thailand.

In conclusion, this section presented evidence about the different definitions of older people and the minimum age for older people in different contexts and countries. For this programme of research, the minimum of age used for older people in the UK will be 65 years whilst in Thailand it will be 60 years.

2.3 Definition of younger people

Although "younger people" is easier to define the age than older people, different organizations define this group with age ranges (see Table 2.4). The UN (2013) has used a definition of ages 15 to 24 years is defined as "youth". In addition, all UN statistical publications on youth use this age range. However, in terms of the law, the definition of young people or youth is defined as between the ages of 18 to 25 years, both in the UK (Government digital service, 2019) and Thailand (Office of the Council of State, 2007; Office of Welfare Promotion Protection and Empowerment of Vulnerable Groups, 2012). Therefore, the age range of younger people in this programme of research will be between 18 and 25 years for both countries.

Table 2.4 The range of age of younger people from different organizations

Organizations	Age range or age of Youth (years)	Reference
UN Secretariat / UNESCO / ILO	15 – 24	UN Instruments, Statistics
UN Habitat	15 – 32	Youth Fund
UNICEF / WHO / UNFPA	15 – 24	UNFPA
UNICEF / The convention on Rights of the Child	Child until 18	UNICEF

2.4 Demographics of aging

There is an increasing share of older people in the total population and this is a major global demographic trend. According to data on world population aging from the United Nations (United Nations, 2017a), the number of people worldwide aged 60 years and over has more than doubled between 1980 and 2017, from 383 million to 962 million. In addition, the number of people aged 60 and above is expected to more than triple by 2100, increasing from 1.4 billion in 2030 and 2.1 billion in 2050, and the number could reach 3.1 billion in 2100. In addition, the number of people aged 80 and over is expected to increase from 137 million in 2017 to 425 million in 2050 and 909 million in 2100 (United Nations, 2019; 2017d).

In addition, worldwide the number of people aged 65 years and over outnumbered children under the age 5 years for first time in history in 2018. Moreover, the UN (2019) expected that people aged 65 years and over worldwide will outnumber younger people aged 15 to 24 years, as illustrated in Figure 2.2.

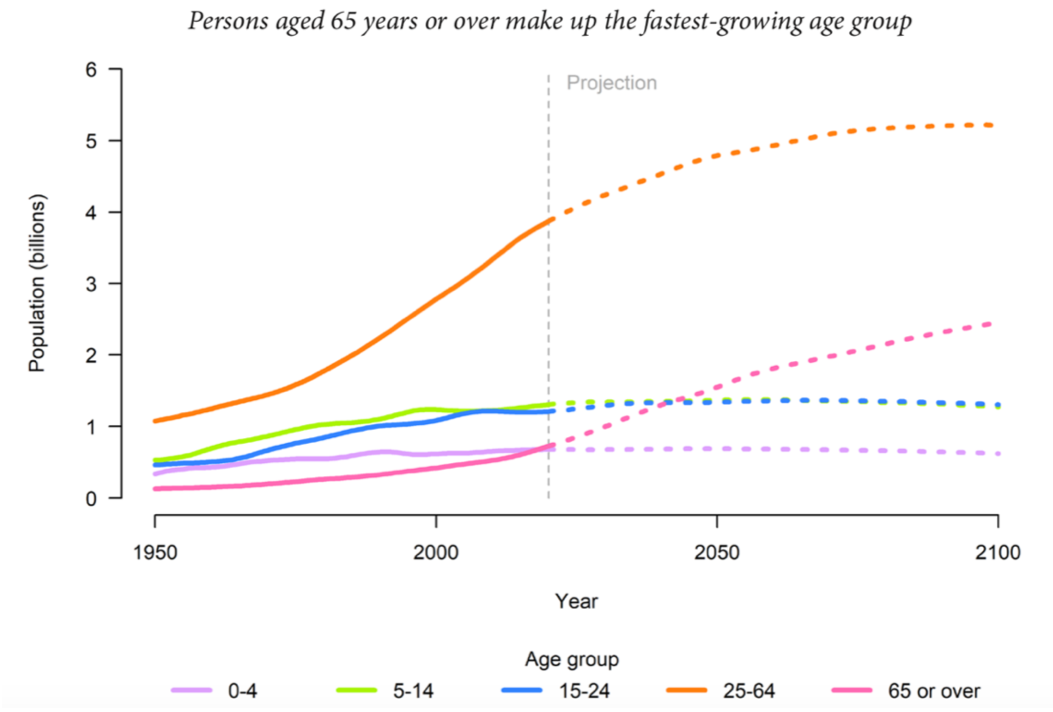


Figure 2.2 The number of estimated and projected global population by age group between 1950 and 2100 (Excluding Australia and New Zealand)
(source: United Nations, 2019)

In the UK, the proportion of older people (defined as aged 65 and above) was 11.8 million as (18.1 percent of the population) in 2015. In addition, it is estimated that by 2050 and 2100 the proportion of older people will increase to 25.4 percent and 30.4 percent, respectively (2017c) (see Figure 2.3). This increase in the proportion of the population who are considered older started many decades ago in developed regions of the world (after World War II), but this phenomenon is just starting in developing regions like Thailand.

From Figure 2.4 it can be seen that the number of older people aged 65 and over in Thailand has grown rapidly and will continue to do so in future decades (Knodel et al., 2015; United Nations, 2017c). Since 1950 the number of older people in the Thai population has increased seven-fold from approximately 1.5 million to 7.2 million by 2015 or 10.6 percent of the total population (United Nations, 2017c). In addition, the UN (2017c) estimated that by 2050 and 2100 the proportion of older people will increase to 29 percent and 33 percent, respectively. In addition, within the next few years, people aged 60 and over will outnumber children under the age of 15 for the first time in Thai history (Knodel et al., 2015).

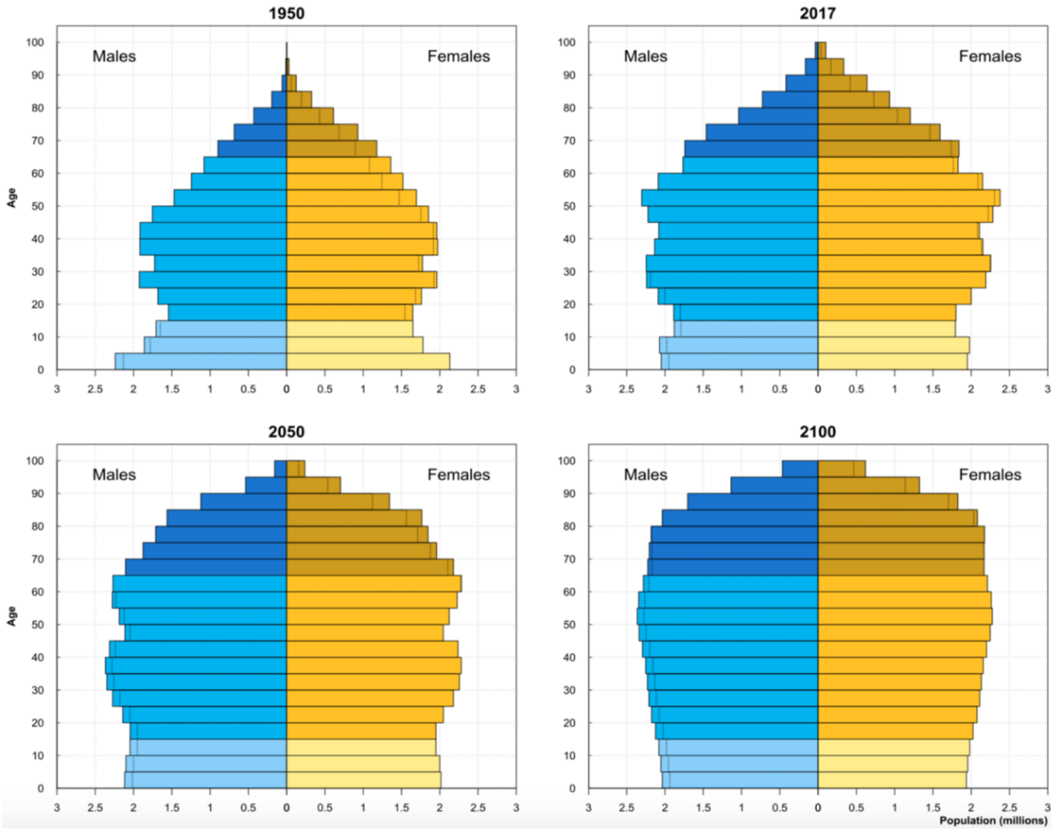


Figure 2.3 Population pyramids for the United Kingdom of Great Britain and Northern Ireland from 1950 to 2100 (source: United Nations, 2017c)

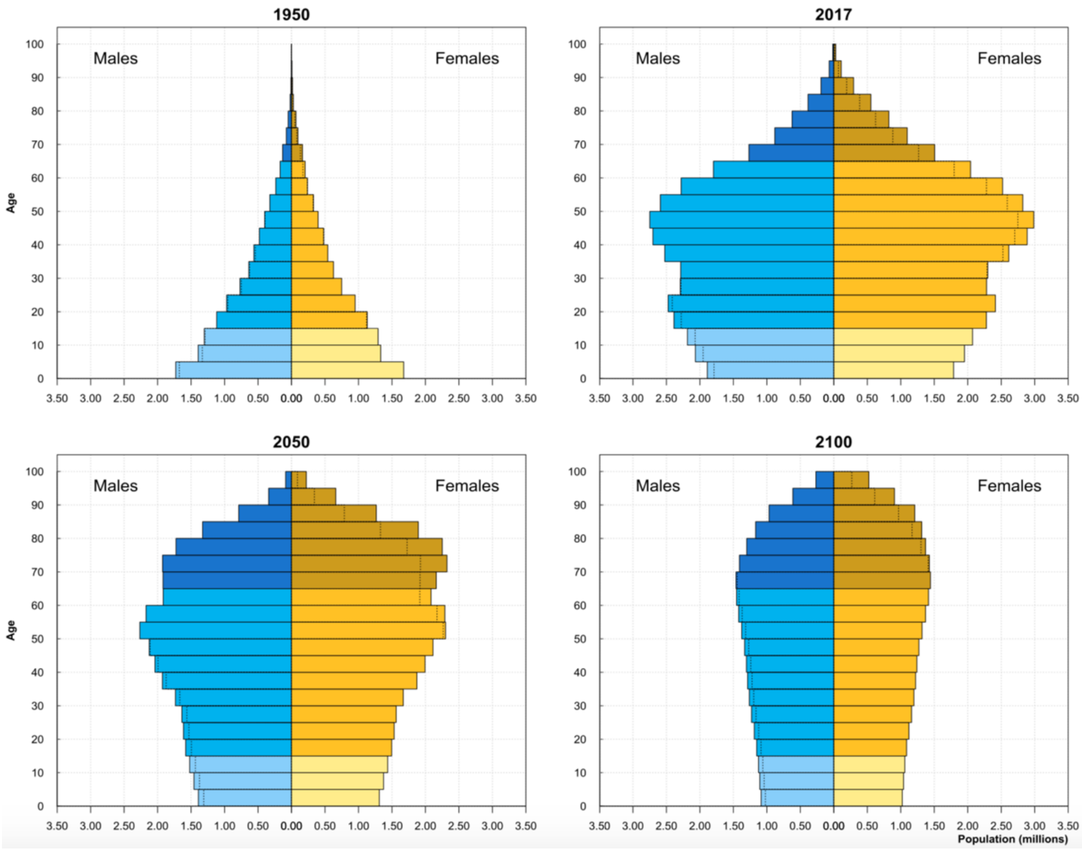


Figure 2.4 Population pyramids for Thailand from 1950 to 2100 (source:United Nations, 2017c)

Population ageing is projected to have a profound effect on the old-age dependency ratio over the next decades. The old-age dependency ratio is defined as the number of people aged 65 years or over divided by the number of people aged 15 to 64 years and is often presented as the number of dependants per 100 persons of working age (United Nations, 2017b). This ratio is considered particularly important as it represents the proportion of the population who can readily care for the older generations, as well as those generating wealth.

Table 2.5 Old-age dependency ratio for the world, United Kingdom and Thailand from 1950 to 2100 (United Nations, 2017b)

Country	Old-age dependency ratio (per 100)			
	1950	2015	2050	2100
World	8	13	25	38
United Kingdom	16	28	44	56
Thailand	6	15	50	62

Table 2.5 shows that globally, the old-age dependency ratio in 1950 and 2015 was 8 and 13, respectively and is predicted to double to 25 in 2050, with a gradual increase to 38 predicted by 2100. The old-age dependency ratio in the UK is projected to rise to 44 by 2050 and could reach to 56 by 2100. In Thailand, by 2050, this ratio is predicted to increase to 50 and could increase to 62 in 2100.

In conclusion, the number of older people aged 65 years or over is rapidly growing and will continue to increase in the foreseeable future. This is inevitable and an important reason why researchers should study issues relevant to older people.

2.5 Characteristics of older people

Age-related changes in fundamental abilities have been well documented by many researchers (Birren and Schaie, 2006; 1995; Stuart-Hamilton, 2006). For example, diminished vision, hearing loss, movement impairments as well as reduced memory. These can be divided into three main groups of characteristics indicating a reduction in functions with age: (1) sensory performance (2) motor performance and (3) cognitive performance. These characteristics have implications for the design of technology and interactive systems (Motti, Vigouroux and Gorce, 2013; Rogers, Stronge and Fisk, 2005). This section presents the characteristics and capabilities of older adults that are related to interactions with technology.

2.5.1 Sensory performance

Sensation is the processing of the properties of stimuli such as colours of the objects and loudness of sounds, and this has been studied most in relation to vision and audition. Vision is the most common physiological change related to aging (Zaphiris et al., 2006; Zaphiris, Ghiawadwala and Mughal, 2005; Birren and Schaie, 1995; Fozard, 1990). Older people typically experience changes in their vision relating to visual acuity, colour discrimination, contrast sensitivity and a heightened sensitivity to glare. Visual acuity, the ability to see fine spatial detail, is dependent on the ability of the eye lens to change shape and accommodate objects close to and far from the observer. Older people have more difficulty focusing on text close to the eye without the assistance of reading glasses or bifocals. Dickinson et al. (2005) studied strategies for teaching older people to use the World Wide Web. They provided a training course in computers and web use for older adults aged over 50 years. The course was intended for beginners with 15 participants. The researchers focused on learning to use the computer before participants were introduced to the web. Before starting the course, participants answered a questionnaire about past computer use, specific issues with computers and what they want to use computer for. The researchers noted that older adults often find computer software difficult to use because screen content is unnecessarily small, so the computers were set up with larger icons and font size in this course. After the course, participants provided feedback and did a final examination to test what had been learned. The researchers found that learners were able to perform a range of tasks using Microsoft Word, Excel, Outlook and Internet Explorer without asking from the trainers for helping. Thus, they inferred that visual decline in older adults is the reason for problems in the use of technology because the inappropriate nature of computers in general with inconveniently small text and interaction target such as icons.

In addition, Barnard et al. (2013) conducted a study about the first use of a tablet computer by older adults without support or instruction. Ten older participants with an age range from 58 to 78 years took part in the study. The participants were asked to perform a number of tasks, which ranged from turning on the device to attempting to send an email. The researchers found that some errors related to the capabilities of participants, such as a reduction of visual capability. For example, the labelling on some of the controls on tablet computers were too small for some participants to see. Furthermore, Lege et al. (2013) stated that the readability of characters on e-books is important for especially older adults with waning visual capabilities.

Older people also typically have reduced contrast sensitivity in colour, especially in the blue and green range, but can more easily perceive colours in red and orange range of the spectrum (Hawthorn, 2000; Rogers et al., 2005). Because of yellowing of the lens of eyes, there may be a difference in the way older adults perceive colours relative to younger adults.

In addition, older adults also experience higher levels of sensitivity to glare from bright illumination (Rogers et al., 2005). Thus, makers of e-book should consider aging for readability of characters on e-books in relation to colour contrast and glare (Lege et al., 2013).

Hearing loss is another of the physical changes that occurs with aging (Birren and Schaie, 2006; 1995; Rogers et al., 2005; Fozard, 1990), which includes processing of speech. For example, older adults have difficulty in differentiating voiced from voiceless consonants such as “p” and “b” (Birren and Schaie, 2006). Rogers et al. (2005) noted that older adults tend to display loss in high frequencies rather than low frequencies. However, older adults have a greater maximum benefit from sentence predictability in comparison to younger adults (Birren and Schaie, 2006). These changes are not a particular problem in using technology which is currently largely visual (although the emergence of voice systems such as Alexa may change this), but the visual changes older adults experience is definitely a problem for reading online.

2.5.2 Motor performance

The motor changes which occur with aging are largely about movement control. For instance, older adults’ movements tend to be slower than those of younger adults (Birren and Schaie, 2006; Rogers et al., 2005; Ferrandez and Teasdale, 1995). In addition, older adults tend to experience difficulty in the performance of tasks in interacting with technology such as moving the mouse on a computer screen (Rogers et al., 2005). Jayroe and Wolfram (2012) found that older people’s fingers were less stable than younger people thus typing on tablets was not easy for them. Lepicard and Vigouroux (2012) conducted a study about interaction of older and younger people with tablet computers and found that older participants were fastest at moving actions on the screen (see Figure 2.8), slower at rotating and slowest at zooming when using tablets, whereas there was no difference between the speed of these movements for younger participants. However, Findlater et al. (2013) found that using a touchscreen reduced the performance gap between older and younger people compared to using a mouse with a traditional desktop computer.

Finally, Werner et al. (2012) found that enlarging and reducing the size of screen contents using the pinch gesture was easy for older people but for those who had motor disability in one hand used both hands to perform this gesture. Scrolling and turning pages by swiping with a finger was also easy for older people.

2.5.3 Cognitive performance

Cognition is a multifaceted construct (Rogers et al., 2005). Amongst the cognitive factors that decrease with age are memory functions, in particular working memory. Working memory is the ability to store information while manipulating it (Baddeley, 1992) and age-related changes in working memory are found across a range of tasks (Craik, 2000). Meyer et al. (1997) examined age differences in web navigation, participants were asked to search a complex web site to find a specific piece of information. The researchers found that older participants took significantly more steps to find the information than younger participants and they inferred that the older participants could not remember the information on the web page which they had visited as well as younger participants.

It can be seen that all of these characteristics could influence the use of tablet computers for older people. Designers of new technology must take into account limitations in the intended users' capabilities (Waycott et al., 2012). Moreover, Motti et al. (2013) noted that age-related changes, characteristics of handheld devices and use situations need to be studied and de Almeida et al. (2015) also stated that age, ability, attitude influence older users' profiles, as well as their experience and frequency of use of a product.

2.6 Tablet computer

There are many tablet computer (usually referred to as just tablets) categories and tablets are classified using physical characteristics into at least three categories. Each of these tablet categories is described below and summarized in Table 2.6 (Sciarretta et al., 2015).

1. *Slate tablets* normally lack a physical keyboard, so a software keyboard or other forms of data entry such as speech recognition is required. The term tablet is commonly associated with these devices since the Apple iPad was first launched in 2010. Within this category, another distinction concerns the screen size: mini-tablets are devices with a smaller screen (about 7 inches diagonally), while standard slates have a screen size of 9 – 10 inches diagonally. However, this category of tablet can be connected to a physical keyboard via Bluetooth and USB if needed.
2. *Convertible tablets* are laptops but with the difference from a standard laptop that the screen can be rotated and folded over the keyboard. The keyboard can be extracted at any time, in order to make the data entry easier or to enable the interaction with applications not designed for use with a touch screen. For example, the Lenovo IdeaPad Yoga is a convertible tablet.
3. *Hybrid tablets* are like similar to convertible tablets, but these comprise two separate devices, a tablet screen and a keyboard. The keyboard can be attached or detached depending on the need of users. For example, the Microsoft Surface is a hybrid tablet. This category has not had wide use

since slates often have keyboards that can be connected via Bluetooth and USB.

Table 2.6 Comparison of the different tablet categories (source: Sciarretta et al., 2015).

Categories of tablet computer		Screen size	Keyboard
Slates	Tablets	9 – 13 inches	Via USB or Bluetooth
	Mini Tablet	7 – 8 inches	Via USB or Bluetooth
Convertibles		10 – 13 inches	Built in
Hybrids		7 – 9 inches	Detachable

Generally, the slate tablet is the most common device so the word “tablet computer” and “tablet” will be used to refer to slate tablets in this research programme. It is argued that the Apple iPad is more intuitive to use for older people or people with disabilities because of its physical and graphical designs, such as a large screen and direct input via touch-based gestures, so a number of researchers have suggested that this devices is appropriate for older people (Jayroe and Wolfram, 2012; Waycott et al., 2012).

2.7 The use of tablet computers by older adults

At present, older people play a prominent role in the increased use of online devices, not only computers but also in the use of new technologies such as tablet computers. According to the Office for National Statistics (2015) UK people aged over 65 years showed the largest group increase in daily computer use from 2006 to 2015 by 8 percent to 45 percent. In addition, the tablet computer was the most popular device for accessing the internet by UK people aged 65 years and over, used by 42 percent of this age group in 2018 (Office for National Statistics, 2018a). This trend is also similar in Thailand, accessing the internet using tablet computers by Thai older people aged 55 to 73 years was higher than those of Thai younger people, used by 33.6 percent of the older age group (Electronic Transactions Development Agency (ETDA), 2016).

Jayroe and Wolfram (2012) compared user interaction with tablets (in this case iPads) and desktop computers for older people by interviewing ten American participants aged 67 to 87 years, after participants had undertaken searching information tasks such as finding the weather for a given location, seeking information on glaucoma on WebMD.com, searching for an image of a frog on a boat in 1965 and downloading a book by Mark Twain. The sessions were recorded by video to understand what participants thought via think aloud protocols. Participants were more comfortable with tablets than desktop computers, but some participants faced issues with the iPad keyboard which did not have a delete button that participants were used to. However, participants stated that the main advantages of tablets were their portability, efficiency, ease of use and speed.

In addition, Werner et al. (2012) conducted an evaluation of the general usability and acceptance of a tablet computer (iPad) by older adults. Participants aged over 60 years were asked to perform tasks. The sessions were recorded by video for retrospective performance analysis. Each participant performed seven tasks: turning on the tablet and looking for the weather forecast using a quick-link on home-screen, retrieving the latest news, searching for information on selected predefined topics, finding an address on a map, reading and writing an email and searching for a predefined video on YouTube. After completing the tasks, they were interviewed about their personal impression on performing the tasks. The researchers found that some participants misunderstood the tablet interface. For example, the participants confused the difference between "back" to main screen and "back" within the web browser. However, all their older participants stated that in general the tablet was very easy to use and starting an application worked very easily and was faster than on a desktop computer.

In addition, participants were asked to rate aspects of their use of tablets. The rating scale used was from "very good" to "fail" but there was no indication of how many steps there were between these two points. The result of the ratings showed that (1) the magnifying feature was rated as "very good", an important benefit in comparison to a desktop computer; (2) reading was rated as "very good" because letters on the screen keyboard were quite big however writing was not easy for many participants as they were not used to typing on keyboard which was rated only as "good"; and (3) enlarging and minimizing screen content by using the pinch gesture were very easy for all participants and this was rated as "very easy" as well as scrolling and turning pages by swiping with a finger. However, some participants had some problems when tapping on the screen for functions such as copy or paste text.

Barnard et al. (2013) studied learning and technology acceptance and adaptation. They investigated two case studies. In the first case study, they studied tablets for navigation while walking. Thirteen participants aged over 65 were interviewed while walking and using the tablets. The participants walked around the University of Leeds. The researchers found that most participants believe that new technologies can be learned by older people. In addition, participants stated that size of the tablet may also be an advantage, big enough to see things well when compared with a smartphone and having the keyboard and the screen in one place makes things easier. However, these results were not related to mobile use of a tablet. For the second case study, they conducted a study about the first use of tablets by older people who have a little experience of digital technologies and who have no instruction about the tablet. The researchers asked ten participants aged 58 to 78 years to do the tasks that ranged from simply turning on the tablet to attempting to send an email. Some participants faced problems with the tablet, for instance the labelling of some controls was too small, and they were confused about how to move using the cursor keys. In addition, some participants lacked confidence in using the tablets.

Wright (2014) studied digital tablet issues for older adults with 52 members of a UK branch of the University of the Third Age, but their ages were not specified. She asked participants to share experiences and problems about the tablets. Wright found that older people easily remembered many finger actions on the tablet such as swiping, tapping and dragging but inadvertently touching the screen could result in typing errors or unexpected page changes. New users of tablets often focused on a small area of screen. For example, new users often looked at the keyboard when typing. In addition, older participants found tablets very helpful for internet activities.

Pereira et al (2013) evaluated tablet size, weight and orientation on productivity and subjective usability and fatigue when the tablet was held by hand. There were thirty participants aged 16 to 64 years in this study. Participants held a tablet with their hand and performed typing tasks with using three different tablets (iPad2: 613 grams, Kindle Fire: 400 grams and Samsung Galaxy Note: 178 grams) with different tablet orientation conditions (portrait and landscape). The sizes of tablet were categorized into three levels: large, medium and small sizes (see Figure 2.5). After participants completed the tasks, they were asked to rate overall usability, productivity, fatigue in their left hand or wrist on a 7-point scales (1: very high to 7: very low). At the end of experiment, tablets were rank ordered from least to most preferred. The researchers found that participants preferred the small and mid-size tablets to large tablets. The ratings of usability and fatigue supported the use of the small to medium sized tablets over large tablets when holding the device with one hand. In addition, there was less wrist extension in the portrait compared to the landscape mode. However, there were no significant differences in muscle activity and measured productivity between use of the tablet in portrait and landscape views.

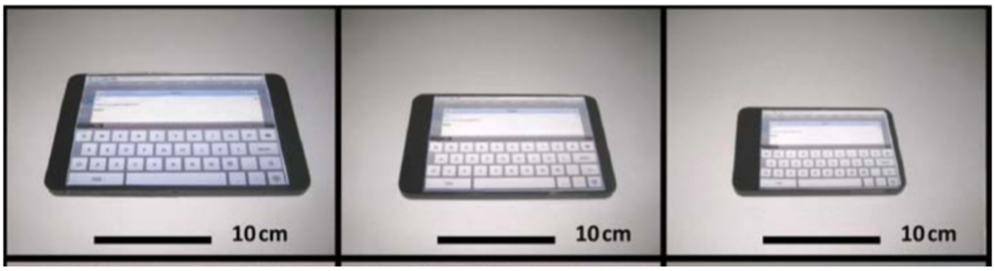


Figure 2.5 Example of tablet size levels (source: Pereira et al., 2013)

Tsai et al. (2015) examined older people's technology adoption. Twenty-one older people aged 69 to 91 years old, residing in independent living in the "Deep South" of the United States were interviewed about the barriers of technological self-efficacy and the impact of using the tablets. The researchers found that most of the participants (62 percent, n=13) said that the design of the iPad was so intuitive that it was easy to use, not intimidating and using tablets made older people feel connected to the world (90 percent, n=19) and their families (34 percent, n=7), as well as feeling current or updated (57 percent, n= 12). In addition, all participants reported being happy with their tablet and many had recommended them for others.

Vaportzis and Clausen and Gow (2017) studied perceptions of technology and barriers to interacting with tablet computers with eighteen older adults aged 65 to 76 years in the UK. There were three focus groups and each group comprised of six participants. The authors asked participants about their thinking about using technologies and tablets, particularly advantages and disadvantages of using tablets. At the end of session, participants were asked to complete a tablet experience questionnaire on five-point Likert scales (1: Poor to 5: Excellent). The result showed that 94.4% of participants rated their experience good to excellent. However, the authors found that lack of instructions and guidance, lack of knowledge and confidence, health issues and cost were barriers of using technologies and tablets for participants. Some participants mentioned that tablets are overly complicated, and they were concerned about society's over-reliance on technology while some of them noted that tablets are convenient to use and easy to use to access information. Overall, the authors found that participants were eager to adopt new technology and willing to learn how to use a tablet.

There is some research (Findlater et al., 2013; Lepicard and Vigouroux, 2012) which has investigated touchscreen performance by older people.

Findlater et al. (2013) compared the performance of twenty older adults aged 61 to 86 years and twenty younger adults aged 19 to 51 years on four actions (pointing, dragging, crossing and steering) with six tasks on a touchscreen (an iPad) and four tasks using an optical mouse on a desktop computer (see Figure 2.6). Each participant used for both the touchscreen and desktop presented in counterbalanced order, with the tasks in randomized order within each device.

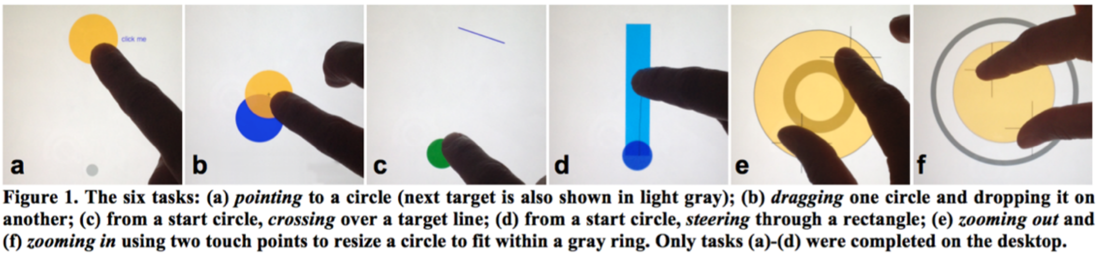


Figure 2.6 Example of actions and tasks on tablet and desktop computer
(source: Findlater et al., 2013)

The researchers found that on the touchscreen, older adults were fastest with pointing followed by crossing. Dragging and steering were slowest and not significantly different from each other. However, older adults' movement times improved from the desktop to the tablet more than those of younger adults, as can be seen in Figure 2.7. In addition, there were no significant differences in error rate between the desktop and the tablet for both younger and older adults. Moreover, the touchscreen tasks were perceived to be easy for both older and younger participants with a mean rating of 1.62 on a seven-point scale from 1 (easy) to 7 (difficult). The researchers concluded that the use of the tablet was easier in comparison with the desktop computer for older adults, but the difference was less so for younger adults. They also noted that the tablet not only reduced the performance gap between older and younger adults compared to a desktop computer setup, but also reduced the likelihood of making error. Overall, the researchers recommended that touchscreens are easy for older adults to use.

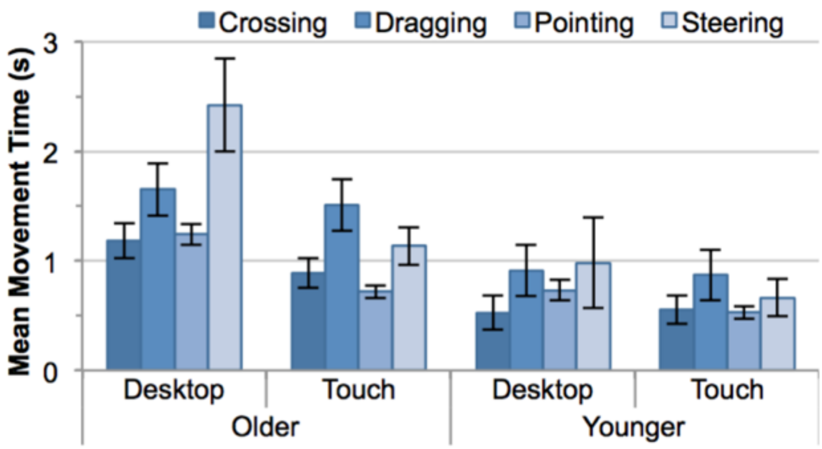


Figure 2.7 Mean movement time per trial for desktop and touchscreen devices
(source: Findlater et al., 2013)

Lepicard and Vigouroux (2012) compared single-touch interaction and multi-touch interaction (see Figure 2.8) for older and younger people. Twelve younger participants aged 23 to 33 years and twelve older people aged 63 to 89 years were asked to do tasks with each interaction type. Each interaction was divided into three actions: move, rotate and zoom. After the participants completed each interaction, they answered questions about visual fatigue and the usability rating of the interaction. Older participants were fastest at moving, slower at rotating and slowest at zooming. One the basis of these results, the researchers suggested that multi-touch interaction is not recommended for older people, particularly rotating and zoom actions, but this is in contrast to the study by Werner et al. (2012) which found that enlarging and reducing the size of screen content using the pinch gesture was easy for older people.

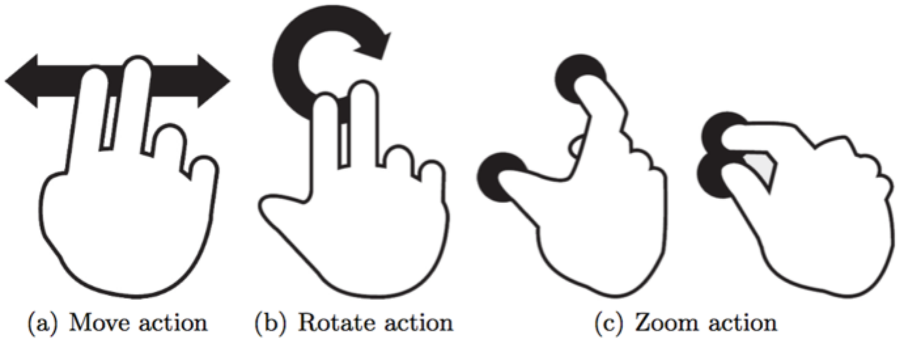


Figure 2.8 Examples of multi-touch interaction (source: Lepicard and Vigouroux, 2012)

Utakrit and Utakrit (2015) investigated attitudes of older Thai people (aged over 60 years) who live in the capital city, Bangkok, and the surrounding area about social networks and knowledge sharing using interviews, with a view to developing the prototype of an online social network for older people. Subsequently, the prototype of a social community web page was developed and was tested by 22 older participants. The participants were asked to do four tasks: (1) register to obtain a username, fill in their profile, attempt to log in and log out of the website; (2) share their knowledge to the website (i.e. writing their knowledge about healthy food on the website); (3) share their favourite photos or video clips from YouTube on the webpage; and (4) find a topic that they were interested in to post on the webpage and also provide comments to others' contributions. After they completed the tasks, the participants rated the satisfaction with the website on a five-point scale (1: very unsatisfied to 5: very satisfied). A few months later, the researchers conducted a follow up study with the same participant group. The researchers found that Thai older participants were satisfied with their use of the website and comfortable to use the social network which gained a high score (mean = 4.82). Furthermore, the researchers noted that online social networks successfully met the needs of older Thai people in Bangkok. However, I have not found any research that has investigated the use of tablets for Thai older adults.

Think aloud protocols are methods for the usability testing of websites for older people as can be seen in some of the research discussed above, for example the studies by (Jayroe and Wolfram, 2012; Olmsted-Hawala and Bergstrom, 2012; Werner et al., 2012). Olmsted-Hawala and Bergstrom (2012) examined the effects of think aloud protocols on usability testing of websites by young adults (18 to 28 years), middle age adults (40 to 50 years) and older adults (64 to 76 years). Ninety-five participants participated in the study and they were assigned to a concurrent think aloud (CTA) or retrospective think aloud (RTA) condition. In the CTA condition, participants were encouraged to think out loud while working on a task, while in the RTA condition, participant thought out loud only after completion of the task while watching a video replay of the task. Participants undertook five information gathering tasks on the US Census Bureau's American FactFinder (AFF) website. The AFF is the Census Bureau's primary data dissemination website about the population, housing and economy on the United States. Two tasks were categorised as easy: for example, "You want to learn more about Maryland, and specifically about how many people live there. How many people live in Maryland?". Other three tasks were categorised as difficult: for example, "You are doing a report on schooling in the U.S. What percent of the population in Florida, California and Texas completed college in 2008?". Each participant and administrator sat in separate rooms during the sessions and they communicated via microphones and speakers. However, while participants in the CTA condition completed all five tasks, due to time constraints, the participants only conducted the RTA about the last task. The other four tasks were only completed in silence without a retrospective think aloud.

Olmsted-Hawala and Bergstrom (2012) analysed how age and think aloud protocols were related to usability performance measures (accuracy: task completed correctly or not, efficiency: time on task, and subjective satisfaction ratings). The researchers stated that they cannot determine whether the CTA or the RTA is better for older people. They found that there was no difference in accuracy, efficiency and subjective satisfaction scores between CTA and RTA protocols for young and older adults. Only the middle age group adults in the CTA condition were more accurate for the difficult task and took a longer time to complete the task in RTA condition. However, age and think aloud protocol did not affect satisfaction ratings. The researchers recommended the use of CTA when interested in obtaining a real sense of users' experience with the interface, but RTA when interested in obtaining a users' insight into what issues there are with a user interface. Unfortunately, they did not investigate whether there were differences in younger and older people's ability with and experience of the protocols themselves.

Savva, Petrie and Power (2015) investigated the effectiveness and efficiency of CTA and RTA with eight blind and eight sighted participants (age ranged from 23 to 64 years). Participants evaluated two websites with each protocol and rated severity problem on a 4-point Likert scale (1: cosmetic to 4: catastrophic) when they encountered a problem with the website. After each protocol, participants were asked to complete the NASA TLX, about their experience of that protocol. Finally, after experiencing each protocol, they also chose the protocol that they preferred. RTA was more effective for measuring problems encountered for both blind and sighted participants, but it was no more efficient than CTA.

For the effect of the protocols on participants, RTA demanded more workload than CTA for both groups but there was no clear preference for either protocol.

No research comparing these protocols with Thai older people has not been performed yet. As Thai older people are defined the minimum of age at 60 years so this age is different from the age of older people in the research of Olmsted-Hawala and Bergstrom (2012).

In summary, research has shown that the attitudes of European and American older adults are more positive than negative toward tablets, but some of older adults still have issues with using tablets such as the labelling on some the controls being too small and hard to see or recognize (Barnard et al., 2013), interaction with the touchscreen being difficult (Barnard et al., 2013; Jayroe and Wolfram, 2012; Lepicard and Vigouroux, 2012) and conceptual problems such as confusion about how to move the cursor, confusion between "back" to main screen and "back" within the web browser (Barnard et al., 2013; Werner et al., 2012). Apart from these problems, some of older adults lack confidence in using a tablet (Vaportzis et al., 2017; Barnard et al., 2013) and lack experience with a non-tactile keyboard (Jayroe and Wolfram, 2012). However, older adults found that tablets are very useful for internet activities (Tsai et al., 2015; Wright, 2014) and the ease of use feature of tablets helped solve the issues related to the lack of technological self-efficacy (Tsai et al., 2015). Furthermore, Thai older people seem like to have good attitudes to accept and use new technologies (Utakrit and Utakrit, 2015) but there is no empirical evidence about acceptance and usability of tablet computers for Thai older people.

2.8 Guidelines for text presentation on the web for older people

Although older people have positive attitudes to use new technologies, such as accessing the web, their use of technologies may be affected by age-related changes in vision or cognition. However, web designers need to consider the specific needs of older adults and making the web more accessible to older adults. There are numerous web design guidelines for older people. In this review, I will mention only text presentation guidelines of web design for older people.

The Setting Priorities for Retirement Years (SPRY) Foundation (1999) published a guide on web design for older adults that based on from the findings of research of Holt and Komlos-Weimer, (1999). The authors developed web design guidelines for older adults based on the practical experience of experts as an outcome of the Older Adults, Health Information and the World Wide Web Conference in 1999. Although there are many checklists in this guide (e.g. menus and navigation, organising the content) for web design, the only checklist related to text presentation and thus relevant to this programme of research is presented in Table 2.7.

Table 2.7 The SPRY guidelines for text presentation on the web for older adults

Topics of text presentation	Recommendations
Font size	12 and 14 point is recommended for body text An 18 point heading is a good choice to accompany with a 14-point body text
Font type	Sans serif fonts such as Arial or Helvetica
Font weight (refers to the thickness of the letters)	Medium weight fonts frequently provide a good contrast with the background (but the guideline did not show how weight will be used on the web) Avoid variations to text such as italics and underlined text
Colour and background	Contrast is important between background and content A good background should contrast with the text on the web. For example: light text on a dark background can be readable as long as the contrast is strong Avoid patterned wallpapers for background
Physical spacing	Line spacing (leading): Even average or default leading may not be sufficient for those with visual problems (i.e. long eye-sighted), which occurs frequently in older adults. This is easily remedied, however, by increasing the leading by even a small amount (1 or 2 points) Avoid condensed font and reducing the space between letters, as this can also make text harder to read
Text justification	English is read from left to right, thus right justified text is uncomfortable to read Fully justified text (with left–right justification) can be difficult to read, especially on shorter width

Topics of text presentation	Recommendations
	texts, but also wider texts may have unattractive "wiggling" white lines traveling up and down through the text Centre justification can be effective for heading text but distracting for body text Left justification is preferred by older adults who find it easiest to read

The American Association of Retired Persons (AARP) published guidelines based on work by Redish and Chisnell (2004). These guidelines reviewed primary research, books and articles about web design and older adult users from January 2000 to September 2004. They mentioned that older adults strongly preferred large text and have difficulty in reading smaller text as older adults lean closer to focus for reading on computer screen. However, the guidelines did not mention the appropriate font size to present on the screen for older adults nor what are appropriate colour combinations for text and background. However, this set of guidelines is only based on the recommendations from many previous studies that are relevant to the effect of text presentations on reading for older adults.

Zaphiris, Ghiawadwala and Mughal (2005) and Zaphiris, Kurniawan and Ghiawadwala (2006) developed a set of web design guidelines for older adults called the SilverWeb Guidelines. The 52 guidelines were established from the literature by them. Then a card sort exercise was conducted with 40 postgraduate students in human computer interaction and design. Participants sorted the guidelines into groups that were categorised by impact on age-related functional impairments. The 52 guidelines were grouped into 9 different categories. Finally, a focus group was conducted with five HCI researchers to develop the final guidelines. The experts reviewed the guidelines and added new guideline categories where needed. This resulted in 38 web design guidelines for older adults in 11 categories.

Heuristic evaluations were conducted using both sets of guidelines on two websites (http://www.nsclc.org and http://www.elderhostel.org). These websites had been used in usability evaluations of websites for older people in the past. There were six participants who were researchers and research students in HCI (aged under 40 years). Participants evaluated the two websites by using the initial and the final guidelines. The results showed that the NSCLC web was rated consistently by both sets of guidelines (the website achieved score of 67% accessible on the first version of the guidelines and 71% on the second version of guidelines). However, for the Elderhostel website the two set of guidelines produced very different results, Participants gave it an accessibility score of 40% on the first version of the guidelines and 71% on the second version. For eight out of nine of the guidelines in the second version, the assessment of the website was exactly the same by all participants. However only eight out of twenty-three guidelines in the first version produced the same assessment. Thus, the researchers concluded that the second version of the guidelines was more robust and more logically structured than the original version.

Some items in the final set of guidelines relevant to text presentation were that blue and green tones should be avoided and that background colour should not pure white for older adults. In terms of font, a sans serif font at 12 to 14 point should be used, text should be left justified and the length of text lines should be short (see Table 2.8).

Table 2.8 The SilverWeb guidelines for text presentations on the web

Topics of text presentation	Recommendations
Font size	The font size should be 12 – 14 point Text should have clear large headings
Font type	The font type should be sans serif (such as Helvetica, Arial) Avoid other fancy font types
Colour and background	Colour should be used conservatively Blue and green tones should be avoided Background screens should not be pure white
Capital and lowercase letters	Main body of text should be in sentence case and not all capital letters
Line spacing	There should be spacing between the lines
Line length	There should be short line lengths
Text justification	There should be left justified text

The U.S. National Institute on Aging (NIA) and National Library of Medicine (NLM) (2002) published guidelines which provided many research-based guidelines for web design for older adults. The guidelines for readable online text recommended that a sans serif font (such as Arial and Helvetica) at 12 or 14 point is optimal for older adults and the text should be left justified. In addition, web designers should use dark text on light background (such as black letters on a white background) and should avoid yellow, blue and green colours in close proximity as these colours are difficult for some older adults to discriminate (see Table 2.9.)

Table 2.9 The NIA/NLM guidelines for text presentations on the web

Topics of text presentation	Recommendations
Font size	Use 12 or 14 point for body text
Font type	Use a sans serif font such as Helvetica or Arial Avoid the use of serif, novelty and display fonts
Font weight	Use medium or bold face font type
Colour and background	Avoid yellow, blue and green colours in close proximity as these colours are difficult for some older adults to discriminate Use dark type against a light background, or white lettering on a black or dark coloured background Avoid patterned backgrounds
Capital and lowercase letters	Present body text in upper and lowercase letters Use all capital letters and italics in headlines only Reserve underlining for links
Line spacing	Use double spacing in all body text
Text justification	Left justification is optimal for older adults

Dunn (2006) published a set of web design guidelines for older adults. He investigated usability for older web users with eight older participants aged over 65 years and 8 younger participants aged under 40 years. The participants were asked to find information on a range of government websites by using a think aloud protocol in a session lasting about 40 minutes. He found that six older participants failed to scroll down a page, while none of the younger participants failed to scroll. The failure of scrolling led older participants to miss information that related to their task. Seven of older participants stated that anything less than 12 point font is too small to read for them. Dunn recommended that websites should provide a bigger texted link or icons and always use high contrast between text and background colours such as black text on off-white background. He also mentioned that using an off-white background is preferable to white as it reduces the chance of eyestrain for slow readers.

Thus, there are a series of recommendations for text presentation from a number of sets of guidelines for web design for older web users from different organizations and researchers. Table 2.10 presents a summary of all recommendations for web text presentation for older adults.

Table 2.10 Summary of recommendation for web text presentation for older adults

Topics of text presentations	Recommendations	References
Font type	Use Sans serif (such as Arial or Helvetica)	SPRY: Holt and Komlos-Weimer (1999) NIA/NLM (2002) Zaphiris et al. (2005; 2006)
	Avoid fancy fonts	NIA/NLM (2002) Zaphiris et al. (2005, 2006)
Font size	Use 12 to 14 point for body text	SPRY: Holt and Komlos-Weimer (1999) NIA/NLM (2002) Zaphiris et al. (2005; 2006)
	Do not use less than 12 point	Dunn (2006)
	Large text	Redish and Chisnell (2004)
Font weight	Medium weight	SPRY: Holt and Komlos-Weimer (1999) NIA/NLM (2002)

Topics of text presentations	Recommendations	References
Capital and lowercase letters	Use uppercase and lowercase letters or sentence case for body text	NIA/NLM (2002) Zaphiris et al. (2005, 2006)
Colour and background	Avoid blue and green tones	SPRY: Holt and Komlos-Weimer (1999) NIA/NLM (2002) Zaphiris et al (2005, 2006)
Colour and background	A good background should contrast with the content of the web	SPRY: Holt. and Komlos-Weimer (1999) NIA/NLM (2002) Zaphiris et al (2005, 2006) Dunn (2006)
	Avoid patterned wallpapers for background	SPRY: Holt and Komlos-Weimer (1999) NIA/NLM (2002)
	Background colours should not pure white	Zaphiris et al. (2005, 2006) Dunn (2006)
Line spacing	Use a small amount of line spacing: 1 or 2 points	Holt and Komlos-Weimer (1999)
	Use double spacing for body text	NIA/NLM (2002)
	Have additional spacing between lines	Zaphiris et al. (2005, 2006)
Line length	Use short line lengths	Zaphiris et al (2005; 2006)
Text justification	Use left justification	SPRY: Holt and Komlos-Weimer (1999) NIA/NLM, (2002)

Topics of text presentations	Recommendations	References
		Zaphiris et al. (2005, 2006)

I found only one of set of design guidelines that relate to multi-touch interfaces for older people (Loureiro and Rodrigues, 2014). They created an initial set of 138 design guidelines from a literature review that related to design or using touchscreens for older people. The 138 guidelines were categorised, resolved that are in divergence and were organised into 10 groups of guidelines. Thus a final set of guidelines consists of a list of 113 grouped design guideline that focused on the aspects on multi-touch design for older people. For text design Loureiro and Rodrigues (2014) recommended using a sans serif font such as Arial and avoiding the other fancy font types and using left justified text for older people. For text colours and background, there should be a high contrast between the foreground and background and blue, yellow or red and green tones should be avoided. In addition, warm colours are the most suitable for older people. These guidelines are very similar to the web design guidelines discussed above.

Overall, the guidelines are useful for text presentation on the web for older people and thus relevant to the current programme of research. However, most recommendations were. developed in the context of desktop computer studies and based on the English language. Thus, the next section examines the recommendations of research in different contexts such as other devices and languages.

2.9 Previous research on the effects of text presentation on reading from screen

Apart from the guidelines of web design for older people, there are several research papers related to text presentation on screen for older people in a number of different languages. In this section, research on the effect of a range of variables on text presentation for reading from a digital device screen for older people will be considered, including font size, font type, text and background colours and included the text layout and language.

2.9.1 Research on the effect of font size

Bernard et al. (2001) examined the effects of font type and size on the legibility and reading time of English text with 27 older participants aged from 62 to 83 years. The participants were positioned at a fixed distance of 57 centimetres from a desktop computer screen and asked to read passages in 12 and 14 point font in four different font types (Arial, Verdana, Georgia and Times New Roman) as quickly and accurately as possible. The passages contained ten randomly placed substitution words (these varied grammatically from the original word, for example the noun “cake” being replaced with the adjective “fake”) but participants were not told the number of substitution words. The researchers found that 14 point text was more legible and faster to read than 12 point font but there was no difference between the serif fonts and sans serif fonts.

In a further study Bernard et al. (2003) compared the effect of text size and format on the readability of Times New Roman and Arial text displayed on a desktop computer with thirty-five younger adults aged 17 to 47 years. Participants were instructed to read from a position approximately 57 centimetres from the computer screen and identify the substitution words in different font sizes (10 and 12 point) and font types (Times New Roman and Arial fonts). They then rated their perception of text readability and preference with a seven point Likert scales. The researchers found that there were no significant differences in accuracy and reading time for font size and font type. For perception of text readability rating, text at 12 point was rated as more legible and easier to read than text at 10 point. In addition, text at 12 point was significantly preferred to text at 10 point.

Darroch, Goodman, Brewster and Gray (2005) investigated the effect of age group and font size on reading text on handheld computer screen (PDAs). There were twenty-four participants and they were divided into two age groups of 12 with 6 males and 6 females. The younger age group as aged 18 to 29 and the older age group as aged 61 to 78 years. All participants were native English speakers. Participants were asked to proofread passages and read them out loud. The passage was presented in sans serif font with different font sizes (at 2, 4, 6, 8, 10, 12, 14, 16 points). Reading speeding, the number of correctly identified words and preference were measured. They found that there was no significant difference in reading time and the number of correctly identified words between font sizes from 6 point to 16 point nor between age groups and they also found that older participants preferred font size at a range of 9 to 12 points but younger participant preferred font size at a range of 9 to 11 points. Overall, they recommended that font sizes in the range of 8 to 12 point were suitable for general users.

In contrast, Kong et al. (2011) evaluated the effect of age, viewing distance, display type, font type, colour contrast and number of syllables on the legibility of Korean characters with ten younger participants aged over 20 years and ten older participants aged over 60 years. The font size ranged from 2 point to 80 point. Each participant was asked to try to read letters which were presented on paper or LCD monitor (see Figure 2.9) in a dark room and rate discomfort while reading using a four point scale (1: no discomfort to 4: most discomfort).

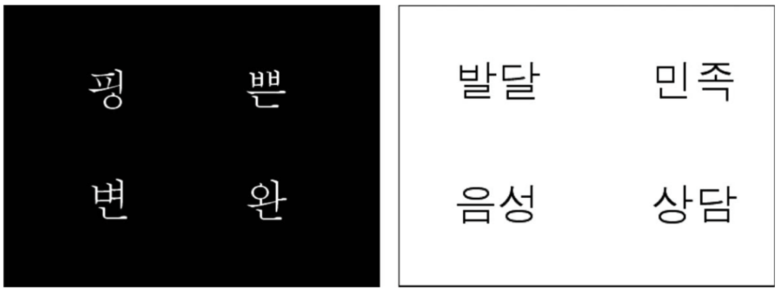


Figure 2.9 Examples of presentation cards (a) One syllable (white on black, Ming font) and (b) Two syllables (black on white, Gothic font) (source: Kong et al, 2011)

For font size, Kong et al. (2011) found that in terms of accuracy 10.2 point and 21.5 point fonts should be used for younger and older people respectively, but in terms of comfort 13 point and 24 point fonts should be used for younger and older people, respectively. Thus, younger people could read letter sizes approximately half the size than those read by older people.

Lin et al. (2013) investigated how legibility and visual fatigue are affected by different text directions, screen sizes and character sizes. There were 60 Chinese participants who were students in high school, aged 15 to 16 years. The Chinese texts were presented horizontally and vertically in Ming font with different character sizes of 8, 10, 12 and 14 point and screen sizes of 6, 8.1 and 9.7 inches (using an iPad). The participants read text and searched for target words in pseudo-text. Dependent variables including search time, accuracy and subjective visual fatigue were recorded. Text direction, screen size and character size all exerted a significant effect on participants' search time. For 6 inch and 9.7 inch screens, 12 point text produced the shortest search time and 12 point was also the best for accuracy. Whereas the smallest character size, 8 point, was the main cause of visual fatigue. Moreover, the researchers suggested that font size on tablets should be 12 point and 14 point size for Chinese younger people.

Kamollimsakul (2014) investigated some of the recommendations from the web design guidelines for older people. He conducted three studies as part of his investigations. In the second study, he investigated the effect of font type and font size on skim reading webpages by younger and older people in the UK and Thailand. There were 30 UK participants (18 younger people aged 18 to 33 years and 12 older people aged 65 to 87 years) and 42 Thai participants (21 younger people aged 21 to 39 years and 21 older people aged 60 to 76 years). Each participant skim read six texts on a website about the Olympic Games and then answered four multiple choice questions. Each text was presented in a different combination of font type and size. The dependent variables were time spent per webpage and the number of correct answers. Participants also rated their preference for the combinations of font sizes and font types. Kamollimsakul found that there was no significant effect of font size in time spent per webpage, but serif font produced significantly faster skim reading times per web page than sans serif font. In addition, there was no significant effect of font size and type on the number of correct answers. However, older participants preferred 16 point text the most. In addition, serif font was rated significantly higher in preference than sans serif for the UK participants while Thai participants rated Thai serif font significantly higher than Thai sans serif.

Asawasakulsorn and Chatrangsan (2014) examined the effects of Thai serif and sans serif typefaces (see Figure 2.10 and Figure 2.11) at font size of 12, 14 and 16 point on reading from a tablet computer. The participants, aged between 19 and 22 years, undertook tasks with an inventory application which presented different font types and font sizes. Dependent variable was time to complete a task. There was a significant difference in time taken between font size 12, 14 and 16 point only for the serif font and there were no significant differences in the time between font sizes for the sans serif font (see Figure 2.12). Asawasakulsorn and Chatrangsan (2014) recommended that Thai website designers should select 16 point font size for Thai Serif typeface fonts to maximize readability on tablets, but designers can select any font size in the range of 12 to 16 point for Thai sans serif fonts.

ก ช ม ร ณ ส

Figure 2.10 Example of Thai serif font
(source: Asawasakulsorn and Chatrangsan, 2014)

ก ช ม ร ณ ส

Figure 2.11 Example of Thai san serif font
(source: Asawasakulsorn and Chatrangsan, 2014)

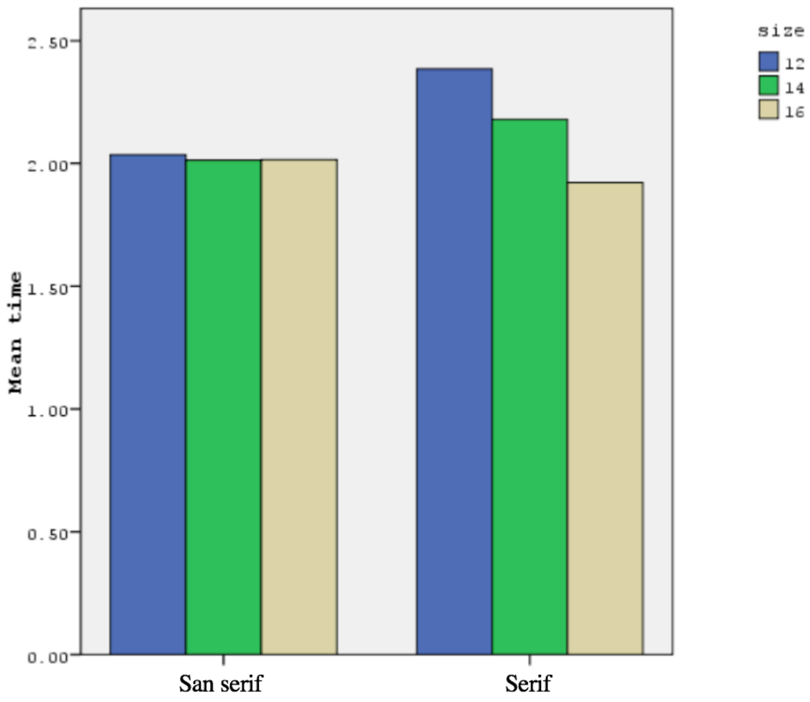


Figure 2.12 Time to complete the assigned task
(source: Asawasakulsorn and Chatrangsan, 2014)

Lege et al. (2013) examined the readability of Japanese characters on two tablets (iPad2 and iPad3) and printed on paper with both younger and older Japanese people. All participants held the tablet or paper on a board with their own hands and sat on a chair with a comfortable position for reading. Participants read aloud the Japanese characters with three different font sizes: 8, 10.5 and 18 points. For tablets, the largest characters, 18 point size, increased reading speed for older participants but it is not clear from the paper whether this is a significant effect. When character size was small, 8 point size, the younger participants shortened their viewing distance; however, the reduction of the viewing distance was less in older participants. The results also show that tablets were slightly more readable than paper and that older participants preferred the tablets to reading from paper. Thus, the researchers concluded that 18 point text should be used on tablets for older adults.

Rello et al. (2016) examined the effect of font size and line spacing on objective and subjective readability and comprehension of English texts. The texts were presented in Arial font with different font sizes, ranged from 10 to 26 points (as six levels: 10, 12, 14, 18, 22 and 26 points) and different line spacings, ranged from 0.8 to 1.8 (as four levels: 0.8, 1.0, 1.4 and 1.8). The 104 participants aged 14 to 54 years took part in the study. Each participant read six English texts with the same line spacing, but six different font sizes on a desktop computer screen. After reading each text, participants answered six multiple-choice questions. Finally, the six texts were presented to participants again and they rated their readability and comprehension on a five-point scale (1: very difficult to 5: very easy).

The dependent variables were eye gaze fixation duration, reading comprehension, and participants' perception of readability and comprehension (as rating on a five-point scale). The researchers found that participants had significantly lower comprehension scores for 10 and 12 point sizes than for 18 point. The smaller font sizes (10, 12 and 14 point) had significantly longer fixation durations than the larger font sizes (18, 22 and 24 point). In addition, the mean fixation duration decreased until 18 point font size. They also mentioned that up to 18 point font size, readability as well as comprehension improved but there was no improvement for bigger font sizes (22 or 26 point). Although, the effect of line spacing on fixation duration and readability rating failed to show significant differences, but 0.8 and 1.8 line spacing negatively affected comprehension scores and comprehension ratings. Finally, comprehension was impaired by the largest line spacing, so the authors recommended that moderately larger line spacing such as 1.5 spacing to ensure readability and comprehension.

As discussed above, Bernard (2001) recommended the use of 14 point English text for older people. This is similar to the web design guidelines for older people (Zaphiris et al., 2006; 2005; The National Institute on Aging (NIA) and (NLM), 2002; Setting Priorities for Retirement Years Foundation (SPRY), 1999) which recommended that 12 and 14 point should be used for body text for older readers (see section 2.8). Darroch et al (2005) recommended that 9 to 12 point should be used for text presentation on a small screen (PDAs) for older readers.

In addition, Kamollimsakul (2014) recommended that 16 point English and Thai text should be used for older people while Kong et al (2011) recommended the use of 21 and 24 point Korea font for accuracy and comfort for older people. However, two studies recommended using 18 point size font, one study on Japanese text presentation on tablet screens for older people (Lege et al., 2013) and another latest study on English text presentation on desktop computer for people aged 14 to 54 years (Rello et al., 2016).

For younger people, 12 point English text was recommended (Bernard et al., 2003) and 9 to 12 point font was recommended to present texts on a small screen (PDAs) (Darroch et al., 2005). Lin et al. (2013) suggested that 12 point and 14 point size Chinese text for tablets for younger people while Kamollimsakul (2014) recommended that 16 point English and Thai text should be used for younger people. In addition, Asawasakulsorn and Chatrangsan (2014) suggested that 16 point for Thai serif font should be used to present the text on tablet computer for younger Thai readers. Table 2.11 shows a summary of research-based recommendations for font size presentation for both younger and older people.

Table 2.11 Summary of recommendation for font size presentations of each language for both younger and older people

Languages	Font sizes (point: pt)		Devices	References
	Younger	Older		
English	N/A	14 pt	Desktop	Bernard et al (2001)
	12 pt	N/A	Desktop	Bernard et al. (2003)
	9 to 12 points	9 to 11 points	PDAs	Darroch et al (2005)
	N/A	12 and 14 pt	Desktop	Zaphiris et al., (2006; 2005) The National Institute on Aging (NIA) and (NLM), 2002 Setting Priorities for Retirement Years Foundation (SPRY), 1999
	16 pt	16 pt	Laptop	Kamollimsakul (2014)
	18 pt	N/A	Desktop	Rello et al. (2016)
Thai	16 pt (Thai serif)	N/A	Tablet	Asawasakulsorn and Chatrangsan (2014)
	16 pt	16 pt	Laptop	Kamollimsakul (2014)
Korea	10.2 and 13 pt	21.5 and 24 pt	Desktop	Kong et al. (2011)
Japanese	N/A	18 pt	Tablet	Lege et al. (2013)
Chinese	12 and 14 pt	N/A	Tablet	Lin et al. (2013)

Note: N/A indicates not applicable

As discussed above, only three studies focused on tablet computer screens (Lege et al., 2013; Lin, Wu and Cheng, 2013; Asawasakulsorn and Chatrangsan, 2014), but only one study for Thai and no study for English have been found. Thus can be seen that it is still not clear which font size is optimal for tablet computer presentations for older people, either in English or Thai languages.

2.9.2 Research on the effect of font types

Ling and van Schaik (2006) investigated the effect of font type and line length on visual search and information retrieval in web pages. The independent variables were two levels of font types/size (Arial font at 10 point and Times New Roman font at 12 point) and four levels of line length (55, 70, 85 or 100 Character per line (CPL)). The dependent variables were accuracy (the percentages of correct answers), speed and aesthetic appeal measured by four ratings. They conducted two experiments. In the first experiment, there were 72 participants aged 26 to 50 years. Thirty-nine took part in the Arial condition and 33 took part in the Times New Roman condition, both with a visual search task. Participants were asked to find a hyperlink on the web pages as quickly and as accurately as possible and no restrictions were placed on the distance participants were seated away from the desktop computer screen. The researchers found that there was no effect of font type on speed or accuracy; however, participants preferred Arial over Times New Roman and also rated Arial as having a higher level of aesthetic value. For line length, they found that long line length (85 – 100 CPL) led to quicker search but reduced accuracy. In addition, participants preferred shorter line lengths over longer line length.

In the second experiment, there were 99 participants with a mean age of 24 years. Fifty-two participants performed an information retrieval task in Arial text and 47 participants in Times New Roman. Participants were asked to complete a series of 40 randomised questions using five websites related to sport, shopping, music, software and computer equipment. When participants found the answer, they had to click the “Your answer” button for typing the answer (see Figure 2.13). After the session, participants completed the aesthetics scale for each line length and chose their preference for line length and font type as in the first experiment. Ling and van Schaik (2006) found that the main effects of line length and font type were not significant for speed, accuracy or aesthetic value. However, the effect of line length was significant for both Arial and Times New Roman. Participants preferred shorter line length over long line length in both font types. From these two experiments, the researchers recommended that Arial font should be used for younger readers. For line length, longer line lengths (85 – 100 CPL) should be used for scan reading while shorter line lengths (55 – 70 CPL) should be used for more thorough reading for younger readers.

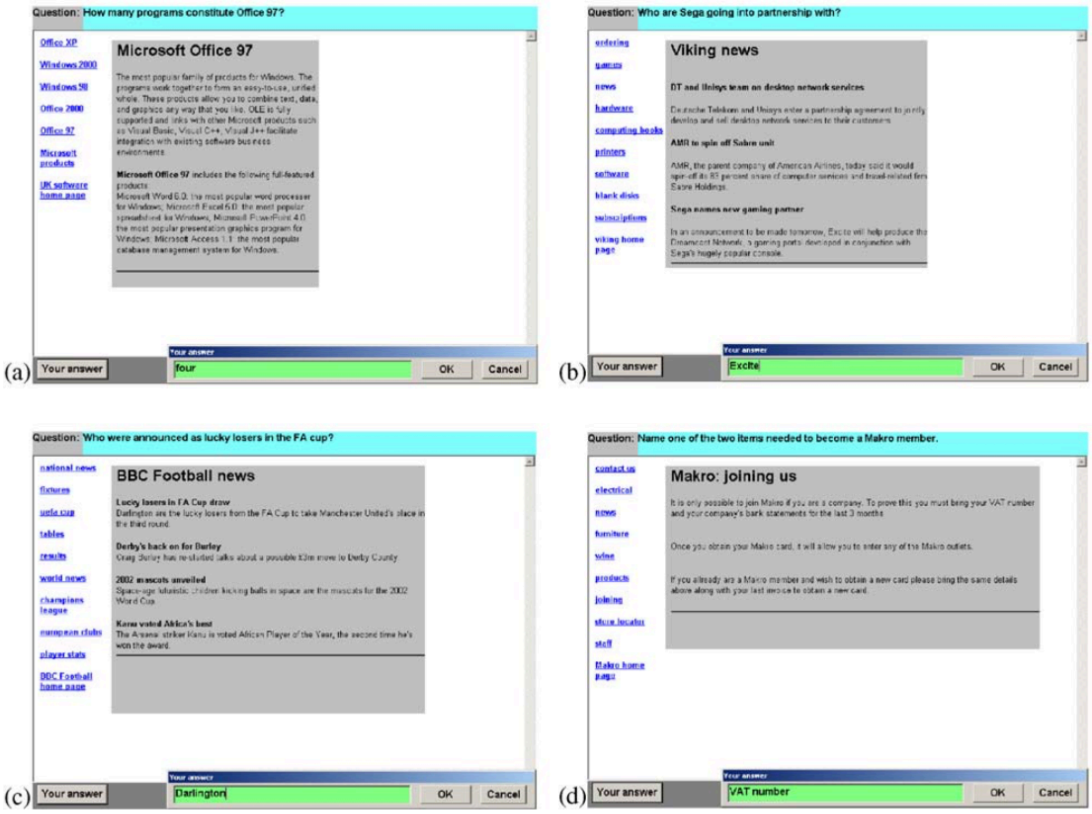


Figure 2.13 Examples of web page were presented in Arial: (a) 55 CPL (b) 70 CPL (c) 85 CPL and (d) 100 CPL in the second experiment (source: Ling and van Schaik, 2006)

Joshi, Kaurand and Wason (2014) studied font legibility for printed text and onscreen text with 39 younger participants aged 20 to 25 years. They used the ten most popular fonts installed on all computers and other devices as determined by a Microsoft survey. Participants read the same passage of text in ten different fonts on a computer screen and hard copy documents. It was perhaps not a good idea to have participants read the same passage 10 times, as they would become very familiar with the text. The researchers found that Arial and Microsoft sans serif had almost the same legibility as printed text and were more readable than other font types. Lucida Sans was the most legible for online reading. Thus overall, this study found that sans serif fonts were faster for online reading.

Ali et al. (2013) evaluated the effect of serif and serif fonts for Malaysian text readability on websites. There were 48 Malaysian undergraduate participants in the study. The participants read two passages as quickly as possible, each containing 140 words at the same level of reading difficulty. The experiment measured the time taken and accuracy in reading passages. There was no significant difference between the readability of serif and san serif font for younger adults.

Research by Bernard et al (2003), Ling and van Schaik (2006) and Kamollimsakul (2014), discussed above, also recommended that san serif fonts should be used for presenting English text on computer screens for younger people, while Ali et al. (2013) found that there was no significant difference between readability of serif and sans serif font in term of Malaysian text on computer screen for younger people. However, the web design guidelines (Loureiro and Rodrigues, 2014; Zaphiris et al., 2006; 2005; The National Institute on Aging (NIA) and (NLM), 2002; Setting Priorities for Retirement Years Foundation (SPRY), 1999) and Kamollimsakul (2014) also recommended that san serif fonts should be used for older people. In addition, Bernard et al. (2001) found that serif fonts were generally preferred less than san serif by older adults.

For the Thai language, Kamollimsakul (2014) recommended that Thai serif fonts should be used for both Thai younger and older people. However, Asawasakulsorn and Chatrangsan (2014) found that there was no significant difference in reading time between serif and san serif fonts for younger people. Thus it can be seen that there is still no clear recommendation for font type presentation on tablet screen for older people, in particular for Thai font type. However, there are many font types available and more are being designed and there are also differences between English and Thai font types. Thus, classification of font types for each language will be presented in section 2.10.1.

2.9.3 Research on the effect of columns formats and line lengths

Dyson and Kipping (1997) conducted research on the ease of reading different column formats and the use of pages or scrolling for online publications in English such as magazines. There were 18 young participants aged between 18 and 44 years in the study. The texts were presented in 10 point size Arial font with two different column formats: single column (approximately 80 characters per line (CPL)) and three columns (approximately 25 CPL) and two different screen formats: a scroll bar format and page format. In the scroll bar format, participants pressed on the up or down arrow keys to change the position of the text on the screen for reading. In page format, the same down arrow key replaced the screen of text with the next page of the document. The up-arrow key returned to the previous page of text. Each participant read silently three documents on a desktop computer screen, two documents presented in one column with different screen formats (a scroll bar format and page format), and another one presented in three columns with page format. Then they answered questions about each text. After that, participants were asked to say which format was easier to read. The authors found that for the youngest participants (aged 18 to 24 years) paging format was faster than scrolling format. In addition, participants read the single column significantly faster than three columns with paged format although there was no difference in comprehension. Participants preferred three columns format and also found it was significantly easier to read than single column.

Zaphiris and Kurniawan (2001) examined the effect of column layouts on reading speed and preference when reading on paper and on screen. There were 42 participants with three different age groups: 14 young age group (18 – 40 years), 14 middle-aged group (40

– 65 years) and 14 seniors age group (65 years and above). Participants in each age group were separated in equal numbers of participants into two conditions (one condition was the reading task on a desktop computer screen and the other condition was the reading task on paper). Each participant read three topics in three different column layouts (one, two and three columns). After reading each topic, participants were asked to answer the three questions about the topic. Participants then chose their preference of the column layout. The researchers found that there was no significant overall difference among the three layouts in reading speed for paper reading or screen reading. However, participants read significantly faster on paper than on screen for text presentation in one- and two-column layouts (see Figure 2.14). However, the research mentioned that the difference between reading on the paper and screen for one and two column layouts may be because when reading online text in only one column, the line lengths are long and participants can easily become lost and need to read the same text over again.

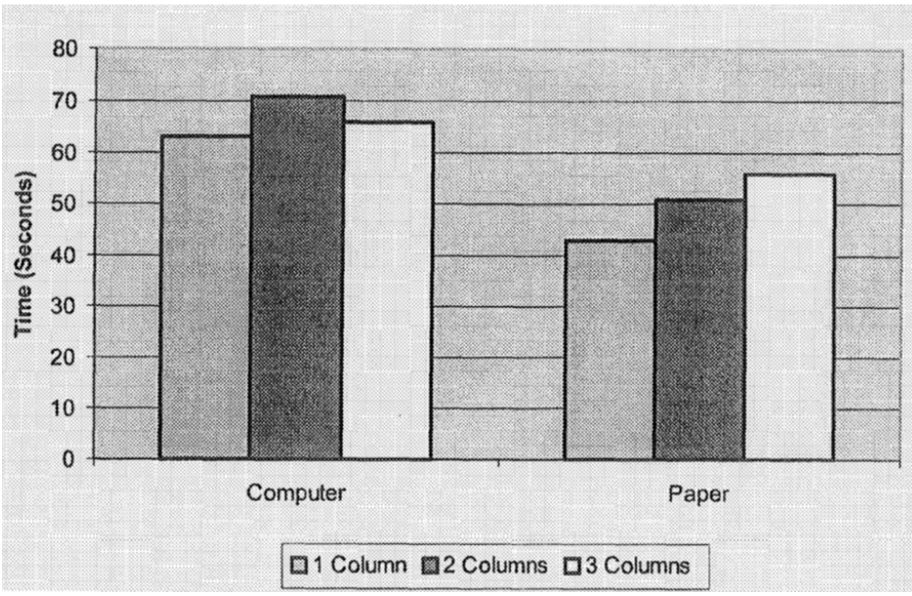


Figure 2.14 Average reading time on computer and paper
(source: Zaphiris and Kurniawan, 2001)

Baker (2005) investigated the effect of multi-column formats and justification on reading performance and satisfaction of online reading with sixty-six undergraduate students. Participants read a passage of 2191 words in six different combination of column formats and text justifications. The dependent variables were column formats (one column: a width of 90 CPL, two columns: 45 CPL; and three columns: (30 CPL) and text justifications (left justification and left–right justification). The dependent variables were reading speed (words per minute), reading comprehension (the number of questions about each passage answered correctly), reading efficiency (reading speed by percentage of correct answers), and satisfaction. The participants read one of six versions of a passage at distance of 60 centimetre from the screen and displayed in 10 point Verdana font.

Baker (2005) found that participants read two columns with left–right justification significantly faster than one column with left–right justification. In addition, participants read one column with left justification significantly faster than one column with left–right justification or three columns with left–right justification (see Figure 2.15). However, there were no significant main effects for either text justification or column format for reading efficiency, reading comprehension and overall satisfaction.

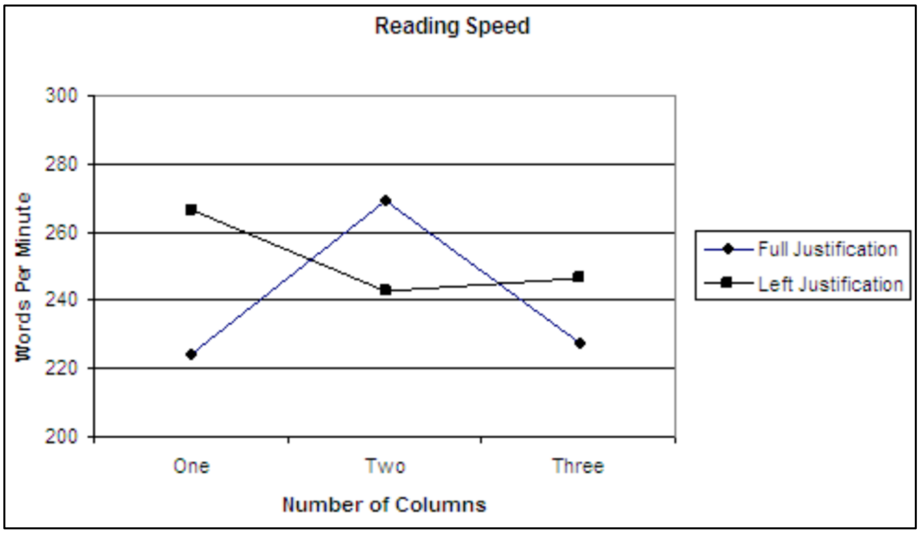


Figure 2.15 Effect of column formats and text justification combinations on reading speed for participants (source: Baker, 2005)

Yi, Park and Cho (2011) examined readability, comprehensibility and satisfaction of reading due to number of columns and line spacing. Twelve Korean undergraduate students who could read English, aged 22 – 27 years participated in this experiment. Each participant was asked to read six English texts and were given freedom in their manner of reading. The texts were presented in 10-point Arial font. The six texts were presented in different combination of column layouts (One column and Two columns) and line spacing (1, 1.5 and 2). The researchers gave the participants the topic of the text and then participants took a pre-test about the topic. Next, they read a given text for two minutes and then took a post-test about the topic. After that participants were asked to rate the text for readability, perceived reading speed, ease of understanding and satisfaction. The comprehensibility was measured by scores of pre-test and post-test. The researchers found that most participants significantly preferred one column reading for readability, while there was no significance effect for line spacing. However, there was a significant interaction between column layout and line spacing in readability rating (see Figure 2.16).

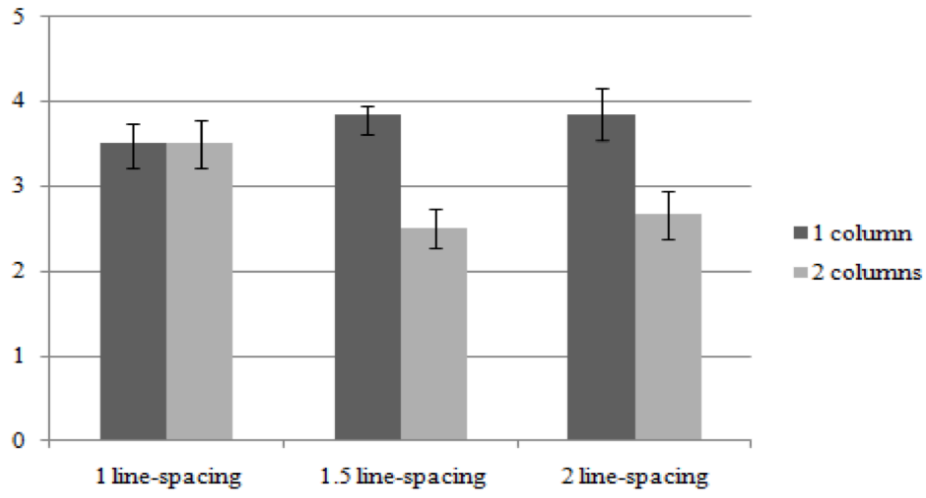


Figure 2.16 Average rating of column layout and line spacing combinations on readability for participants (source: Yi et al., 2011)

In addition, Yi et al (2011) found that there was no significant effect of either column layouts or line spacing on learning and perceived reading speed but the interaction between the column layouts and line spacing was significant for perceived reading speed. For satisfaction, most participants significantly preferred the one column with 1.5 line spacing. However, the researchers stated that one column with 1.5 line spacing is the best for readers.

Kuhna, Kivela and Oittinen (2012) evaluated three prototypes of iPad magazines with different layout, navigation and interaction in relation to usability, readability and visuality with forty undergraduate and post-graduate students (mean age: 25 years). The three protypes were manual, automatic and responsive. A test magazine was created with the three different designed layouts. The manual and automatic prototypes presented mainly two columns text with left-right justification while responsive prototype presented mainly one column text with left justification (see Figure 2.17). Each participant interacted with two of the three magazine prototypes (manual or automatic prototype and responsive prototype). Participants browsed at least 10 of 22 articles provided and then read one article more thoroughly. After approximately 10 minutes of interaction with the magazine on the first prototype, participants answered the System Usability Scale questionnaire (SUS) for only first prototype. Then participants browsed at least 10 articles with the second prototype for 5 minutes. Participants were asked to choose four views in which they gave comments about the layout in comparison to the previous prototype. Participants then completed a layout questionnaire on a seven-point Likert scale (-3: fully disagree or too little to +3: fully agree or too much) for each screenshot. In addition, participants were asked to comment on each layout prototype.

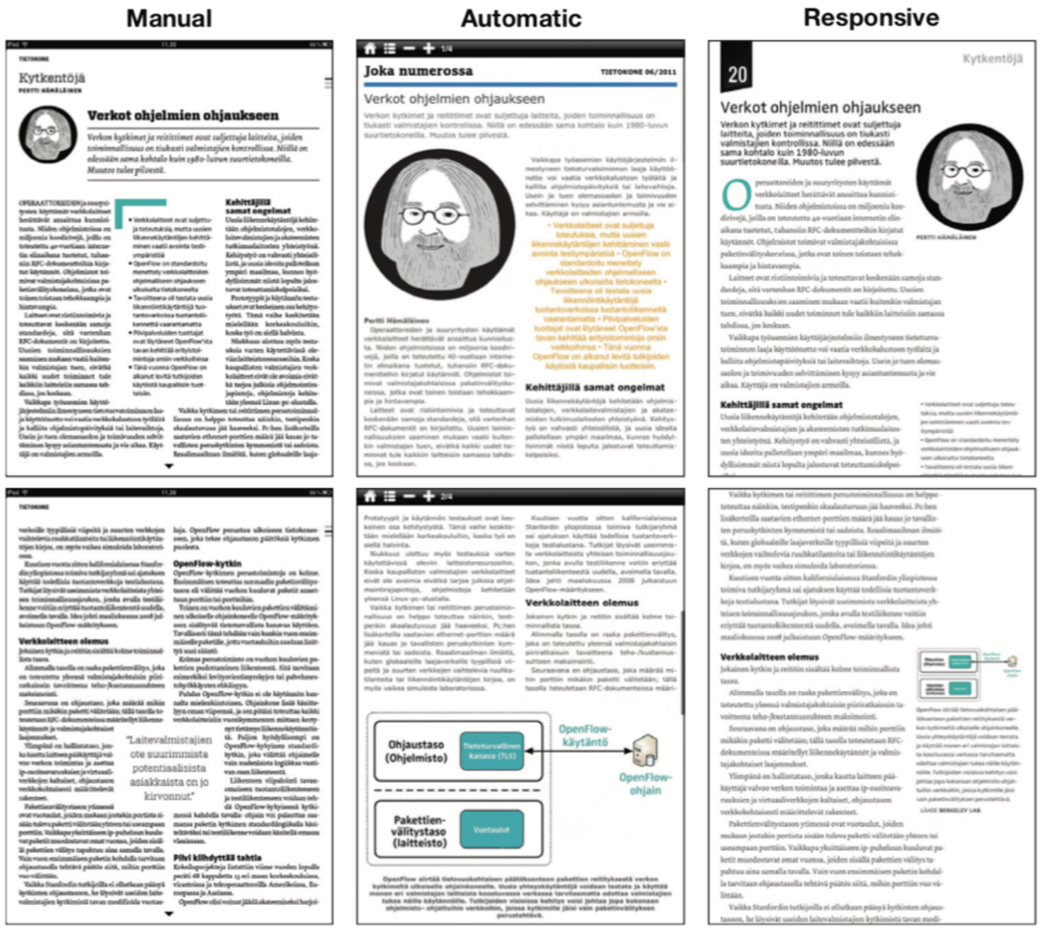


Figure 2.17 Examples of three layouts of magazine solutions with a text heavy article (source: Kuhna et al., 2012)

There were no significant differences between the three magazine layouts on the SUS questionnaire. For the layout questionnaire, the responsive prototype received significantly the higher scores for clarity of the layout, use of colours, readability and font type. For comments, the number of positive and negative comments resulted in a significant difference between three solutions. The responsive prototype received clearly positive comments in relation to readability compared to the other prototypes (see Figure 2.18).

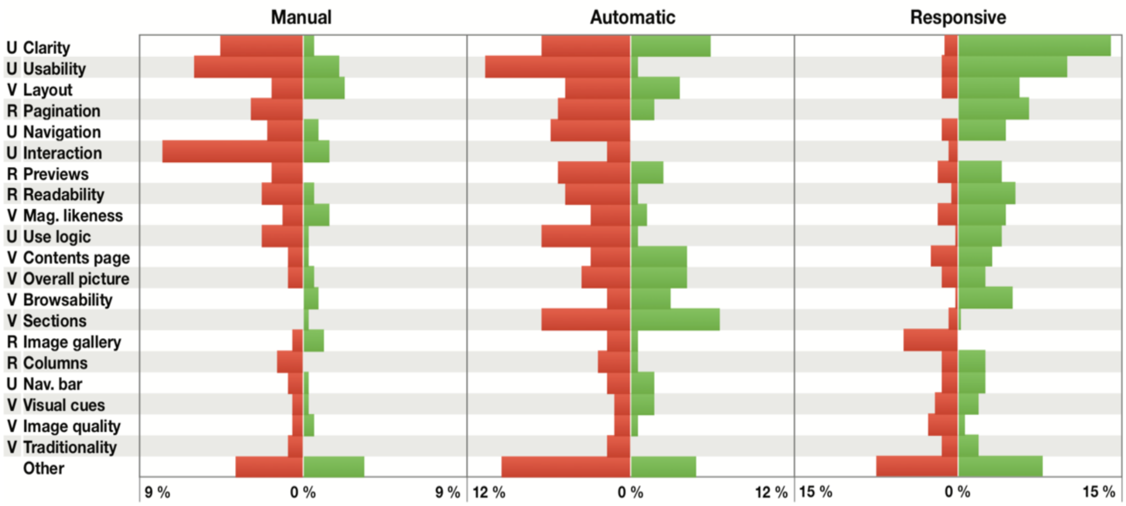


Figure 2.18 The total number of comments for the manual, automatic and responsive prototypes. Red bar = negative comments and Green bar = positive comments. U = Usability, R = Readability and V = Visuality (source: Kuhna et al., 2012)

In terms of line length, Chan et al. (2013) investigated the effects of line length, number of lines and line spacing on Chinese screen-based proofreading performance and amount of scrolling. There were 39 participants between aged 21 to 26 years. The texts were displayed with different line lengths: 26, 36 and 46 CPL; different line spacing: 1, 1.5 and 3 and different number of lines: 2, 4 and 8 lines. Participants proofread passages carefully and highlighted errors in the passages as quickly as possible (see Figure 2.19). The number of lines and line spacing had significant main and interaction effects on both proofreading time and error detection rate, while line length had no significant effect. However, the researchers suggested that for Chinese the display should be set line length at 36 CPL with 1.5 line spacing to balance time and detection rate and thus improve performance on proofreading on a computer screen.

Figure 2.19 Examples of experiment (source: Chan et al., 2013)

Sahito et al. (2015) examined the effects of four different line lengths (30, 60, 90 and 120 CPL) on reading speed and reading efficiency. There were 70 participants aged 20 to 40 years in this study. The text was presented in Times New Roman at 12 point. Participants read text and were asked to detect deliberately placed erroneous words. They were also asked to rate their reading experience. Most participants preferred 90 CPL when reading text on a tablet. Participants aged 30 to 40 years preferred 60 CPL and participants aged 20 to 30 years preferred 90 CPL followed by 120 CPL. Moreover, many participants of the older age group found that long lines on a tablet computer were difficult to read, so the researchers recommended that 90 CPL should be used for reading from a tablet.

In term of line length, Ling and van Schaik (2006) recommended for younger people reading in English, 85 – 100 CPL (as typical of line length when text is displayed in one column) should be used for scan reading, while 55 – 70 CPL (as typical of line length when text is displayed in two columns) should be used for thorough reading. The Silverweb guidelines recommend that short line lengths should be used for older readers (Zaphiris et al., 2006; 2005). In addition, Chan et al. (2013) suggested that the length of Chinese texts should be approximately 36 CPL (as typical of line length when text is displayed in three columns) for text presentation on computer screen for younger people. However, Sahito e al. (2015) recommended that 90 CPL should be used for English text presentation on tablet screen.

Overall, one-column format was recommended to use for text presentation on screen for younger people (Dyson and Kipping, 1997; Yi et al., 2011) while Baker (2005) recommended two columns for fast reading for younger people. In addition, Dyson and Kipping (1997) found that younger participants preferred three columns. Finally, Zaphiris and Kurniawan (2001) found there was no significant difference in reading time for one, two and three columns for older people. There are no recommendation or evidence for column format presentation on screen in the Thai language for older people. Thus, column format will be another variable to investigate the effect on reading in the current programme of research.

2.9.4 Research on the effect of text justification

Ling and van Schaik (2007) examined the effect of line spacing and text alignment on online behaviour and preferences to generate design guideline for web pages. There were 65 undergraduate participants aged 26 to 50 years in the study. Twenty-six took part in the left-justified text condition and 39 took part in the left-right justified text condition. The authors stated that sample sizes were unequal because participants were allocated to between-subject factor per class and class sizes differed. The independent variables were three levels of line spacing (1, 1.5 and 2) (a within participants variable) and two levels of text alignment (left justified and left–right justified) (a between participants variable). The dependent variables were accuracy, speed and aesthetic appeal measured on four rating scales. The texts were presented in 10 point Arial font. Participants were asked to find a hyperlink on the web pages as quickly and as accurately as possible (the procedure was the same as their previous study (Ling and van Schaik, 2006, discussed in Section 2.9.2). Increasing wider line spacing produced reading times which were significantly faster and more accurate. In addition, although left-justified text produced better performance, participants preferred left–right justified text.

Moreover, as discussed in Section 2.9.1, Kamollimsakul (2014) conducted three studies to create web design guidelines for older people. In his first study, Kamollimsakul investigated the effect of line spacing (1, 1.5 and 2 line spacing) and text justification (left justified and left–right justified) on reading webpages with younger and older people in the UK and Thailand. The dependent variables were time spent per webpage, number of webpages visited and percentage of correct answers. There were 24 UK participants (12 younger people aged 24 to 31 years and 12 older people aged 65 to 78 years) and 36 Thai participants (18 younger people aged 20 to 38 years and 18 older people aged 60 to 76 years) in the study. Each participant undertook all six tasks and each task was presented in a different combination of line spacing and text justification. The tasks were finding items about the Olympic Games on a website (see Figure 2.20). At the end, participants rated their preference and overall reading experiment on five-point Likert scales for each combination of line spacing and text justification.

Figure 2.20 Example of hyperlinks on the experiment website for finding correct answer: blue rectangle was a correct hyperlink (source: Kamollimsakul, 2014)

Kamollimsakul found that line spacing and text justification had no significant main effect on the time spent per webpage and percentage of correct answers for either UK or Thai participants. On preference, UK and Thai participants significantly preferred 1.5 or 2 line spacing. For text justification, they significantly preferred left-right justification. There was also no significant difference between left and left–right justification in reading experience rating for UK participants while there was a significant difference between left and left-right in the rating for Thai participants. The researcher recommended that 1.5 or double line spacing should be used on the web for both younger and older adults in the UK and Thailand. For text justification, left–right justification should be used for Thai younger and older adults while either text justification (left or left – right) should be used for UK younger and older adults.

As discussed above, although Baker (2005) found that there was no significant main effects in reading speed, comprehension score and overall satisfaction between left and left–right justification for younger participants, he found two columns with left–right justification produced reading times significantly faster than one column with left–right justification. In addition, one column with left justification produced reading times significantly faster than one column with left–right justification or three columns with left–right justification. Thus the effect text justification may interact with the number of columns or the line length of text for younger readers.

Ling and van Schaik (2007) found that left justified text produced better performance; however, participants preferred left-right justified text. In addition, Kuhna et al. (2012) found that younger participants rated the main one column text with left justification layout of one of three online magazine prototypes easier to read than other prototypes which were presented in two columns text with left-right justification. Moreover, Kamollimsakul (2014) who recommended left–right justification for Thai younger and older adults while both text justifications (left or left–right) should be used for UK younger and older adults. However, the web and interface design guidelines recommend that left-justified text should be used for older readers (Loureiro and Rodrigues, 2014; Zaphiris et al., 2006; 2005; The National Institute on Aging (NIA) and (NLM), 2002; Setting Priorities for Retirement Years Foundation (SPRY), 1999). Thus, column format will be another variable to investigate for its effects on reading in the current programme of research.

2.9.5 Research on the effect of line spacing

As discussed above, Yi et al. (2011) investigated the effect of number of columns and size of line spacing in English texts on readability, comprehensibility and satisfaction with Korean undergraduate students. The researcher recommended one column text with 1.5 line spacing. In addition, 1.5 line spacing was also recommended for Chinese text for younger readers (Chan et al., 2013). In addition, the first study by Kamollimsakul (2014) recommended 1.5 or double line spacing for presenting text on screen for younger and older people in the UK and Thailand. Thus, all the latest research with a number of different types of devices and in a number of different languages, 1.5 line spacing recommended for English text presentation on screen. Therefore, the 1.5 line spacing will be used in the studies of text presentations on tablet computers in the current programme of research.

2.9.6 Research of the effect of text and background colours

Gradisar, Humar and Turk (2007) investigated the impact of text and background colour combinations on the legibility of text on a web page. There were 477 students aged 18 to 21 years in the study. They used main eight colours: white, yellow, red, magenta, blue, cyan, green and black. The independent variables were 56 combination of text and background from the eight colours. Participants were divided into six groups. The first four groups experienced 10 colour combinations, while the last two groups experienced only 8 colour combinations. A black on white background was added to each group as a baseline. Participants were asked to identify characters displayed on a 21-inch Dell CRT display (resolution: 1280 x 1024 pixels) and speak them out. Participants sat at distance of 1 metre from the screen.

The best results were with yellow text on black background, cyan on black, white on blue, black on yellow, white on black, and green on black. In addition, a lighter text on a darker background resulted in a lower mean number of correct answers than a darker text on lighter background. Moreover, the colour combinations with either black or white background and one of the remaining seven colours for text were compared. The mean number of correct answers of the combination with black background was significantly higher than the combination with white background. Then the combination with either black or white colour for text and one of the remaining seven colours for background were compared. The mean numbers of correct answers of the combination with black text was significantly higher than those with white text.

Greco, Stucchi, Zavagno and Marino (2008) investigated the effect of the combination of text and background colour on the legibility of texts. There were three experiments. For the first experiment, 30 participants aged 18 to 56 years took part. Nine colours (blue, green, yellow, red, violet, brown, grey, black, and white) were used from 27 colours available in Microsoft PowerPoint. 13 colours were categorised as dark and the other 14 colours were categorised as light. Japanese words in 24 point with 1.5 line spacing were presented on a laptop screen. Participants read words in 702 colour combinations and rated their legibility on a three point rating scale (1: unsatisfactory, 2: passable and 3: excellent). Light text on dark background or dark text on light background obtained mean ratings of legibility greater than the dark text on dark background and light text on light background. In addition, dark text (as black and blue text) on light background was rated as the most legible. In addition, among the light texts on dark backgrounds, brown, green, blue and black were the most legible while violet was the least legible.

For a second experiment, the same researchers examined the effect of the combination of text and background colour on pleasantness. They used the same 702 colour combinations from the first experiment. There were 30 participants aged 18 to 55 years. None of the participants had participated in the first experiment. The procedure the same as the first experiment but participants rated pleasantness on a three point rating scale (1: ugly, 2: passable and 3: very fine). Dark text on light background was rated as the most pleasant. The black and blue texts were the most pleasant text colours and the light red was also the most pleasant background; but colour combinations with yellow background were rated as not pleasant.

For a third experiment, they examined light text on dark background and dark text on light background on legibility There were 31 participants aged 18 to 27 years and none of the participants had participated in their previous two experiments. There were 364 colour combinations. The Japanese words were presented on a white wall via a large projector in different lighting conditions (dark, half-light and bright). The 364 combinations were presented in each lighting condition. Participants rated the legibility for each colour combination on a nine point rating scale (1: less legible to 9: most legible). In this study, the authors only focused on the effect of colour on legibility on the dark condition. The results of legibility of text was not so contradict with results of the first and second experiment. White background had the best rating for legibility for all text colours and black and blue text had the highest ratings with all background colours. From these three experiments, Greco et al. (2008) found that dark text (black or blue) on light background was the most legible and pleasant, independent of lighting condition.

Yamazaki, Koizumi, Shimada and Eto (2014) examined the effect of white and light blue background on web-based English grammar tests and circle-counting tasks. Thirty Japanese university students participated in the study. All participants took the English tests with black text on light blue and white background colours. Each participant's brain activity was measured and recorded by using Hitachi NIRS (EGT-400) with 52 channels to assess the activation of brain functions associated with the blood haemoglobin concentration (see Figure 2.21). The average percentages of correct answers for both English tests and circle counting tasks for light blue background were higher than those for white background. In addition, the researchers found that participants performed better when they responded to questions in black text on light blue background than on white background. The result of blood haemoglobin concentration changes in the participants' brain areas associated with linguistic processing were more activated for grammar questions in black text on light blue background.

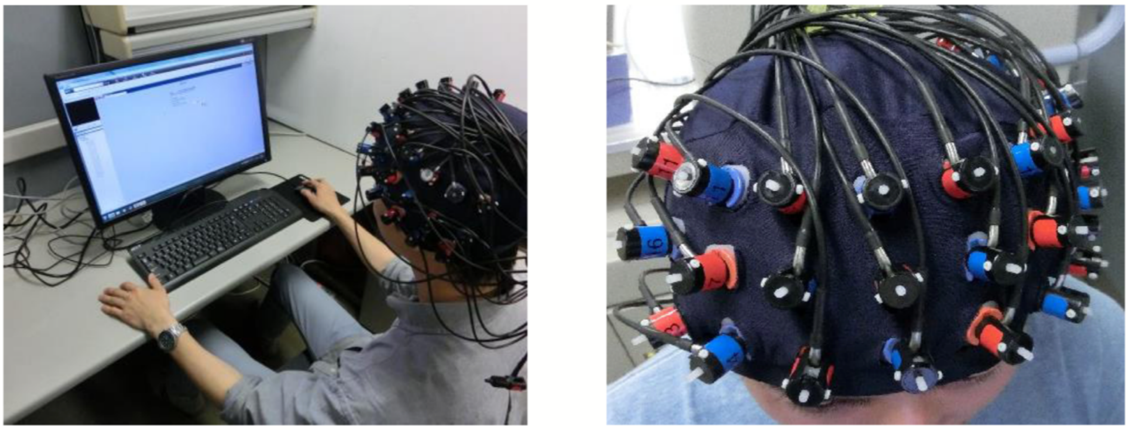


Figure 2.21 During participant performed the task and wore the headgear to monitor the activity of the participant's brain (source: Yamazaki et al., 2014)

In addition, Yamazaki and Eto (2015) noted that the background colour of a tablet screen can make a difference in the reading performance. They conducted a preliminary experiment to see how different background colours on tablet computer screens can affect attention for older people. Ten Japanese participants aged over 65 years performed circle-counting tasks on a tablet with white, blue and light blue background and the circles presented in black. The participants counted the number of circles in a short period time and then answered questions on fatigue, concentration and readability. The mean percentage of correct answers was higher with the blue and light blue backgrounds than with a white background. In addition, participants were able to concentrate most and felt least tired when counting black circles on the light blue background and they stated that the light blue background colour was the easiest to read. The researchers suggested that black text on light blue background should be used for older people and also that white background may not be the best choice for older people.

In addition, Kamollimsakul (2014) investigated the effect of text colour and background colour on skim reading webpages by younger and older adults in both Thailand and the UK. There were 27 UK participants (18 younger adults aged 18 to 36 years and 9 older adults aged 66 to 79 years) and 36 Thai participants (18 younger adults aged 19 to 29 years and 18 older adults aged 59 to 70 years) in this study. Participants undertook skim reading text on a website about the Olympic Games in which the pages were presented with different text and background colours (black/white, white/black and sepia/off-white) and then answered four multiple-choice questions. The dependent variables were time spent per webpage and the number of correct answers. After completing the tasks, participants rated their preferences for the different colour combinations on a five-point scale. There were no significant effects of text and background colour combination in time spent per webpage and percentage of correct answers. However, the overall preference of participants for black text and white background were significantly higher than both white text and black background and sepia text and off-white background.

Furthermore, Huang et al. (2013) investigated the effect of age on visual comfort for reading coloured documents displayed on an iPad2 tablet computer with 20 younger (aged 20 to 30 years) and 20 older (aged over 60 years) Taiwanese participants. There were two experiments, both conducted using the iPad placed at an angle of 15 degrees against a desk in a darkened room and at a viewing distance of 300 millimetres. The texts were presented horizontally but there was no mention of what the texts were. The participants made a forced choice between their preference for two layouts (see Figure 2.22). For the first experiment, the text and background colours were presented in greyscale combinations which were black, dark grey, medium grey, light grey and white. For the second experiment, the text colours were black, medium grey and white. The background colours were 18 colours: dark red, red, light red, dark yellow, yellow, light yellow, dark green, green, light green, dark cyan, cyan, light cyan, dark blue, blue, light blue, dark purple, purple and light purple. From the results of the two experiments, the researchers recommended that text and background colours on tablets should be use a moderate lightness or contrast difference between text and background colours for younger people and use large lightness or contrast difference between text and background colours for older people. Both experiments measured the lightness/contrast differences using the CIELAB system.

(a) (b)

Figure 2.22 Examples of screen layouts for (a) experiment 1 and (b) experiment 2 (source: Huang et al, 2013)

Overall, some researchers (Gradisar et al., 2007; Greco et al., 2008) recommended that the combination of light text and dark background should be used to present on the computer screen for younger people. In addition, Kamollimsakul (2014) recommended that black text on white background should be used for both UK and Thai older web readers. In addition, the web design guidelines recommend that the background should be not pure white (Dunn, 2006; Zaphiris et al., 2006; 2005) and that green and blue tones should be avoided for presenting text on websites for older people (Zaphiris et al., 2006; 2005; The National Institute on Aging (NIA) and (NLM), 2002; Setting Priorities for Retirement Years Foundation (SPRY), 1999). In addition, the one set of interface guidelines recommended that warm colours are the most suitable for older people (Loureiro and Rodrigues, 2014). However, this literature review found only one paper by Yamazaki and Eto (2015) which focused on presentation of colour combination on a tablet screen. They recommended that black text on light blue background should be used to present on tablet screens for older people. There is still a lack of evidence to support which text and background colour presentation is best on tablets for older people.

In summary, from the existing research and the web design guidelines, what recommendations for text presentation on tablet computers for older adults are still not clear. The research has covered numerous languages and the use of tablet computer is quite different from desktop computer, for example the environment of use, viewing distance, and mobility aspects. Thus, this research programme will investigate text presentations on tablet computers for older adults in English (in the UK) and in Thai (in Thailand). As discussed above, those text presentations will be the combination of font type and font size, the combination of the text and background colours and the combination of column format and text justification.

2.10 Font type and font size for Thai and Latin alphabets

There are many font types for the different languages in the world. However, this section discusses only font types and measurement of font size for Latin and Thai alphabets that will be used in the current programme of research.

2.10.1 Font type categories

Most font types for the Latin alphabet can be classified into the following seven families: Oldstyle, Modern, slab serif, San serif, Fringe, Script and Decorative (Miller, 2002). These font families are illustrated in Figure 2.23.

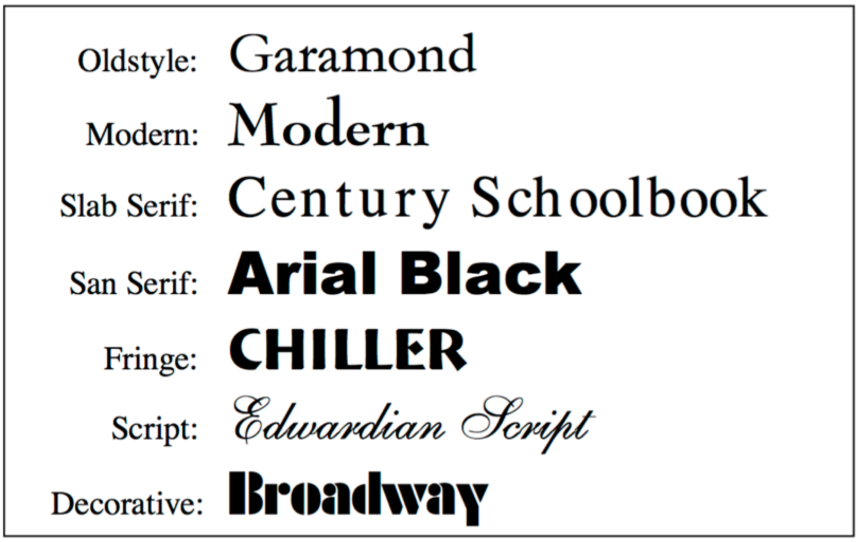


Figure 2.23 Examples of Latin font types (source: Miller, 2002)

The categories of font types have the following characteristics: (1) Oldstyle has a warm and graceful appearance. Oldstyle fonts always have serifs. The serifs of the lowercase letters of this style slant and connect to the stokes, the main line of characters, with the slight curve. Additionally, the strokes of the letters' forms make an overall gentle transition from thick to thin. (2) Modern fonts are not very readable and are not the best choice for lengthy body text. This category has serifs like oldstyle fonts but the serifs on all characters are horizontal and look thinner. (3) Slab serif fonts also have serifs and the serifs are thick and in horizontal lines. The strokes have very slight transitions from thick to thin or there may be no transition at all in some fonts. (4) San serif fonts have no serifs at all. The strokes that create letter forms have almost invisible transformations from thick to thin. (5) Fringe fonts are distorted from typical fonts and this type is difficult to read. However, this category is very identifiable and fun to use. (6) Script fonts emulate hand lettering in many varieties. Some of the most common uses of these fonts are calligraphic as seen in wedding invitation cards and (7) The Decorative category is fonts that are created for emphasizing the content. Similar to fringe and script font types (Miller, 2002).

For Thai font types, Asawasakulsorn and Chatrangsan (2014) noted that there are main five categories: Serif, Sans serif, Script, Calligraphic and Decorative. These are illustrated in Figure 2.24.

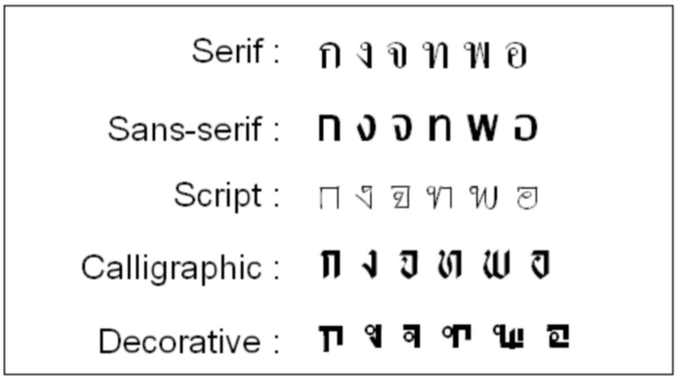


Figure 2.24 Examples of Thai font type categories
(source: Asawasakulsorn and Chatrangsan, 2014)

The characteristics of the Thai font types are as follows: (1) Serif fonts are the formal font type. Thai characters usually have a circle which is called the head at the beginning when writing the character. This type is popular for use in publications. (2) San serif is adapted from serif font by removing the circle at the beginning of characters. Moreover, these fonts are simpler and more modern than serif fonts. (3) Script fonts emulates handwritten characters and this font type has a unique appearance. (4) Calligraphic fonts have a sharp angle head of characters. This font type is a very formal appearance and can be seen in wedding invitation cards and drafting, such as in architects' drawings, in Thailand. (5) Decorative fonts have many alternatives created by various designers. In general, serif and san serif fonts are usually used in publications and online media in Thailand.

In summary, there are many categories of font types in each language but the serif and san serif types are the most common use for websites as was seen in section 2.9.2.

2.10.2 Font size and Character heights

For the Latin alphabet, the font size is the height of a character from the lowest descender to the highest ascender (FoodDrinkEurope, 2012). The common font size measure is the point but there are different definitions for a point in different countries (Punsongserm, Sunaga and Ihara, 2017). Thus, measures of x-height provide a convenient metric for typographers and researchers for the Latin alphabet (Punsongserm et al., 2017). The x-height is the distance from the baseline to the mean line (see Figure 2.25). According to FoodDrinkEurope (2012) the x-height at 1.2 millimetre (mm) for Arial font of 6.7 point and for Times New Roman at 7.9 point. From those data, the researcher calculated the font size by its x-height in order to compare the Latin letters with Thai letters measured on the Bo Baimai height (see the next paragraph). Thus, 18 point of Arial font has a x-height of 3.1 mm and 18 point Time New Roman font has an x-height of 2.7 mm.

Figure 2.25 Line and areas of the Latin alphabet (source: FoodDrinkEurope, 2012)

For the Thai alphabet, font size is the height of a character form the bottom line (upper tone mark area) to the top line (lower vowel area). In addition, the height of character “บ” (Bo Baimai) is used to measure font size (Punsongserm et al., 2017). Figure 2.26 shows the lines and areas of Thai alphabet and phases of the Bo Baimai height within the consonant and vowel areas. However, Punsongserm et al. (2017) investigated on the legibility of Thai letters. They reported that the Bo Baimai height of 2.5 mm is representative of a small point size for conventional Thai fonts which range from 12 to 21.35 point. Moreover, they found that the 18 point size of TH Saraban font (Thai serif font) is equivalent to a Bo Baimai height of 2.5 mm. Although, they did not mention the Bo Baimai height for the Kanit font (Thai Sans serif font) they did mention that for some Thai san serif fonts at 17.7 point is equivalent to a Bo Baimai height of 2.5 mm.

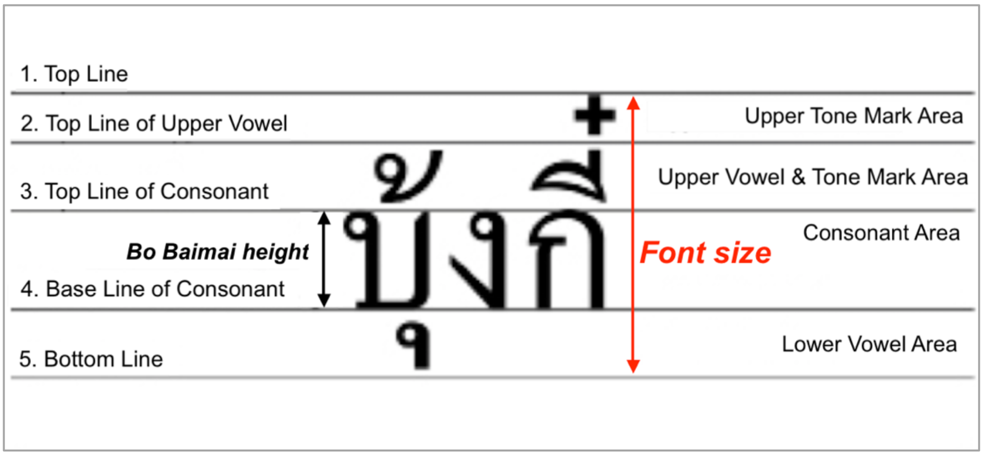


Figure 2.26 Lines and areas of Thai font (source: Punsongserm et al., 2017)

It can be seen that Latin and Thai alphabet font sizes are quite different due to the fact that there are tone marks on the top of consonants in the Thai alphabet. Therefore, the analysis of text presentation font sizes will be separate for each country in this programme of research.

2.11 Conclusions

The literature review in this chapter has presented information about the demographics and characteristics of older people. It has discussed the definition of younger and older people that will be used in this thesis, based on calculating an appropriate minimum age for older adults for the UK and Thailand. This chapter also presented research about the use of tablet computers by older people and the web design guidelines for older people, including research on the effects of text presentation on reading from screens, the categories of font type and the measurement of font size in the Latin and Thai alphabets.

From previous studies it can be seen that there is a considerable amount of research on text presentation on personal computers (Rello et al., 2016; Joshi et al., 2014; Kamollimsakul, 2014; Lin et al., 2013; Chan et al., 2013; Ahmad Zamzuri Mohamad et al., 2013; Kong et al., 2011; Yi et al., 2011; Greco et al., 2008; Ling and van Schaik, 2007; Gradisar et al., 2007; Ling and van Schaik, 2006; Baker, 2005; Bernard et al., 2003; 2001; Zaphiris and Kurniawan, 2001; Dyson and Kipping, 1997) and needs of older people in using digital devices (Tsai et al., 2015; Sciarretta et al., 2015; Page, 2014; Gitlow, 2014; Dickinson et al., 2005; Hawthorn, 2000). In contrast, there have been few studies which have investigated the usability and acceptability of tablet computers for older people (Vaportzis et al., 2017; de Almeida et al., 2015; Wright, 2014; Barnard et al., 2013; Jayroe and Wolfram, 2012; Werner et al., 2012) and there have been few studies focused on text presentation on tablets for older people (Yamazaki and Eto, 2015; Huang et al., 2013; Lege et al., 2013). In addition, there have been no studies focused on usability and acceptability of tablet computers for older people in Thailand.

Therefore, this programme of research will investigate the usability and acceptability of tablet devices for older people in Thailand and the UK and text presentation on tablet computer for older people in the UK and Thailand.

Chapter 3

Study 1: An exploratory study of the usability and acceptability of tablet computers for older people in the UK and Thailand

3.1 Introduction

This study investigated the usability and acceptability of tablet computers for older people both in the UK and Thailand. Although some research has shown that the older people can use tablet computers very easily (Tsai et al., 2015; Wright, 2014; Findlater et al., 2013), other research has found that tablets are difficult to use for older people in the US and some Europe countries (Vaportzis et al., 2017; Barnard et al., 2013; Jayroe and Wolfram, 2012; Lepicard and Vigouroux, 2012; Werner et al., 2012), particularly because of problems with the interaction.

Three studies (Vaportzis et al., 2017; Wright, 2014; Barnard et al., 2013) were conducted in the UK. Wright et al. (2014) found that older participants easily remembered to interact on tablets by many finger actions (e.g. tapping, swiping) while Barnard et al (2013) found that tapping on tablets is one of the problems for older participants and they found that labelling on some control on the tablets was too small for some of older participants to see. The latest study (Vaportzis et al., 2017) found that some older participants stated that the health issue (e.g. their eye-sighted or wrist) was one of barriers for using the tablets but older participants were interested to learn how to use the tablets. However, there is still not clear about usability and acceptability of tablet computer for UK older people. Moreover, there has been no research investigating the usability and acceptability of tablets for Thai older people.

The ISO 9241-11 defines usability as ensuring that interactive products are effective and efficient to use and satisfying from the user's perspective (Petrie, 2009). Moreover, measures for the components of usability are defined in ISO/IEC 25022: measures of effectiveness relate to tasks completed or objectives achieved; measures of efficiency relate to the time taken to complete tasks and satisfaction of users can be measured the positive and negative comments recorded during doing the tasks (Bevan et al., 2016). The negative comments during the tasks can be provided a series of usability problems. Thus, those problems were categorised using the usability problems classification of Petrie and Power (2012). However, efficiency (as the time to complete task) is not measured for this current study due to CVP condition participants performed the task and thought out loud at the same time. This might not be suitable when compared with the RVP condition that participants were asked to perform the task in silence and then think out loud when reviewing the video. Acceptability measures whether people would actually use interactive products as can be measured by the attitudes of users toward the interactive product (Tolley, Morrow and Owen, 2013).

One of key method for usability testing is verbal protocols as users said what they were doing and thinking as they did it (Sharp, Rogers and Preece, 2019). Two of the most common verbal protocols are concurrent verbal protocol (CVP) which users speak out loud what they are thinking while conducting the task ,and retrospective verbal protocol (RVP) which users retrospectively verbalise their thoughts about the task while reviewing a recording of performance of the task (Shneiderman et al., 2016; Olmsted-Hawala and Bergstrom, 2012). In addition, the concurrent verbal and retrospective verbal protocols were used in some of the research about usability of a tablet computers by older people (Jayroe and Wolfram, 2012; Werner et al., 2012; Shneiderman et al., 2016).

Moreover, Olmsted-Hawala and Bergstrom (2012) examined the effects of verbal protocols on usability testing of websites by young adults (18 to 28 years), middle age adults (40 to 50 years) and older adults (64 to 76 years). The researchers found that there was no difference in accuracy of the task, time to complete the task and subjective satisfaction scores of the interface website between CVP condition and RVP condition for young and older adults. However, the researchers suggested that the CVP is appropriate to obtain the real sense of the users' experience with the interface while RVP is appropriate to obtain the users' insight into what the issues are with the system (see section 2.7, Chapter 2). Nevertheless, Olmsted-Hawala and Bergstrom (2012) did not either ask participants about the verbal protocols nor ask to choose the protocol for their preference, only focus on the usability of the websites. Thus, there is no evidence to support which verbal protocol will be suitable to use for usability testing for older people both in Thailand and the UK.

Therefore, this current study used both CVP and RVP for usability testing of websites on a tablet computer by older people and investigated attitudes of older people to using a tablet computer in Thailand and the United Kingdom. In addition, this study also explored the use of both verbal protocols for older people in both countries.

The research questions investigated in this study are:

- The usability and acceptability of using a tablet computer:
    1. Are older users able to complete tasks with a tablet computer?
    2. What are the problems which older users encounter when undertaking tasks on a tablet computer?
    3. What are the comments about using the tablet in the study?

4. What are the attitudes of older users to using a tablet computer in general?

- The use of verbal protocols:
  1. Which is easier for older people, concurrent verbal protocol or retrospective verbal protocol?
  2. Is there a different in workload between concurrent verbal protocol and retrospective verbal protocol?
  3. Which elicits more usability problems about tablet computers for older users, concurrent verbal protocol or retrospective verbal protocol?
  4. Is there a difference between older people's preference for concurrent and retrospective verbal protocols?

3.2 Method

3.2.1 Design

The design used was a within participants one with one independent variable with two levels: CVP and RVP. Older participants in the UK and Thailand were asked to undertake four tasks with a tablet computer. Two tasks were undertaken with CVP and two with RVP, on two different websites. The order of the protocols, websites and tasks were counter-balanced (see Appendix A). Measures taken were task completion, errors made, NASA Task Load Index (NASA TLX) questionnaire of two protocols and responses to questions about attitude to tablet and the protocols. The NASA TLX consists of six component subscales: Mental demand, Physical demand, Temporal demand, Performance, Effort and Frustration (Hart and Staveland, 1988; 2006). The six subscales were matched as fifteen possible combination. This questionnaire is widely used about interface design or evaluation studies (Hart, 2006).

3.2.2 Participants

Eighteen older participants took part in the study, eight participants in the UK and ten participants in Thailand. In the UK, there were four male and four female participants, their ages ranged from 65 to 81 years old, with a mean age of 71.75 years. Four of the UK participants were still working and the other four were retired.

In Thailand, there were three male and seven female participants, their ages ranged from 61 to 71 years old, with a mean age of 64.9 years. Three Thai participants were still working and the other seven were retired.

To thank them for their participation, the UK participants were offered a gift voucher valued at £25 and 500 Baht for Thai participants.

3.2.3 Equipment and materials

The study was conducted on a mini tablet computer (iPad mini) running iOS 9.2.1. The sessions were recorded using QuickTime programme on a separate Apple machine running OS X EI Capitan and also using an iPhone earpod with microphone to record the audio.

All materials were created in two languages, English (for UK participants) and Thai (for Thai participants). Materials were initially created in English and then translated into Thai. Translation quality is important in cross-cultural research. There are many techniques for translation quality control. A committee approach is one of the techniques: a group of bilingual individuals translates from source to the target language (Brislin, 1970). The mistakes of one member can caught by other committee members (see procedure in Appendix N). Therefore a, committee approach was used for translation quality control in this study.

Materials in the study were:

1. Initial questionnaire

The initial questionnaire consisted of three parts: (1) the use of websites which included how participants had learnt to use the web, expertise and experience with the web (2) the use of tablet computers, which included how participants had learnt to use the tablet, expertise and experience with the tablets and (3) demographic questions, which included information about age, gender, occupation. The set of questions can be seen in Appendix B in both the English and Thai versions.

2. Websites and Tasks

The websites and tasks used in the study were based on common activities when people access the internet via computers or tablets. The most common internet activities for the 65 and over age group in both countries are finding information about goods and services, using social networking (such as Facebook, twitter), reading online news or magazines (Electronic Transactions Development Agency (ETDA), 2016; 2017; Office for National Statistics, 2017; 2018a). Therefore, the tasks used in this study related to finding information about goods and services.

Four websites were used: these were chosen to be relatively unfamiliar to the participants. For the UK participants, these were a travel planning website (www.hipmunk.com) and an e-commerce website (www.walgreens.com). Both these websites are from the United States, so it was anticipated that participants would not have used them before. For Thai participants, the travel planning website was www.traveloka.com and the e-commerce website was www.watsons.co.th. There was a limited number of Thai websites which could be used in this study, as there are no websites in Thai in other countries. Both these websites are from Thailand and the contents of the websites presented in Thai. However, none of the Thai participants had used either of the websites before. The homepages of these websites are shown in Appendix C.

For each website, there were two tasks (the tasks for very similar for the Thai and UK websites):

1) Hipmunk.com:
   - Find the cheapest direct non-stop flight for two adults from Heathrow Airport London (UK) to any Bangkok Airport (Thailand), leaving on 28th of August 2016 and returning on 1st October 2016
   - Find the cheapest, five star rated hotel in Paris, France for a room for two persons for two nights from 25th August 2016
2) Walgreens.com:
   - Find the cheapest yoga mat in an aqua colour
   - Find the cheapest, five star rated baby safety gates
3) Traveloka.com:
   - Find the cheapest direct non-stop flight for two adults from Suvarnabhumi Airport Bangkok (Thailand) to Melbourne Airport (Australia), leaving on 20th October 2016 and returning on 10th December 2016
   - Find the cheapest, four star rated hotel in Osaka, Japan for a room for two persons for two nights from 10th of October 2016
4) Watson.co.th:
   - Find the cheapest hair straightener
   - Find the cheapest, five star rated anti-wrinkle skincare cream

3. Interview schedule

A post-study interview consisted of two parts: (1) reviewing CVP and RVP methods and (2) exploring the use of and attitudes towards tablet computers. The questions were about the websites and the tasks that participants had undertaken, their attitudes toward tablets and their preference for CVP or RVP. The set of questions can be seen in Appendix G.

3.3 Procedure

The timeline for the procedure of the study is shown in Figure 3.1

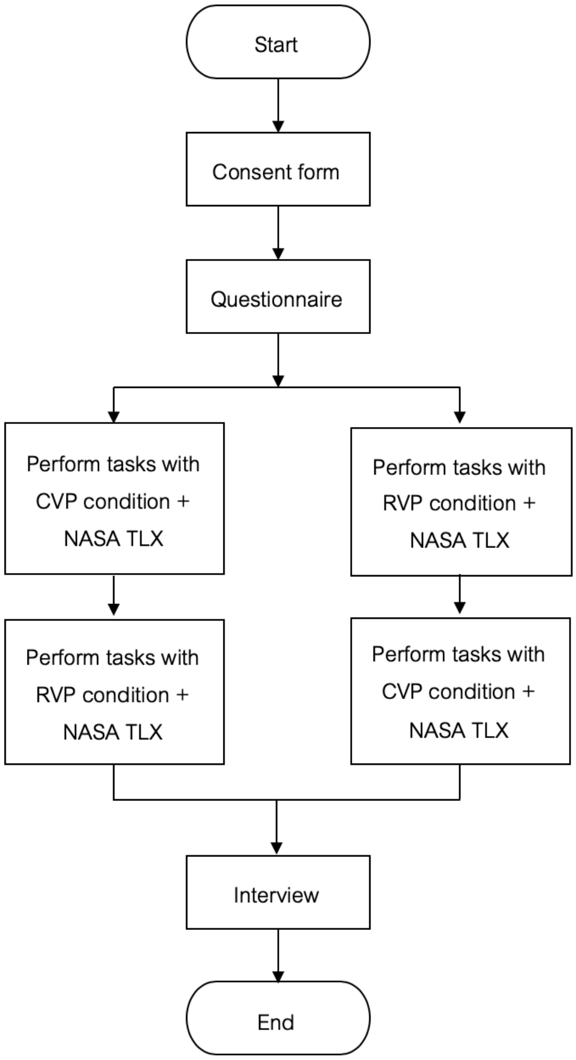


Figure 3.1 Timeline of Procedure for Study 1

In both in Thailand and the UK the study took place in a quiet room. Before starting the study, the researcher explained the aim of the study and the tasks (see Appendix D). Next participants were asked to read and sign the informed consent form (see Appendix E). The Informed consent form explained the aim of the study and informed the participant about the process of the study. After that the participants were asked to complete the initial questionnaire (see Appendix B). Next the researcher showed the participant the basics of using a tablet computer, if needed. Then the researcher gave a demonstration of how to perform the first type of verbal protocol to be undertaken. The participant then had a practice with the protocol, doing one or two tasks, until they felt comfortable. Then they were given the first website and undertook the two tasks. After that participants were asked to complete the NASA TLX about that protocol (see Appendix F). The procedure was then repeated for the other protocol.

During the CVP condition participants performed the task and thought out loud at the same time, whereas during the RVP condition participants were asked to perform the task in silence, then they reviewed the task by viewing video of the task in order to think out loud.

After completing the tasks, participants were interviewed about the websites and tasks, their attitudes towards using tablet computers and also their preference for the CVP and RVP methods. At the end of session, participants were debriefed (See Appendix G) and encouraged to ask questions about the study. Participants then were asked to sign Section B of the consent form and they were given a gift voucher for their participation.

3.4 Data analysis

The initial questionnaires, the usability problems and the NASA TLX were analysed using quantitative analyses. The ratings on the use of the web, overall on usability problems and overall scores on the NASA TLX, a Shapiro-Wilk test showed that they were normally distributed ($p > .05$) while the ratings on the use of tablets were not normally distributed ($p < .05$). For analysis of the difference of problems between two verbal protocols and two user groups, a Shapiro-Wilk test showed that the number of problems was normally distributed ($p > .05$). Thus, parametric statistical tests were applied to the use of web ratings and of NASA TLX scores and the number of usability problems, but non-parametric statistical tests were applied to the ratings of use of tablets. (see section 3.5.1 to 3.5.4).

To compare the means difference in using the webs and tablets of UK and Thai participants, t-test was used in these variables. In addition, two-way mixed ANOVA was applied to the overall problems encountered by participants in order to investigate whether there were any differences in overall problems between the two verbal protocols (CVP and RVP) and the between-participant variables (UK and Thai), and any interaction between these variables.

To investigate the difference in encounter major problems by the UK and Thai participants, a Chi-square test was used, as these are frequency data.

Usability refers to effectiveness, efficiency and users' satisfaction. Effectiveness could be measured as the number of participants successfully completing a task, efficiency was the time to complete a task, and users' satisfaction was measured via the positive or negative comments when doing the tasks. As discussed above, the efficiency is not a suitable to report in this study so time to complete the tasks is not reported in this study.

For acceptability, participants were interviewed about the use of and attitudes towards tablets, preference of two verbal protocols and also problems on the websites that participants have not talked out or want to highlight any problems when doing the tasks. The UK participants were interviewed by my supervisor who is a native English speaker and I observed during the interviews and made notes. For Thai participants, they were interviewed by the researcher. The audio recordings of each participant were transcribed, and topics were identified related to older people's attitudes and their problems when using the tablet.

Content analysis was used in this study. Content Analysis is a research technique for making replicable and valid inferences from texts. In addition, this technique can be used with any online content or texts to analyse the data into categories (Krippendorff, 2018). At first, the researcher listened repeatedly to the recordings to ensure that accurate transcripts were. Then the researcher compared the audio recording with my notes that the researcher had recorded during the session to avoid the missing any important information. In addition, my supervisor helped me with transcription for the UK participants' audio recordings as the researcher could not understand in some words or sentences. The researcher used an open coding technique for grouping information into interesting topics.

3.5 Results

This section presents the results on the participants' use of web and tablets and also their experience of the two verbal protocols. In particular, it presents the main issues participants encountered doing tasks on websites using a tablet computer, their attitudes towards using a tablet computer and their preference of one of the verbal protocols. To check whether non-significant results were due to a lack of statistical power, the researcher conducted a power calculation using the G*power program[2] with power set at 0.80 (i.e. an 80% chance of finding a correct significant difference) and α = .05.

3.5.1 Use of the web

Table 3.1 presents the results on how participants learnt to use the web. It can be seen that across both countries, more than half the participants learnt how to use the web from family members (66.7%), followed by a third (33.3%) who learnt by themselves. Few participants learnt from their friends (16.7%) or from their colleagues (11.1%). Interestingly, over a quarter of participants have taken a course to learn how to use the web (27.8%) but no participants learnt from reading a guide.

Learning to use the web from family members was the most common method in both the UK and Thailand (50.0% and 80.0%, respectively). Participants in Thailand (40.0%) learnt to use the web by themselves more frequently than in the UK (25.0%) while learning by taking a course was mentioned by 37.5% of participants in the UK and only 20.0% in

[2] G*Power program: available at http://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower.html

Thailand. Furthermore, 20.0% of Thai participants learnt from their friends and colleagues whereas only 12.5% of UK participants learnt from friends and no UK participants learnt from their colleagues.

Table 3.1 Means of learning to use the web for UK and Thai participants (% and number of participants who used the web)

Learning to use the web	UK Participants (N=8)	Thai participants (N=10)	All participants (N=18)
With a family member	50.0% (4)	80.0% (8)	66.7% (12)
By themselves	25.0% (2)	40.0% (4)	33.3% (6)
Took a course	37.5% (3)	20.0% (2)	27.8% (5)
With a friend	12.5% (1)	20.0% (2)	16.7% (3)
With a colleague	0.0% (0)	20.0% (2)	11.1% (2)
By reading a guide	0.0% (0)	0.0% (0)	0.0% (0)

Table 3.2 presents results on what devices participants use for accessing the web. Overall, 61.1% (11 out of 18) of participants have used a mobile phone for accessing the internet. 50.0% (9) have accessed the web using a desktop computer, 44.4% (8) have used a tablet computer and 38.9% (7) have used a laptop computer.

Table 3.2 Devices used in accessing the web used by UK and Thai participants (% and number of participants who used the web)

Devices	UK participants (N=8)	Thai participants (N=10)	All participants (N=18)
Smartphone	62.5% (5)	60.0% (6)	61.1% (11)
Desktop computer	62.5% (5)	40.0% (4)	50.0% (9)
Tablet computer	50.0% (4)	40.0% (4)	44.4% (8)
Laptop computer	62.5% (5)	20.0% (2)	38.9% (7)

The smartphone is the most popular device for participants to access the web in Thailand (used by 60.0% of participants, 6 out of 10) while the desktop computer, laptop computer and smartphone are the most popular devices for participants to access the web in the UK (all were reported by 62.5% of participants, 5 out of 8). However, the tablet is the second most popular device for accessing the web for Thai participants. 40.0% of Thai participants use a tablet for accessing the web (two Thai participants who only used a tablet for teaching and social network applications but not to access the web are not included in these figures) while two participants use a laptop computer. Although the tablet is the least popular device for accessing the web in the UK, 50.0% of the UK participants use one for accessing the web.

Participants in the UK have been using the web for on average 15.5 years (Standard Deviation (*SD*) = 6.4) while participants in Thailand have been using it for on average 4.5 years (*SD* = 4.6). An independent sample t-test shows that this difference was significant ($t(16) = 4.23$, $p < .05$).

Participants in the UK use the web in a typical week on average 8.31 hours (*SD* = 5.6) whereas participants in Thailand use it for on average 6.83 hours (*SD* = 6.9). An independent sample t-test failed to show that this difference was significant ($t(16) = 0.49$, *n.s.*[3]).

In addition, participants were asked to rate their level of experience and expertise in using the web on a scale from 1= “Not at all” to 7 = “Extensive”. The results show that level of experience and expertise of using the web for Thai participants (Mean (*M*) = 2.40 and 2.30, respectively) are lower than those of the UK participants (*M* = 5.00 and 4.88, respectively) as can be seen in Figure 3.2. Independent sample t-tests revealed that there was a significant difference between the UK and Thai participants in level of experience of using the web ($t(16) = 4.85$, $p < 0.05$) and there also was a significant difference for in expertise in using the web ($t(16) = 4.74$, $p < 0.05$).

[3] *n.s.* indicates not statistically significant (*p-value* ≥ .05)

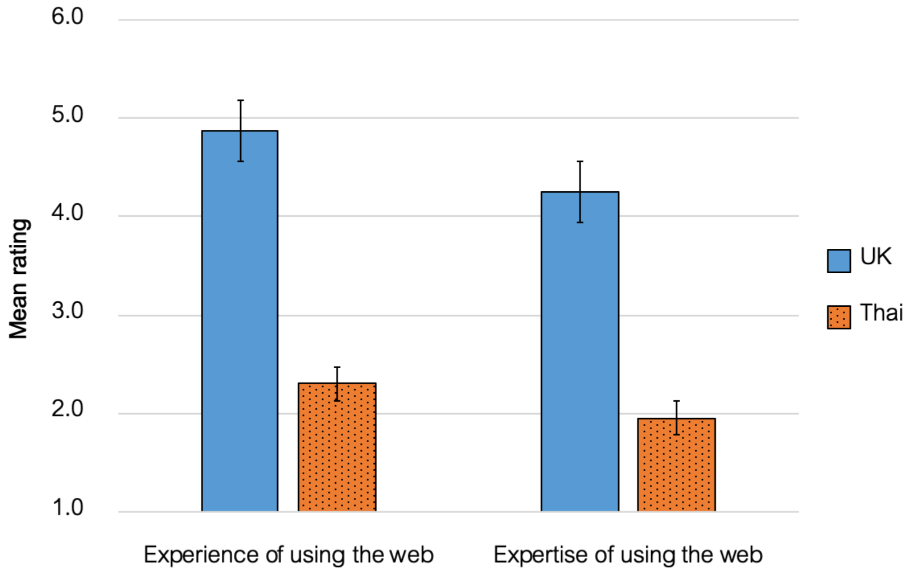


Figure 3.2 Experience and expertise in using the web of UK and Thai participants

3.5.2 Use of the tablet computers

Ten participants (55% 10 out of 18), four UK participants (50%, 4 out of 8) and six Thai participants (60%, 6 out of 10) had used a tablet before.

For those participants who had used a tablet, the most common method for learning to use a tablet was from family members (60.0%, 6 out of 10). Some participants learnt by themselves (30.0%, 3), have taken a course (20.0%, 2) or from colleagues (20.0%, 2), while only 10.0% of participants learnt from their friends or by reading a guide. Thus, it can be seen that older people have learnt how to use a tablet from their family members more than other methods (see Table 3.3).

50.0% of the UK participants and 66.7% of Thai participants learnt how to use the tablet from their family members. 50.0% of UK participants learnt by themselves while only 16.7% of Thai participants learnt by themselves. Some Thai participants learnt from colleagues (33.3%) or by taking a course (33.3%) whereas none of the UK participants learnt by either of these methods. Only 25.0% participants in the UK learnt from their friends but no participants learnt by that method in Thailand. In contrast, no participants in the UK learnt by reading a guide but 16.0% of participants in Thailand learnt by that method.

Table 3.3 Means of learning to use a tablet computer for Thai and the UK participants (% and number of participants)

Learning to use the tablet	UK Participants (N=4)	Thai participants (N=6)	All participants (N=10)
With a family member	50.0% (2)	66.7% (4)	60.0% (6)
By themselves	50.0% (2)	16.7% (1)	30.0% (3)
With a colleague	0.0% (0)	33.3% (2)	20.0% (2)
Took a course	0.0% (0)	33.3% (2)	20.0% (2)
with a friend	25.0% (1)	0.0% (0)	10.0% (1)
By reading a guide	0.0% (0)	16.7% (1)	10.0% (1)

The UK participants have been using a tablet for on average 4.25 years (SD = 2.63) whereas Thai participants have been using one for on average 1.95 years (SD = 1.57). However, an independent samples t- test did not show this difference to be significant ($t(8)$ = 1.76, *n.s.*).

Moreover, the UK participants use a tablet for on average 4.00 hours (SD = 1.41) in a typical week while Thai participants used one for on average 6.88 hours (SD = 5.15) in a typical week. However, an independent samples t-test did not show that this difference was significant ($t_{(6.07)} = -1.30$, *n.s.*). The results also failed to show a significant difference in either the length of time participants have been using a tablet or the length of time using the tablet in a typical week, but this may be due to the small sample size.

Participants were asked to rate their level of experience and expertise in using the tablet on a scale from 1 = “Not at all” to 7 = “Extensive”. Mann-Whitney U tests showed that there were significant differences in both level of experience in using tablets (U = 2.00, $p < .05$, r = .72[4]) and in level of expertise in using tablets (U = 1.50, $p < .05$, r = .75) between the UK and Thai participants. Figure 3.3 shows that the level of experience and expertise in using a tablet for Thai participants (Mdn = 3.00 (IQR = 0.75) and Mdn = 2.50 (IQR = 1.00), respectively) are lower than those of the UK participants (Mdn = 4.50 (IQR = 1.25) and Mdn = 5.00 (IQR = 0.50), respectively).

[4] In term of effect size: (r) ≥ .01 indicates a small effect size, r ≥ .03 indicates a medium effect size, r ≥ .05 indicates a large effect size (source: Rules of thumb on magnitudes of effect sizes, University of Cambridge, from http://imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize)

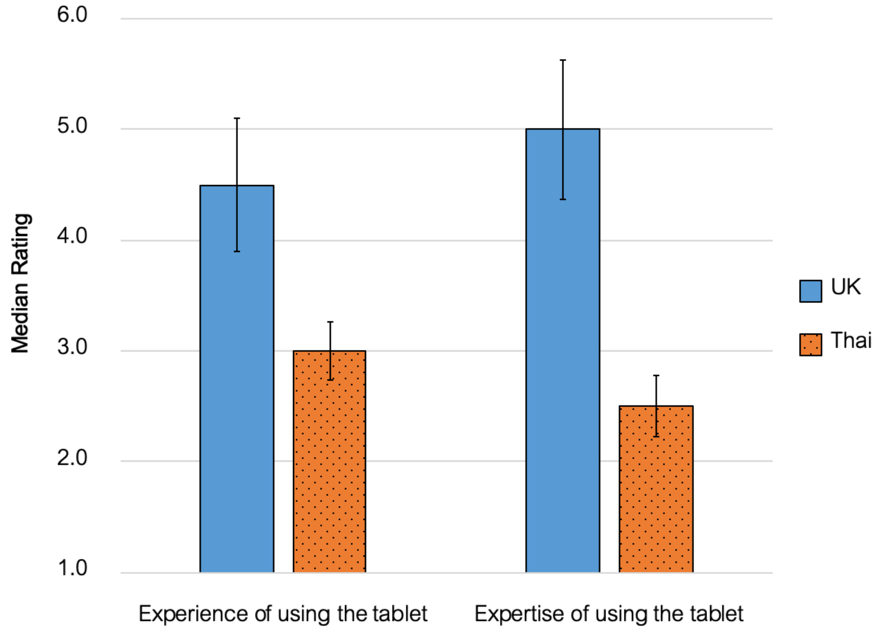


Figure 3.3 Experience and expertise in using the tablet of the UK and Thai participants

3.5.3 Problems encountered with the websites and the tablet computer

All participants were able to successfully complete the tasks. The recording of videos for each participant were reviewed, in order to reveal the problems participants encountered while doing the tasks on the websites. Participants were asked to rate the severity of the problems they encountered while undertaking the tasks in the CVP and RVP condition, but some participants found this very difficult during CVP (it clearly distracted them from the task), so the researcher did not insist that participants made the ratings.

To analyse for differences of overall problems between the two verbal protocols and nationalities a two-way mixed Analysis of Variance (ANOVA) was used. The results showed that overall Thai participants identified significantly more problems than UK participants with a large effect size[5] ($F_{(1,16)} = 5.67$, $p < .05$, $\eta_p^2 = .26$). The mean number of problems identified by Thai participants was 3.00 problems ($SD = 1.81$) while by UK participants the mean was 1.88 ($SD = 2.06$). The result showed that there was no significant main effect for verbal protocol ($F_{(1,16)} = 3.11$, $p = .10$, $\eta_p^2 = .16$). The power calculation indicated that there is an 84% chance of correctly detecting the main effect with 12 UK participants and 12 Thai participants, making a total sample of 24 participants. Thus for a robust result, at least 4 more UK participants and 2 more Thai participants would need to participate.

[5] In term of effect size: partial eta- squared (η_p^2) ≥ .01 indicates a small effect size, η_p^2 ≥ .06 indicates a medium effect size η_p^2 ≥ .14 indicates a large effect size (source: Rules of thumb on magnitudes of effect sizes, University of Cambridge, from http://imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize)

There was no interaction effect between protocol and nationality ($F_{(1,16)} = .17$, $p = .69$, $\eta_p^2 = .01$). The power calculation indicated that there is an 80% chance of correctly detecting the effect of the interaction with 182 UK participants and 182 Thai participants, making a total sample of 364 participants. Thus for a robust result, 174 more UK participants and 174 more Thai participants would need to participate.

Moreover, the analysis was conducted of the problems which were rated as “major” by participants in each of the categories and in the two verbal protocols. A Chi-square test showed that Thai and UK participants did not encounter a significant difference in the number of major problems ($\chi^2 = 5.67$, $df = 3$, *n.s.*). The power calculation indicated that there is an 80% change of correctly detecting the difference with 22 UK participants and 22 Thai participants, making a total sample of 44 participants. Thus for a robust result, 14 more UK participants and 12 more Thai participants would need to participate.

In addition, CVP and RVP did not significantly produce a difference in the number of major problems ($\chi^2 = 1.54$, $df = 3$, *n.s.*). The power calculation indicated that there is an 80% change of correctly detecting the difference with 37 UK participants and 37 Thai participants, making a total sample of 74 participants. Thus for a robust result, 29 more UK participants and 27 more Thai participants would need to participate.

Overall, participants found forty-two problems related to interactivity; eighteen problems by UK participants and twenty-four of problems by Thai participants. All of the UK participants and Thai participants had problems with interactivity. Four of the UK participants had problems with tapping while two Thai participants encountered this type of problem. For example, when they tapped on some controls, but they did not work, probably because their hands are drier than younger people’s and some of them tapped using their fingernails rather than their finger pads, not realising this will not work. On the other hand, four Thai and two of the UK participants said that tablet was too responsive for them, they activated functions when they did not mean to by touching the screen accidentally.

Table 3.4 summarizes the major problems which were mentioned in both CVP and RVP conditions by participants and those observed by the researchers. In addition, the specific problems were grouped into each major category (see Appendix I).

Table 3.4 The number of usability problems encountered during the tasks for each major problem category by UK and Thai users

Major category	UK		Thai		Total
	CVP (problems)	RVP (problems)	CVP (problems)	RVP (problems)	
Physical presentation	4	6	10	17	37
Content	0	1	1	4	6
Information architecture	0	0	2	3	5
Interactivity	8	10	10	14	42

Three of the UK participants found that some controls were not clear, and six Thai participants found that it was not clear where on the tablet screen to tap (e.g. on a label, text or picture). In addition, two Thai participants misunderstood some signs on the website and one UK and one Thai participant were confused about how to move the cursor. In addition, two of the UK participants found that there was no feedback that the website was still working or searching for something for them. In addition, one of the UK participants found that it was not clear how to return to a previous state when a mistake had been made. Four Thai participants found that the initial or previous words in a text box were not cleared when a new search was initiated, and one of the UK participants also faced this problem. One Thai participant found that the total price of the hotel was not summarised for him when he searched for two nights' accommodation.

Thirty-seven problems related to physical presentation were encountered; ten problems by the UK participants and twenty-seven of problems by Thai participants. Four of the UK and all ten Thai participants had problems with text presentation (e.g. texts or labels were too small, text and background colours did not have enough contrast), and one of the UK participants found that one of textboxes was too small for typing into. In addition, some participants forgot to zoom in when the texts were too small, and they found that zooming in made them lose some information and orientation. One Thai participant said that it should not be necessary to zoom in for reading and the website should be in larger text. Five Thai and one of the UK participants found that the colour contrast between text and background was not sufficient. In addition, three of the UK and two Thai participants found that they could not see the all information on the webpage when they zoomed in for reading. In addition, one UK participant stated that the tablet was too small.

Six problems related to content were encountered; one of the problems by UK participants and five problems by Thai participants. One of the UK and one Thai participant said that the website did not show information clearly enough. Another two Thai participants said that the meaning of some words on the websites was not clear to them. In addition, two Thai participants said that a photo of the product on the website was not clear.

Five problem related to Information architecture were encountered, which was found by five Thai participants: on www.watson.co.th, it was not clear in which category to search for the target product.

In summary, some of participants misunderstood that some texts are interactive, and some are not, so were not clear where they could tap and where there was no point in doing so. In addition, the symbols on some controls were not clear, for instance the pictures which represent adult, children and infant passengers on travel website (see Appendix C, in figure, 3 showing the Traveloka web page). Moreover, some menus on the e-commerce website were not clear about what category from the menu to search in for a particular product.

Texts and some buttons on the websites were too small for some participants. However, when participants zoomed in to make the text or button larger, that made them lose some information on the webpage and become disoriented. In addition, the website did not show information clearly enough, this included text colours and background colours that did not have sufficient contrast. In addition, the feedback when the website was loading was not clear for participants. There was also no information when participants got lost. For example, when participants tapped in the wrong place and wanted to go back, they were not clear about how to do that. Furthermore, the default words in text boxes were not clear when participants tapped on the text box for a new search.

3.5.4 Experience with Concurrent and Retrospective verbal protocols

To investigate how difficult participants found the two verbal protocols, they completed the NASA TLX index about each protocol. A mixed ANOVA with a 2 x 2 x 5 design was used to analyse the results. Nationality (British and Thai) was used as the between-participants variable. The two within-participants variables were protocols (CVP and RVP) x NASA TLX sub-scales (Mental Demand, Physical Demand, Temporal Demand, Performance and Effort). The frustration subscale was not included in the analysis as only six participants out of 18 rated the protocols as being frustrating in any way. There was a significant main effect for NASA TLX subscale ($F_{(4,64)} = 9.81$, $p < .05$, $\eta p^2 = .38$) but there was no significant main effect for protocol ($F_{(1,16)} = 0.89$, $p = .36$, $\eta p^2 = .05$.) and there was no significant effect for nationality ($F_{(1,16)} = 0.29$, $p = .60$, $\eta p^2 = .02$). The power calculation indicated that there is an 80% chance of correct detecting the main effect for protocols with 37 UK and 37 Thai participants, making a total sample of 74 participants. Thus for robust results, 29 more UK participants and 27 more Thai participants would need to participate.

Moreover, there is an 80% chance of correct detecting the main effect for nationality with 91 UK and 91 Thai participants, making a total sample of 182 participants. Thus for robust results, 83 more participants and 81 more Thai participants would need to participate.

However, there was no a significant interaction between NASA TLX Subscale and Nationality ($F_{(4,64)} = 1.32$, $p = .27$, $\eta p^2 = .08$) and also no any interaction between variables. The power calculation indicated that there is an 80% chance of correct detecting the effect of the interaction with 19 UK participants and 19 Thai participants, making a total sample of 38 participants. Thus for robust result, 11 more UK participants and 9 more Thai participants would need to participate.

Figure 3.4 shows the mean scores for each of the NASA TLX subscales for all participants. Mental demand was the highest rating while Physical Demand was the lowest rating. Moreover, participants rated Performance and Effort higher than Temporal and Physical demand.

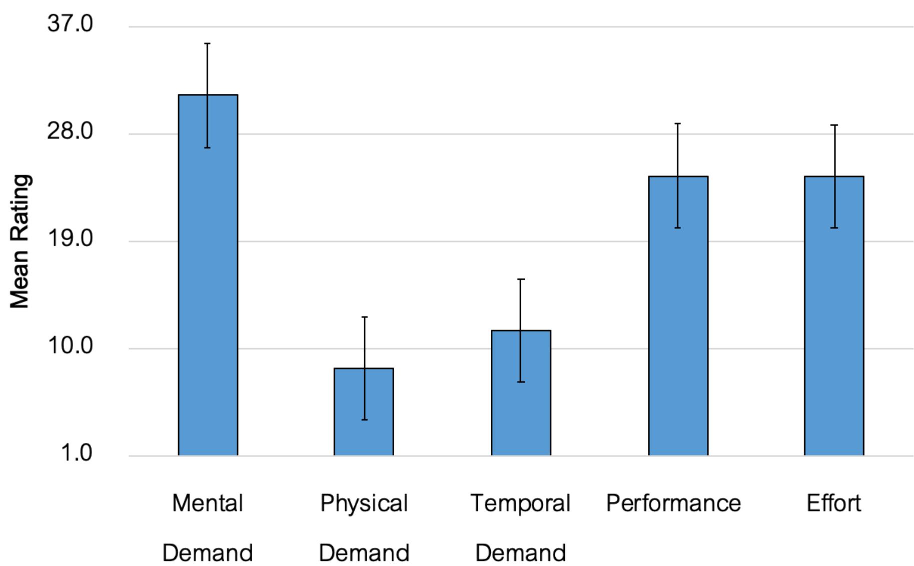


Figure 3.4 Mean scores on five NASA TLX subscales for all participants

Bonferroni post-hoc comparisons were used for investigating where the significant differences between NASA TLX subscales. The analysis found that participants rated Mental demand significantly higher than Physical demand ($p < .05$) and Temporal demand ($p < .05$). In addition, participants rated Performance and Effort significantly higher than Physical demand ($p < .05$).

Figure 3.5 shows the mean scores for each of the NASA TLX subscales for UK and Thai participants. Thai participants rated Mental Demand, Physical Demand and Effort higher than the UK participants while the UK participants rated Temporal Demand and Performance higher than Thai participants. To compare NASA TLX subscales rating between UK and Thai participants, the Bonferroni post-hoc analysis found that there was no a significant difference in NASA TLX subscales rating between UK and Thai participants for each subscale.

Apart from the tasks, participants were interviewed about (1) their opinions of the two verbal protocols and preferences for them (see section 3.5.5) and (2) use of and their attitudes towards tablet computers (see section 3.5.6).

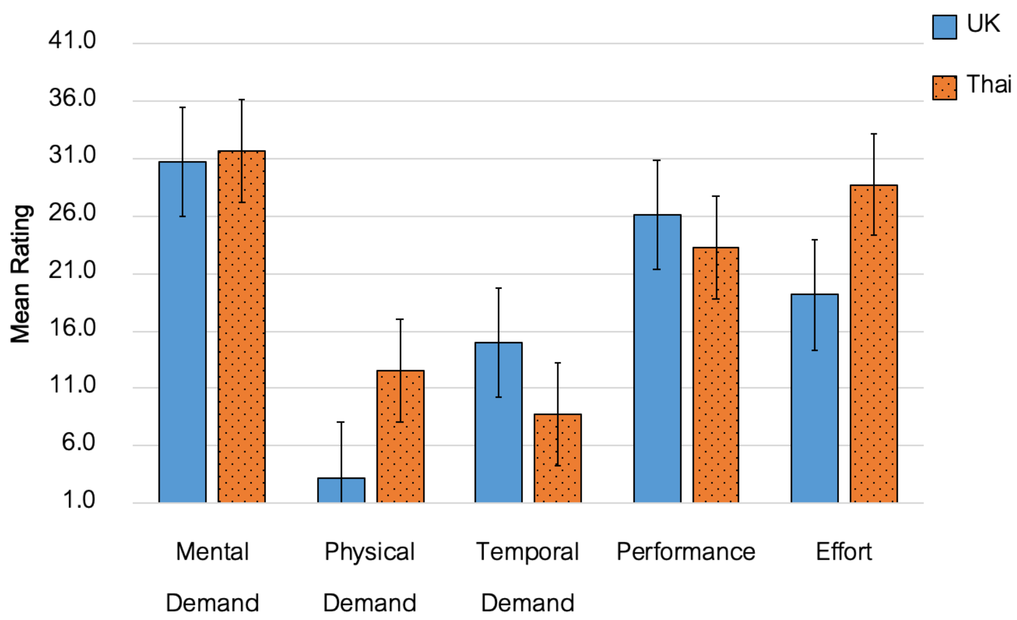


Figure 3.5 Mean scores on five NASA TLX subscales for the UK and Thai Participants

3.5.5 Opinions of and preferences for Concurrent and Retrospective verbal protocols

Participants were asked to select which of the two protocols they preferred and the reasons why, as well as which was easier for them to articulate their thoughts. Overall, two-thirds of the participants preferred CVP (i.e. 66.7% or 12 out of 18) and the other third (33.3%, 6 out of 18) participants preferred RVP. A chi-square test showed this was not a significant difference ($\chi^2 = 2.0$, df=1, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 34 UK participants and 34 Thai participants, making a total sample of 68 participants. Thus for robust result, 26 more UK participants and 24 more Thai participants would need to participate.

Six (out of 8, or 75%) of UK participants preferred CVP and two preferred RVP (25%), while six Thai participants preferred CVP (60%, 6 out of 10) and four preferred RVP (40%). See Figure 3.6. Again, this was not a significant difference (χ^2=0.502, df=1, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 33 UK participants and 33 Thai participants, making a total sample of 66 participants. Thus for robust result, 33 more UK participants and 33 more Thai participants would need to participate.

Of the participants who chose the CVP, some mentioned that they like to talk to themselves while they were doing some activities and they are typically not silent when using the web (i.e. they talk to themselves while using the web). While those who choose RVP mentioned that they do not like to talk to themselves while they were using the web and some of them said that they can concentrate better on doing the task silently.

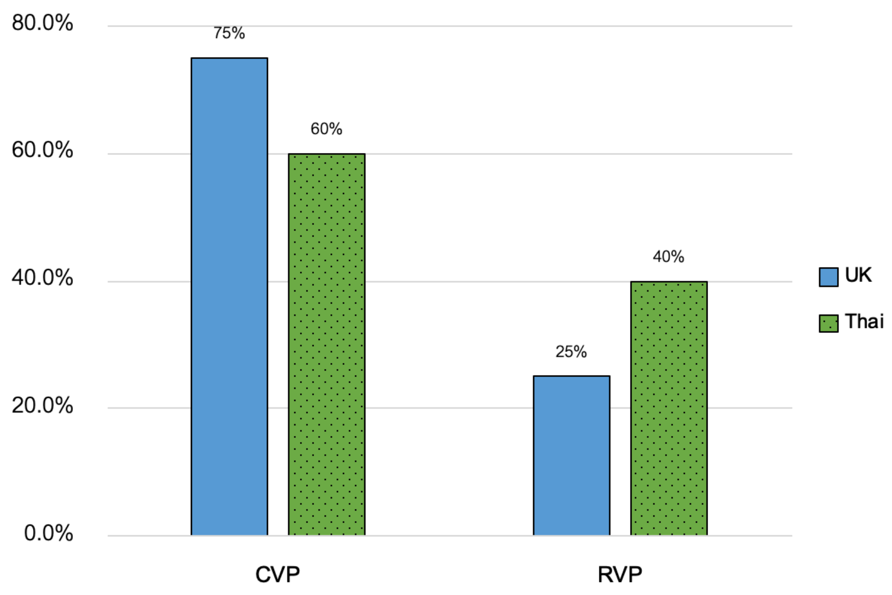


Figure 3.6 Preference of participants for CVP and RVP in the UK and Thailand

3.5.6 Attitudes of older participants to the use of tablet computers

All the UK participants were able to complete the tasks and in the post-study interviews said that in general the tablet was easy to use and that they enjoyed using it. They said that gestures such as scrolling down and up, zooming in and out were easy to carry out, although two participants complained that zooming in made them lose some information on the webpage. Two participants had problems with tapping because their hands were quite dry.

One participant said that the keyboard was too small for her, so she found it difficult to type easily. And one participant did not like the “spinner” feature used on one of the websites.

Nevertheless, all participants in the UK reported that they found that the tablet is easier and faster to use than a desktop computer. Three participants, who had never used a tablet before, said that they were tempted by the tablet after the study, although another said that he was not tempted because he was planning to get a smartphone very soon. These results indicate that the UK older participants have positive attitudes toward using tablets.

All the Thai participants were able to complete the tasks. Some participants stated that using the tablet is similar to using a desktop computer and they are able to transfer some knowledge from using a desktop computer to using the tablet. However, one participant complained that the screen and keyboard on the tablet were too small for her. One participant, who had never used a tablet before, said that if he used the tablet for approximately one month, he thought that he would be able to work with it very well. Another participant said that after the study she would try to use a tablet because it was very tempting. Finally, one participant said that using a tablet would be very useful for her because she can study a map on the tablet while travelling and it also would give her something fun to do when she has time to fill, such as when waiting for someone. These results indicate that Thai participants also have positive attitudes toward using tablet computers.

Overall, the results show that all the UK and Thai participants have positive attitudes towards using tablets. Some of the participants stated that they thought a tablet is easier, faster and also more convenient than a desktop computer. In addition, they mentioned that a keyboard on the tablet screen is easy to use for them, but one participant felt that tablet keyboard is too small, and some participants found that it difficult to type very well on it. Overall, participants said that tablet is useful for older people and they enjoyed using it. However, as already mentioned, some participants still had some problems when doing the tasks on the tablet due to buttons and text that were too small and poor contrast between text and background. These problems were highlighted, and one participant stated that these problems made him quite frustrated.

3.6 Discussion

This study investigated the usability and acceptability of tablet computers for older people in the UK and Thailand. All participants, both those who were novices with tablets and those who have some experience with a tablet before, were able to complete the tasks. However, some of participants still misunderstood some controls on the websites. For example, they confused which texts are interactive and which are not. In addition, some participants found that feedback on the website was not clear such as when a page was loading, or the website was retrieving travel information. They also had some problems related to physical presentations such as texts or buttons that were too small. This results support previous research (Budiu and Nielsen, 2010; 2011; Dahn, Ferdinand and Lachmann, 2014) which recommended that websites or applications on the tablet should use larger texts or buttons and give clear feedback.

Moreover, the participants enjoyed using a tablet and they generally stated that the tablet is easier, faster and more convenient than a desktop computer. This is similar to some of the previous research (Barnard et al., 2013; Jayroe and Wolfram, 2012; Werner et al., 2012) which found that tablets were easier for older people to use than desktop computers or personal computers. In addition, some of the participants said that they are able to transfer some knowledge from using a desktop computer to using the tablet, which was similar to Dan et al., (2014) who found that older adults' feedback on the use of tablet was related to their prior desktop computer experiences.

With regard to the physical interaction with the tablet, some of the participants have some problems with tapping. When they tapped on some controls, the controls did not work probably because their hands are drier than younger people's. Sometimes participants made a tap that was too long so other functions on the tablet appeared, such as 'copy' and 'select all'. These results are similar to those of Jayroe and Wolfram (2012) who found that older people's fingers were more tremor than younger people's, thus typing was not easy for them and Werner et al. (2012) who found that some of their participants had problems when tapping on the screen; as with our participants, their taps were too long. In addition, some of the participants found that zooming in made them lose some information on the webpage and they also found that zooming out too far made them confused about what to do when special functions appeared. However, the majority of participants tapped and zoomed in and out without any difficulties.

Overall, participants felt that tablets would be useful for older people. Some participants have already been using a tablet to read news, search for information online and to listen to music. Therefore, the results show that the tablet is relatively easy to use for older people and that they have positive attitudes toward using the tablet. The current study is similar to previous studies (Vaportzis et al., 2017; Wright, 2014; Werner et al., 2012; Mitzner et al., 2010) who found that older people have more positive than negative attitudes about the new technologies.

For verbal protocols, CVP and RVP did not significantly produce a difference in overall problems. Moreover, a difference was found between five subscales of NASA TLX. Participants found that the mental demand more workload than physical and temporal demand while they were doing the tasks on the tablets with two verbal protocols. In addition, they also found that performance and effort demand more higher workload than physical demand. The mental demand was the highest demand whereas the physical demand was the lowest for their doing the tasks with two verbal protocols. This may mean that participants were demanding concentrate or attend to achieve the tasks with two verbal protocols. However, the interaction between nationality and protocol did not significantly impact the NASA-TLX scores.

On preferences for the two protocols, overall twelve participants preferred CVP and six participants preferred RVP. Participants who preferred CVP said that they like to talk to themselves while doing some activities whereas some of them preferred RVP because they can concentrate with their work in silence while doing the task. However, there was no significant preference amongst participants.

This study has a potential number of limitations. Firstly, there was a small number of participants in the study. In particular, it was difficult to recruit older participants in Thailand. Older Thai people were nervous about undertaking a study of new technology, but the researcher tried to find Thai participants as much as possible for the period of time available for this study. However, this was an exploratory study, to confirm previous research on the problems which participants encounter with tablets with participants from two further countries. Three studies had used participants from the UK, two studies were conducted in the US and four studies were conducted in some Europe countries, previously. In addition, this study aims to show the first of series of problems which Thai participants encounter in using the tablets. A larger study of the use of CVP and RVP with older participants would certainly be worthwhile.

The second limitation was the Thai websites that were used in the study. There was a very limited number of websites in Thai to be able to choose websites that participants would not have used before, which was a concern initially. However, this turned out not to be a problem, as none of the Thai participants had used the websites chosen for the study.

3.7 Conclusions

This study focused on older people's attitudes to and use of tablet computers in the UK and Thailand. Overall, participants were able to complete the tasks but had still some issues such as text that was too small and a lack of clear feedback. In addition, some interactions with the tablet were problematic, such as holding a tap for too long on the same screen position. However, participants felt that using the tablet was not difficult and they thought that the tablet is very useful and convenient.

Two different verbal protocols were used as the methods for eliciting information in this study. This was quite surprising, as CVP increases the cognitive load on the participants, as they have to undertake the task and talk about it at the same time. However, several participants said that they often “talk themselves through” tasks with technology, as they are unfamiliar with how to do them, so undertaking the CVP was quite natural. For workload measurement by NASA TLX, Thai participants rated Mental Demand, Physical Demand and Effort higher than the UK participants while the UK participants rated Temporal Demand and Performance higher than Thai participants. In addition, Physical Demand and Temporal Demand were rated lower than others for both UK and Thai participants.

This study highlighted some problems older people encounter when using tablet computers. It also shows their attitudes towards using the tablets. Older people in both in the UK and Thailand have positive attitudes toward tablet computers and are interested in using them. These results lead to the investigation on readability of tablet computers was conducted in next studies.

Chapter 4

Study 2: The effect of font type and font size on reading text on a tablet computer for younger and older people in Thailand and the UK

4.1 Introduction

As discussed in Chapter 1, older people are increasingly using tablets in both the UK and Thailand. In addition, tablets have often been proposed as a particularly appropriate digital technology for older people, due to their portability and easy to use interface designs. Although there is some research which said that older people are able to use tablets very easily and have positive attitudes toward tablets, there is also evidence from research that older people face some issues in using tablets such as text or labels being too small. The issues also include gestures with the tablets, for example, zooming functions (which make the text bigger) make readers become disoriented and lose information on the web (see Chapter 2 and 3). In addition, a lack of confidence and knowledge are barriers for older people to use tablets. From this perspective, one of the main problems is text presentation on the tablet for older people.

From the literature review, it is clear that there is little research on the effect of font type and font size on computer screens for Thai people (Asawasakulsorn and Chatrangsan, 2014; Kamollimsakul, 2014), but there is a considerable literature on the effects of font type and size on computer screens for people in other countries (Rello, Pielot and Marcos, 2016; Joshi, Kaur and Wason, 2014; Lege et al., 2013; Lin, Wu and Cheng, 2013; Kong et al., 2011; Ling and van Schaik, 2006; Zaphiris, Kurniawan and Ghiawadwala, 2006; 2005; Darroch et al., 2005; Bernard et al., 2003; 2001). In addition, there are few research-based recommendations for the optimal font type and size for text presentation on computer screens for older people, as most of these relate to larger desktop machines rather than tablets (Kamollimsakul, 2014; Zaphiris et al., 2006; 2005; Bernard et al., 2001) or for languages other than English (Kamollimsakul, 2014; Lege et al., 2013; Kong et al., 2011). However, little research has investigated reading from smaller screens by older people, and only two studies (Darroch et al., 2005; Lege et al., 2013) could be found which have investigated reading from small screens by older people, one on personal digital assistants (PDAs) and only one on tablets, which was conducted in Japanese.

To present the research on font type and font size for English and Thai, the next paragraphs will summarise the results of previous research that were conducted on the effects of font type and font size on reading texts via a screen in English and Thai.

For font size, Bernard et al. (2001) found that English font at 14 point size was more legible and faster to read than font at 12 point on desktop computer screen for older people. In 2003, they conducted the effect of font type (Arial and Times New Roman) and font size (10 and 12 point) on reading text on computer screen for younger participants. They found that font type and font size no effect on reading time and the number of correctly identified words. However, Bernard et al (2003) found that the text at 12 point size was more legible, easier to read than text at 10 point size and also text at 12 point size was significantly preferred to text at 10 point size. In addition, Darroch et al (2005) investigated the effect of age group and font size on reading text on handheld computer screen (PDAs). They found that there was no significant difference in reading time and the number of correctly identified words between font sizes from 6 point to 16 point nor between age groups. They also found that older participants preferred font size at a range of 9 to 12 points but younger participant preferred font size at a range of 9 to 11 points.

Kamollimsakul (2014) examined the effect of font type and font size on reading on laptop screen for both younger and older participants in the UK and Thailand. He found that there was no significant effect of font size on time spent per webpage and in the number of correct answers for younger and older participants in both countries, but overall participants preferred font at 16 point size both in the UK and Thailand. Another Thai font study in Thailand (Asawasakulsorn and Chatrangsan, 2014), found that with serif font at 16 point tasks took less time than with serif font at 12 and 14 point when doing the tasks on a tablet. The latest English font size study (Rello et al., 2016) investigated the effect of font size on desktop computer screen with participants aged 14 to 54 years. They found that 18 point size produced higher comprehension scores than 12 and 10 point and 18 point size had significantly shorter fixation durations than the smaller font sizes (10 12 and 14 points).

For font type, as discussed above Bernard et al (2003) did not find a difference in reading times and the number of correct words identified between serif and sans serif fonts. In addition, Lin and Van Schaik (2006) found font type did not affect the reading speed and accuracy; however, participants preferred sans serif over serif. Joshi et al (2014) found that English sans serif fonts were faster to read than English serif fonts on computer screen for younger readers. Kamolimsakul (2014) found that English and Thai font types did not affect reading time and the number of correct answers, but UK participants preferred sans serif font while Thai participants preferred serif font. In addition, Asawasakulsorn and Chatrangsan (2014) found that there was no significant difference between the reading time of Thai serif and san serif fonts for younger people but the task of their study was the use of application that presented different font types.

In addition, the numerous web design guidelines often recommend that sans serif font at 12 and 14 point are the optimal font type and size for text presentation on computer screens for older people (see more detail in Chapter 2, section 2.8). However, there are still many Thai and UK news websites that use different font types. For example, in the UK, BBC website (www.bbc.co.uk) presents the text in a sans serif font while the York Press website (www.yorkpress.co.uk, York Press is the local print newspaper in York), presents the text in a serif font. In Thailand, two popular news websites, the Thairath website (www.thairath.co.th) presents the text in Thai sans serif font, while the Daily News website (www.dailynews.co.th) presents the text in Thai serif font.

Thus, it can be seen that it is not clear which font type or font size should be used for online presentation for readers, in particular, older readers. In addition, the results of those studies are still not sufficiently clear to make recommendations for text presentation on tablet computers for older people and the effect of font type and font size also may vary between languages using different orthographic systems and between user groups with different ages. Furthermore, there is as yet no specific evidence for recommendations of the combination of font type and font size on tablet computers for English and Thai language for readers. Particularly, the recommendations for older readers.

Therefore, this study investigated the effect of font type and font size on reading time, reading comprehension and preference on tablet computers of younger and older adults both in Thailand and the UK. Font type and font size were selected to investigate as independent variables for this study because the combination of these factors is used in many studies as discussed above and in the literature review (see Chapter 4, section 2.9).

The research questions for this study are:

1. Do serif and sans serif fonts make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
2. Do 14 point, 16 point and 18 point size fonts make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
3. Do Thai and English make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?

4. Do younger and older people differ in reading time, reading comprehension, rating of reading and preferences for font type and size when reading on a tablet computer?

There may also be interactions between the four variables of font type and size, age and language.

4.2 Method

4.2.1 Design

The study was undertaken in both Thailand and the United Kingdom. Data from each country was analysed separately as the font types used in the two countries were not exactly the same and the readability of the texts may not be exactly the same in English and Thai (see section 4.2.3 for details). In addition, the length of English and Thai texts is not exactly the same length for this experiment, and this may affect the comparison of reading time between UK and Thai participants. However, the results will be compared between the two countries. A mixed design was used, with three independent variables: two within-participants variables and one between-participants variable. The two within-participant variables were Font Type (two levels: serif and sans serif) and Font Size (three levels: 14, 16 and 18 points). The between-participants variable was Age Group (two levels: younger and older participants). Country (or language) was not an independent variable in the statistical analyses, but comparisons between the two countries were made where of interest.

Each participant was asked to read six texts in English (for UK participants) or Thai (for Thai participants) on a tablet computer screen, one in each combination of font type and font size. Texts were of a length to fit on a single screen of the tablet, so no scrolling was needed. Participants were asked to skim read, which means reading faster than normal speed, following Kamollimsakul's (2014) research. This is appropriate because skim reading is not as time consuming as detailed reading and Kamollimsakul (2014) found that participants did not become nervous when doing this task. In addition, skim reading also produced less fatigue for his participants. After reading each text, participants answered three multiple choice questions about the text to measure reading comprehension. At the end of the study, the participants were asked to select their overall preferred text presentation combination and rate each combination on how easy it was to read and how tiring it was to read.

Four dependent variables were measured: reading time, number of correct answers on comprehension questions, ratings of reading and the overall preference for the combinations of font type and font size.

4.2.2 Participants

90 participants took part in the study, 54 UK participants and 36 Thai participants.

The inclusion criteria of older Thai participants were to be a native Thai speaker of 60 years or above, living independently, while those of older UK participants were to be a native English speaker of 65 years or above, living independently.

The criteria of younger participants were to be a native speaker (native Thai speaker for Thai participants and native English speaker for UK participants) of 18 to 24 years in both countries.

In the UK, 36 older and 18 younger participants took part. The older participants comprised 18 men and 18 women, their ages ranged from 62 to 84 years, with a mean age of 69.4 years. One older participant was 62 years old, lower than the original criterion of 65 years or older, however, he was already retired, so was included in the sample. All older participants were native English speakers. Nine participants were still working and twenty-seven were retired. Twenty-six older participants wore glasses for reading, one wore contact lenses. Two of the older participants had also participated in Study 1.

All thirty-six older participants had experience of using the web, from 3.5 to 38 years[6] (*mean (M)* = 18.51, *standard deviation (SD)* = 6.38). In addition, they rated their level of experience and expertise in using the web at an average of 4.89 (*SD* = 1.19) and 4.47 (*SD* = 1.28), respectively (on a scale of 1: not at all to 7: extensive). Twenty-seven participants had experience in using tablets, the other 9 participants had not used a tablet before (experience with a tablet was not necessary for the study). Those with experience had used tablets from 0.25 to 15 years (*M* = 5.17, *SD* = 3.07) and they rated their level of experience and expertise in using tablets at an average of 4.54 (*SD* = 1.53) and 4.29 (*SD* = 1.61). The one older participant who claimed experience in using the tablet for 15 years counted his experience in using an older device (PDAs) that was similar to tablets in his experience.

The older participants were recruited from a participant pool of older people who work with the HCI Research Group at the University of York and a local social networking site.

The younger participants comprised 9 men and 9 women, their ages ranged from 18 to 23 years, with a mean age of 19.2 years. 17 participants were undergraduate students and one was a master's student at the University of York.

[6] The results are those provided by the participants themselves. Clearly having used the Web for 38 years is not possible, as the Web has only existed for approximately 30 years. One participant probably confused the length of his experience with the Web with his experience of using computers in his answer.

All younger participants were native English speakers. Six younger participants wore glasses for reading, and one wore contact lenses. All eighteen younger participants had experience in using the web, from 8 to 13 years (M = 10.14, SD = 1.64). In addition, they rated their level of experience and expertise in using the web at an average of 5.72 (SD = 1.02) and 5.39 (SD = 1.04), respectively. Eleven participants had experience in using tablets, from 1 to 7 years (M = 3.42, SD = 1.98) and they rated their level of experience and expertise in using the tablet at an average of 4.73 (SD = 1.01) and 4.91 (SD = 0.94), respectively. Seven participants did not have an experience of using a tablet.

The younger participants were recruited from posting advertisements, putting flyers at college receptions around the University of York and also from emailed advertisements to undergraduate students in the class by my supervisor.

In Thailand, 36 participants took part in the study, 18 younger and 18 older participants. The older participants comprised 3 men and 15 women, their ages ranged from 61 to 74 years, with a mean age of 66.0 years. All participants were native Thai speakers. Only one was still working and the rest of them were retired. Seventeen older participants wore glasses for reading. Three participants had already participated in Study 1.

Sixteen older participants had experience in using the web, from 1 to 15 years (M = 7.25, SD = 4.22). In addition, they rated their level of experience and expertise in using the web at an average of 3.63 (SD = 1.26) and 3.44 (SD = 1.21). Nine participants had experienced in using tablets, from 1 to 8 years (M = 4.16, SD = 2.41) and they rated their level of experience and expertise in using the tablet at an average of 4.22 (SD = 1.20) and 4.33 (SD = 1.00), respectively. Two older participants did not have any experience in using the web and nine participants did not have any experience in using tablets.

The older participants were recruited from a local social community at a temple and by snowballing recruitment, particularly people who were known by the parents of the researcher.

The younger participants comprised 6 men and 12 women, their ages ranged from 19 to 23 years, with a mean age of 20.8 years. All participants were native Thai speakers. 17 participants were undergraduate students at Naresuan University, Phistsanulok, Thailand and one was a nurse. Five younger participants wore glasses for reading, one wore contact lenses. All eighteen younger participants had experience in using the web, from 7 to 15 years (M = 9.28, SD = 1.96). In addition, they rated their level of experience and expertise in using the web at an average of 4.39 (SD = 0.92) and 4.00 (SD = 0.84), respectively. Seven participants had experience in using tablets from 0.2 to 8.4 years (M = 3.35, SD = 3.19) and they rated their level of experience and expertise in using tablets at an average of 3.57 (SD = 1.13) and 3.29 (SD = 1.11), respectively. Eleven participants did not have any experience in using the tablet.

The younger participants were recruited from the Division of Student Affairs at Naresuan University by snowballing recruitment.

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

4.2.3 Equipment and materials

A fourth generation iPad tablet computer running iOS and Safari was used in both Thailand and in the UK.

All materials were created in two versions: one in English (for UK participants) and one in Thai (for Thai participants).

Materials in the study were:

1. Initial questionnaire

The initial questionnaire consisted of three parts: (1) questions about use of websites, which included how participants had learnt to use the web, including expertise and experience with the web (2) questions about use of tablet computers, which included how participants had learnt to use the tablet, including expertise and experience with the tablets and (3) demographic questions, which included information about age, gender, and occupation. The set of questions can be seen in Appendix M both for the English and Thai versions.

2. The experimental texts and questions

A website was created to present the texts, comprehension questions, and post reading questionnaire, with versions in English and Thai.

Seven English texts (six experimental texts and one practice text, see Appendix O) were adapted from Wikipedia articles which would be of general interest to both younger and older participants in both countries. The texts were about animals (Emperor penguins, Flamingos and Meerkats), interesting places (the Leaning Tower of Pisa and Niagara Falls) and fruits (Durian and Dates). The practice text was Durian and it was also used as the practice text in Studies 3 and 4.

For the English texts, each text comprised 228 - 233 words in 15-16 sentences arranged in three paragraphs. The length of texts was selected such that in all text presentations it would fit on one tablet screen, so participants did not need to scroll to read the text, which would add another level of complexity to the reading task (Sanchez and Wiley, 2009; O'hara and Sellen, 1997). The texts were adjusted to have very similar readability levels using a number of measures. Table 4.1 shows the measures used, in each case texts were within +/-10% of the mean on all of these measures.

The researcher subsequently realised that a Latin Square design would have been a better way of eliminating the effects of the particular texts, but this careful matching of the texts on a range of measures should have achieved a similar result.

Texts were presented in Times New Roman for the serif font and Arial for the sans serif font with three different font sizes. The font sizes were 14, 16 and 18 point.

Table 4.1 Measures for matching the objective readability levels of the texts

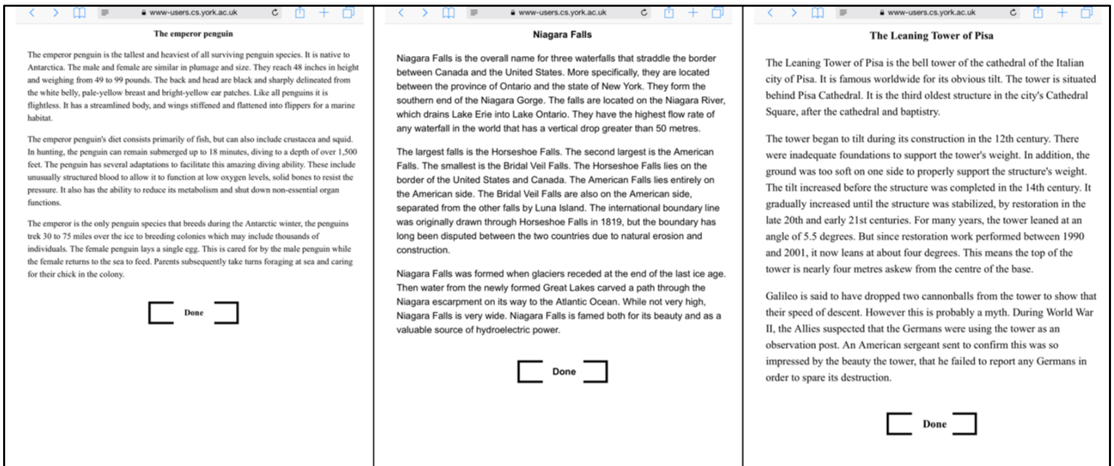
Measure	Mean	+/- 10% range
Flesch-Kincaid Score	59.4	52.1 – 65.1
Gunning Fog Index	10.5	9.7 – 11.5
Sentences > 20 syllables (%)	59.4	50 - 64
Words > 12 letters	0	0
Passive sentences	2.7	1 - 4

For the Thai texts, one of the authors translated the English 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 (see procedure of translation in Appendix N).

Each Thai text had three paragraphs and comprised 260 – 263 words. The serif font used for the Thai texts was TH Sarabun font which is the official font type for documents in Thailand and is also used on many Thai news websites (such as www.dailynews.co.th) and the sans serif font was Kanit. The Kanit font is also popular for Thai websites. These two font types are illustrated in Figure 4.1. The Thai texts were also presented in three different font sizes which were 14, 16 and 18 point as the same as English texts. In addition, the examples of the combinations of font type and font size in English and Thai language for the study are shown in Figure 4.2 and Figure 4.3, respectively.

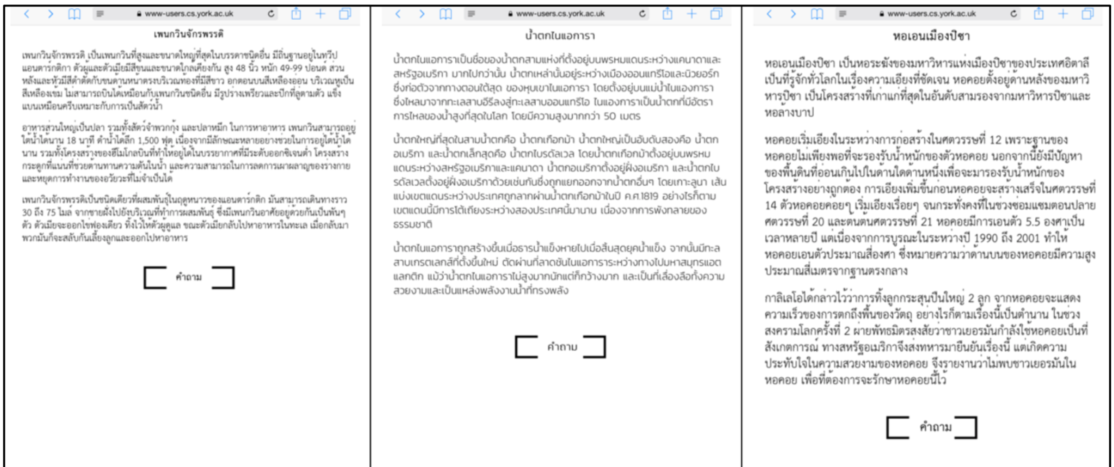
Figure 4.1 Thai Serif (TH sarabun font) and Sans serif (Kanit font);
"ประเทศไทย" means Thailand

In both languages the texts were presented on the tablet screen left justified and with 1.5 line spacing. Previous research on reading (albeit from large computer screens) found this was the preferred presentation arrangement for web users, both young and older in the UK and in Thailand (Petrie et al., 2013; Kamollimsakul, 2014).



(a) Serif font with 14 point (b) Sans serif font with 16 point (c) Serif font with 18 point

Figure 4.2 Examples of the combinations of font type and font size in English



(a) Thai Serif font with 14 point (b) Thai Sans serif font with 16 point (c) Thai Serif font with 18 point

Figure 4.3 Examples of the combinations of font type and font size in Thai

Three multiple choice questions were developed for each text. A four-set of questions was initially created for each text and their level of difficulty was assessed. To do this, five participants (students and staff in the Department of Computer Science at the University of York) read each text, answered all the questions for it and rated for the difficulty of each question (on 9-point Likert items, 1 = very difficult to 9 = not at all difficult) in two different ways. First, they rated the difficulty of the question immediately after they answered it. After answering all the questions for that text, they were asked to look at the text again then rate the difficulty of finding the answer in the text. For example, considering its position in the text, whether there were very similar pieces of information that could be confused with the answer and so on. At this point they also were asked whether they had known the answer before reading the text.

From this data, three questions were selected for each text with the following criteria:

- no participant knew the answer beforehand (so the researcher considered they were not likely to be common knowledge)
- ratings of 6.1 – 6.9 for the basic difficulty rating
- ratings of 7.5 – 8.3 on the difficulty in text rating

The website was coded to record the time the participants took to read each text. To do this, the website recorded the time that they opened the page with the text to the time they moved on to the question page. The website also recorded their answers to the questions and transferred them into a database for later analysis.

3. Final questionnaire

The final questionnaire measured participants' reactions to the font type and size combinations. The questionnaire presented an example of each combination and asked the participant to rate each combination on a series of seven-point Likert items. Ratings were of how easy it was to read the text (1 = very easy to read, 7 = very difficult to read) and how tiring it was to read the text (1 = not at all tiring to read, 7 = very tiring to read). Participants also identified their most preferred combination of font type and font size (see Appendix P).

4.3 Procedure

A flowchart of the study procedure is presented in Figure 4.4.

The study was conducted in Thailand and the UK with the same procedure. Firstly, the researcher explained the aim of the study and also the reading task and participants were asked whether they had any questions about the study. When the participants were happy, they signed an informed consent form. Participants then completed the initial questionnaire. If needed, the researcher showed participants the basics of using the iPad tablet (although no part of the study required expertise in using the tablet, apart from the ability to tap on the

Next button). Participants were given a practice skim reading text (the Durian text) to accustom themselves to the task and the tablet.

The participants then skim read each of the six texts with a different combination of font types and font sizes on the tablet sitting in any comfortable position for reading, but with the tablet resting on the table in front of them. The order of the font type and font size combinations was counterbalanced between participants to minimize practice and fatigue effects. After reading each text, participants answered the three multiple choice questions about the text without being able referring back to the text.

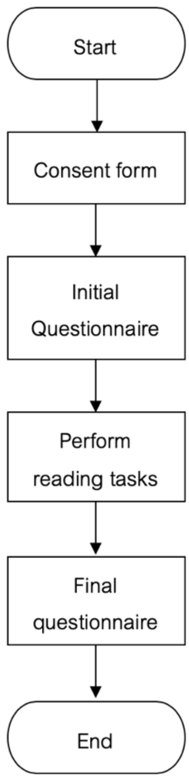


Figure 4.4 Flowchart of the procedure for the study

After reading all six texts, participants completed the online final questionnaire, about their ratings of how easy and how tiring it was to read text in each combination and gave their most preferred combination. During these questions, the texts were available for participants to view to remind them of each combination. The website recorded the reading time, answer to the questions and the final questionnaire. At the end of session, participants were debriefed and encouraged to ask questions about the study (see Appendix Q). They were thanked for their participation and offered a gift voucher.

4.4 Data analysis

As is often the case, a Shapiro-Wilk test showed that the reading times were not normally distributed ($p < .05$) but had a positive skew. To reduce skew and the effects of outliers, a Winsorizing process was applied (Field, 2013; Cressie and Hawkins, 1980). Any times which were longer than the mean plus two standard deviations (mean+2SD) or shorter than the mean minus two standard deviations (mean-2SD) were adjusted to the mean plus/minus two standard deviations respectively. The reading times then met the assumptions for parametric analysis. Thus, a mixed ANOVA was applied to the reading times in order to investigate whether there were any differences in reading time between the two within-participant variables (font types and font sizes) and the between-participant variables (age-groups), and any interaction between these variables.

The scores for the comprehension questions on each text were also not normally distributed ($p < .05$), and the data were not suitable to be adjusted with Winsorization. Aggregate scores were created by summing the scores for the serif and the sans serif texts separately (3 texts each, so scores range from 0 – 9) and the three font sizes (2 texts each, so scores range from 0 – 6) and also total scores (6 texts each, so scores range from 0 – 18). Then, non-parametric statistical tests were applied for analysis of this data.

Non-parametric statistical tests were also applied for the ratings of ease, how tiring and difficulty reading was, ratings were aggregated to create ratings for the serif and sans serif font and of the three font sizes, as above.

To investigate the differences between more than two group means when the participants responded to more than one condition, the Wilcoxon Signed-Ranks test was applied to the comprehension scores and the ratings of reading as there were two font types. The Friedman test was applied for the comprehension scores as there were three font sizes.

To investigate the differences between independent groups (the two age groups), the Mann-Whitney U test was applied to total comprehension scores and ratings of reading for different font types and font sizes.

In addition, to investigate the relationships between rating of ease of reading and how tiring it was to read of each participant, a Spearman's Rank-Order Correlation was applied to two ratings of reading.

To investigate the difference in preferences for the combinations of font type and font size between younger and older participants, a Chi-square test was used, as these are frequency data.

4.5 Results

This section presents the effect of font type and font size on reading time, reading comprehension, rating of ease and tiring for reading on each combination and participants' preference of the combination of font type and font size. As discuss in Chapter 3, section 3.5, the power calculations were reported for non-significant results.

4.5.1 Reading time

For the UK study, a mixed ANOVA on reading time (Age Group x Font Type x Font Size) found that there were significant main effects for Age Group ($F_{(1,52)}$ = 7.65, p < .05, η_p^2 = .13) and Font Size ($F_{(2,104)}$ = 20.90, p < .05, η_p^2 = .29) but not for Font type (η_p^2 < .01). There were no significant interactions between any of the variables, Font Size x Age Group and Font Size x Font Type produced a medium effect size[7] (η_p^2 > .04), Font Type x Age Group and Font type x Font size x Age Groups produced a small effect size (η_p^2 < .01). The power calculation indicated that there is an 80% chance of correctly detecting the effect and the effect of the interaction with 129 younger and 129 older participants a total sample 258 participants. Thus for the robust result, 111 more younger participants and 93 more older participants would need to participate.

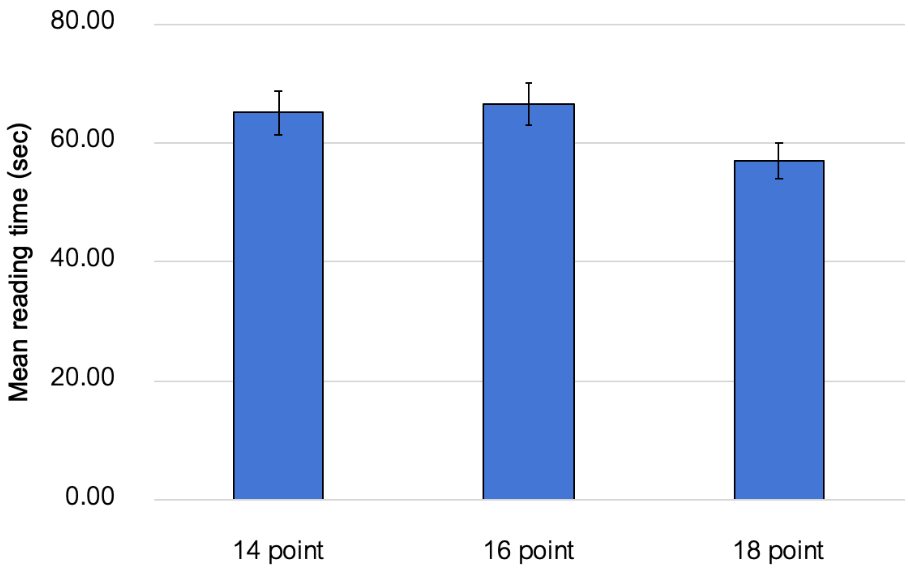


Figure 4.5 Mean reading time of UK participants per text for each font size

[7] In term of effect size: partial eta- squared (η_p^2) ≥ .01 indicates a small effect size, η_p^2 ≥ .06 indicates a medium effect size η_p^2 ≥ .14 indicates a large effect size (source: Rules of thumb on magnitudes of effect sizes, University of Cambridge, from http://imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize)

The Age Group main effect was that older participants took significantly longer to read the texts (*M* = 68.60 seconds, *SD* = 25.50) than younger participants (*M* = 51.50 seconds, *SD* = 20.60).

The Font Size main effect is illustrated in Figure 4.5 Bonferroni post-hoc comparisons showed that there were significant differences in reading time between 18 point text and 14 point text and 18 point text and 16 point text (all comparisons $p < .001$). For all participants reading the 18 point text (*M* = 57.08 seconds, *SD* = 21.87) was significantly quicker than either the 14 point text (*M* = 65.03 seconds, *SD* = 27.37) or 16 point text (*M* = 66.55 seconds, *SD* = 25.45), which were not significantly different in reading time from each other.

For the Thai study, a mixed ANOVA on reading time (Age Group x Font Type x Font Size) found that there were significant main effects for Age Group ($F_{(1,34)} = 19.88$, $p < .05$, $\eta_p^2 = .37$) and Font Size ($F_{(2, 34)} = 12.14$, $p < .05$, $\eta_p^2 = .26$) but not for Font Type ($\eta_p^2 < .01$). The power calculation indicated that there is an 80% chance of correctly detecting the effect with 129 younger and 129 older participants, making a total sample 258 participants. Thus for robust result, 111 more younger participants and 111 more older participants would need to participate.

There was also a significant interaction between Font Type and Font Size ($F_{(2, 68)} = 10.30$, $p < .05$, $\eta_p^2 = .24$). The Age Group main effect was that older participants took a significantly longer time to read the texts (*M* = 146.15 seconds, *SD* = 48.93) than younger participants (*M* = 88.77 seconds, *SD* = 36.50).

The Font Size main effect is illustrated in Figure 4.6. Bonferroni post-hoc comparisons showed that there were significant differences in reading time between 18 point text and 14 point text and 18 point text and 16 point text (all comparisons $p < .005$). Reading the 18 point text (*M* = 108.67 seconds, *SD* = 49.36) was significantly quicker than either the 14 point text (*M* = 119.60 seconds, *SD* = 55.09) or 16 point text (*M* = 123.22 seconds, *SD* = 49.71), which were not significantly different from each other.

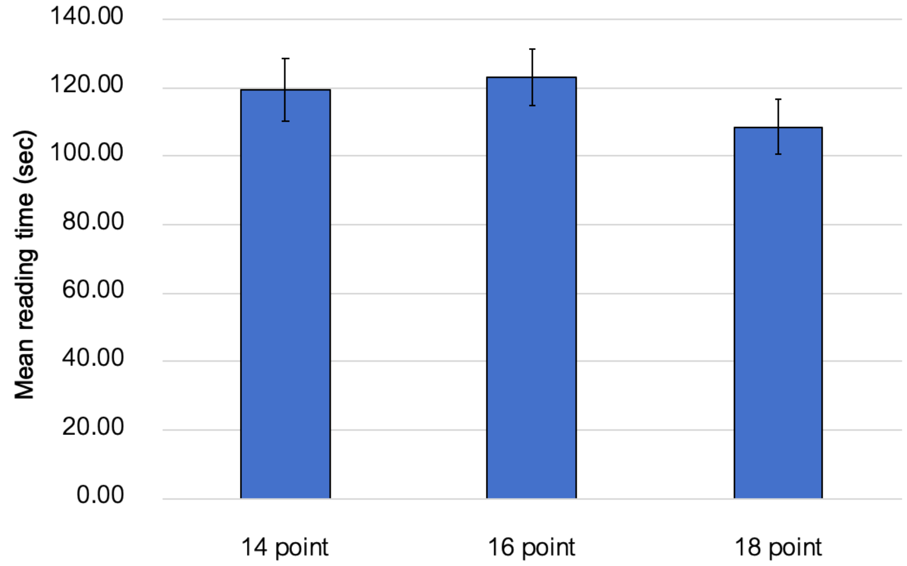


Figure 4.6 Mean reading time of Thai participants per text for each font size

The significant interaction between Font Type and Font Size is illustrated in Figure 4.7. Bonferroni post-hoc comparisons showed that for the sans serif font, 18 point was read significantly quicker than 14 and 16 point (all comparisons $p < .001$), but for the serif font there were no significant differences in reading time. Comparing the Font Types at the same point size, 14 point serif was read significantly quicker than 14 point sans serif ($p < .05$), there was no significant difference between serif and sans serif at 16 point, and at 18 point sans serif was read significantly quicker than serif ($p < .001$).

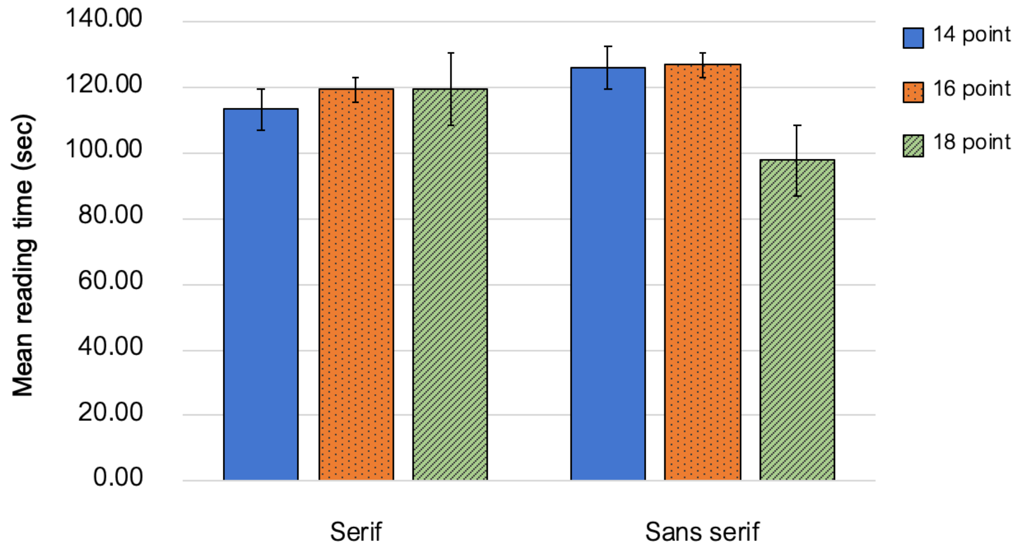


Figure 4.7 Mean reading time of Thai participants for font type and size

Overall, Age groups had effect on reading time for both countries. Older participants took a longer time to read the texts than younger participants in both countries. In addition, participants took a significantly shorter time to read 18 points text than 14 and 16 point texts in both countries while no significant difference in reading times between serif and sans serif fonts for both Thai and UK participants. Moreover, Thai Sans serif font at 18 point size had significantly shorter reading times than at 14 and 16 point size.

4.5.2 Comprehension of texts

For the UK study, on the effect of font type on comprehension of the texts, a Wilcoxon signed ranks test showed that there was a significant difference between serif and sans serif fonts ($Z = 4.24$, $p < .01$, $r = .58$). All participants answered significantly more questions correctly in the serif font (*median (Mdn)* = 6.00, *Interquartile (IQR)* = 2.00) than in the sans serif font (*Mdn* = 5.00, *IQR* = 3.00).

For font size, a Friedman test showed that there was a significant difference in comprehension scores between 14, 16 and 18 point text ($\chi^2 = 31.04$, $df = 2$, $p < .001$) (see Figure 4.8).

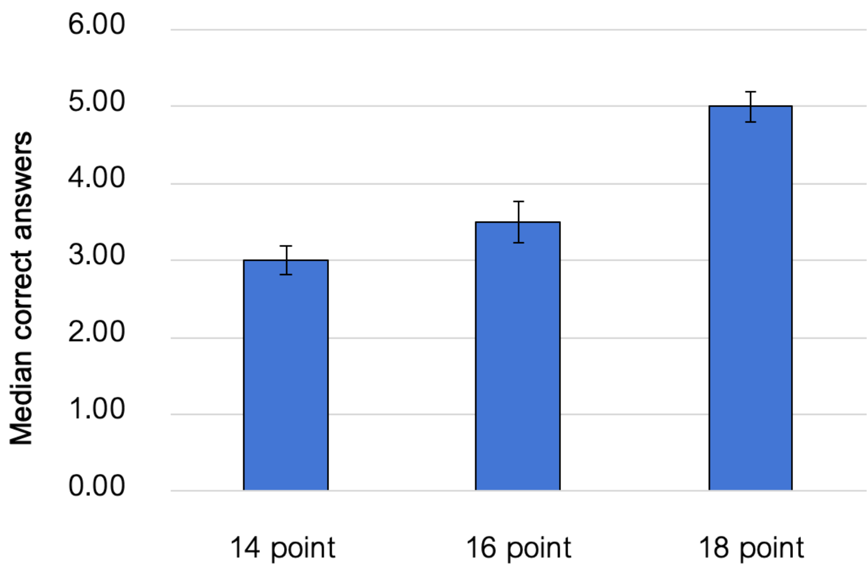


Figure 4.8 Median number of correct answers of UK participants for each font size

The Wilcoxon signed ranks test showed that there were significant differences in comprehension scores between 14 point and 18 point ($Z = 3.11$, $p < .005$, $r = .73$), between16 point and 18 point ($Z = 3.41$, $p < .005$, $r = .46$) and between 14 point and 16 point ($Z = 3.11$, $p < .005$, $r = .42$). Participants answered significantly more questions correctly in 18 point (*Mdn* = 5.00, *IQR* = 1.75) than in 14 point (*Mdn* = 3.00, *IQR* = 2.00) or 16 point (*Mdn* = 3.50, *IQR* = 3.00) and participants also answered more questions correctly in 16 point than in 14 point.

To investigate the interaction between font type and font size, the Wilcoxon signed ranks test revealed there was a significant difference between serif font and sans serif font in comprehension scores at 14 point size, but not for 16 and 18 point (Z = 5.71, p < .001, r =.78). Participants answered significantly more questions correctly in the serif font (Mdn = 2.00, IQR = 0.00) than in sans serif font (Mdn = 1.00, IQR = 1.00) at 14 point size.

However, Mann-Whitney U test found that there was no significant difference in comprehension scores overall between younger and older participants (U = 281.0, p = .43, r = .11). There were also no significant differences in comprehension scores for each font type and font size between the two age groups. The power calculation indicated that there is an 80% chance of correctly detecting the difference with 167 younger participants and 167 older participants, making a total sample of 334 participants. Thus for robust results, 148 more younger participants and 131 more older participants would need to participate.

For the Thai study, on the effect of font type on comprehension of the texts, Wilcoxon signed ranks test showed that there was significant difference between serif and sans serif font types (Z = 2.21, p < .05, r =.58). All participants answered significantly more questions correctly in the serif font (Mdn = 6.00, IQR = 5.00) than in the sans serif font (Mdn = 4.00, IQR = 3.00).

On the effect of font size on comprehension of the texts, Friedman test showed that there was a significance in comprehension scores between the three font sizes (χ^2 =16.49, df = 2, p < .05). Figure 4.9 shows the median number of correct answers for each font size. Wilcoxon signed ranks tests showed there was a significant difference in comprehension scores between 14 point text and 16 point text (Z = 3.46, p < .05, r = .58) or 18 point text (Z = 2.93, p < .05, r = .49). Participants answered significantly more questions correctly at 16 point (Mdn = 4.00, IQR = 3.00) and 18 point (Mdn = 4.00, IQR = 3.00) than at 14 point (Mdn = 3.00, IQR = 2.00). Comprehension at 16 point and 18 point clearly did not differ significantly (Z = 0.50, p = .62, r =. 08).

In addition, Wilcoxon signed ranks test revealed there was a significant difference between serif font and sans serif font in comprehension scores at 14 point size (Z = 3.16, p < .005, r =.53), but not for 16 and 18 point size. Participants answered significantly more questions correctly in the serif font (Mdn = 2.00, IQR = 1.00) than in the sans serif font (Mdn = 1.00, IQR = 2.00) at 14 point size.

A Mann-Whitney U test found that overall younger participants answered significantly more questions correctly than older participants (U = 83.00, p < .05, r = .42). In addition, younger participants answered significantly more questions correctly than older participants in sans serif (U = 75.50, p < .05, r =.46) but there was no a significance in serif between younger and older participants (U = 118.50, p = .16, r =.23). Younger participants also answered significantly more questions correctly than older participants at 14 point (U = 100.00, p < .05, r = .34) and at 18 point (U = 95.50, p < .05, r =.36) but there was no significant difference at 16 point (U = 103.00, p = .06, r = .32). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 71 younger participants and 71 older participants, making a total sample of 142 participants. Thus for robust results, 53 more younger participants and 53 more older participants would need to participate.

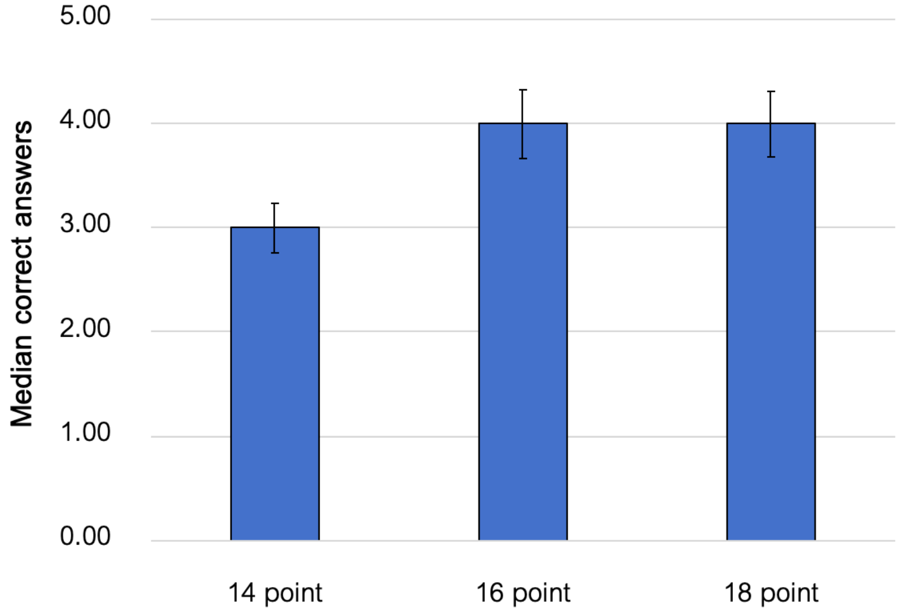


Figure 4.9 Median number of correct answers of Thai participants for each font size

4.5.3 Participants ratings of ease of reading and how tiring it was to read

Participants rated ease of reading and how tiring it was to read for each combination of font type and font size on 7-point Likert items (1 = "very easy to read/not at all tiring to read" to 7 = "very difficult to read/very tiring to read"). So lower scores mean greater ease or less tiring.

To investigate the relationship between the ratings of ease of reading and how tiring it was to read for each combination of font type and font size, a Spearman's Rank-Order correlation was calculated for these two ratings of reading. There was a significant positive relationship found between the two ratings of reading for both UK and Thai participants for each combination of font type and font size. Thus, the rating of ease of reading positively related to the rating of how tiring it was to read for each combination of font type and font size in both countries. Table 4.2 illustrates the results of Spearman's Rank-order correlation (r) test for each combination of font type and font size.

Table 4.2 The result of Spearman's Rank-Order Correlation test on median of rating ease of reading and how tiring it was to read of UK and Thai participants for each combination of font type and font size

Combinations (font type / font size)		UK (ratings of ease of reading and how tiring reading was)	Thai (ratings of ease of reading and how tiring reading was)
Serif	14 point	r = .75*	r = .71*
	16 point	r = .62*	r = .47*
	18 point	r = .52*	r = .55*
Sans serif	14 point	r = .65*	r = .67*
	16 point	r = .38*	r = .76*
	18 point	r = .59*	r = .84*

Note: * correlation is significant at the 0.01 level (2-tailed)

As the results of the two ratings of reading were correlated, the researcher combined the values of the rating of ease of reading and how tiring it was to read of each participant for each combination of font type and font size. The mean of the two ratings of reading of each participant was calculated and produced a new value of rating of reading variable which was called the rating of "difficulty of reading". Thus, the results of this new rating of difficulty of reading for UK and Thai participants are presented below.

For the UK study, Wilcoxon Signed-Ranks test showed that there was a significant difference on ratings of difficulty of reading between the serif font and sans serif font (Z = 5.85, p < .001, r =.80). All participants found the serif font (Mdn = 3.17, IQR = 1.30) more difficult than the sans serif font (Mdn = 2.00, IQR = 1.12).

The Friedman test showed that there was a significant difference in difficulty of reading between different the three font sizes (χ^2 = 55.69, df = 2, p < .001). To compare on each pair of font size, the Wilcoxon Signed-Ranks test showed that all pairs of sizes were significantly different from each other (p < .001). Participants found that 18 point text (Mdn = 2.00, IQR = 1.00) was less difficult to read than 14 point text (Mdn = 2.50, IQR = 1.00) or 16 point text (Mdn = 3.00, IQR = 1.75). In addition, participants also found that 16 point text was less difficult to read than 14 point text. The median of rating of difficulty of reading for three font sizes are illustrated in Figure 4.10.

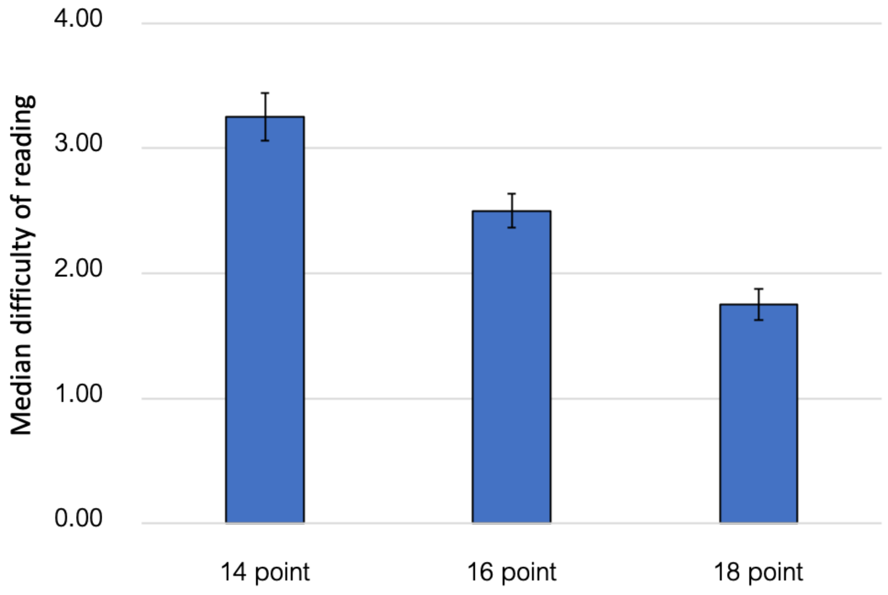


Figure 4.10 Median rating of difficulty of reading of UK participants for each font size

To investigate the interaction between font type and font size, the Wilcoxon Signed-Ranks test revealed that there was significant difference in difficulty of reading between serif font and sans serif font at 14 point size (Z = 4.94, p < .001, r = .67), 16 point size (Z = 5.39, p < .001, r = .73) and 18 point size (Z = 4.64, p < .001, r = .63). Participants found that sans serif font (*Mdn* = 2.75, *IQR* = 1.50) was significantly less difficult to read than serif font at 14 point (*Mdn* = 3.50, *IQR* = 2.50). Participants found that sans serif font (*Mdn* = 2.00, *IQR* = 1.38) was significantly less difficult to read than serif font at 16 point (*Mdn* = 3.00, *IQR* = 1.38) and they also found that sans serif font (*Mdn* = 1.50, *IQR* = 1.00) was significantly less difficult to read than serif font at 18 point (*Mdn* = 2.00, *IQR* = 1.00).

To investigate the difference in rating of difficulty of reading for the different font type and font size by younger and older participants, Mann-Whitney U tests showed that there was no significant difference on rating of difficulty of reading between younger and older participants on either serif font (U = 317.00, p = .90, r = .02) or sans serif font (U = 299.50, p =.65, r = .06). There was also no significant difference on rating of difficulty of reading between younger and older participants in font size at 14 point size (U = 293.00, p = .57, r = .08), 16 point size (U = 300.50, p = .66, r = .06) and 18 point size (U = 297.50, p = .62, r = .07). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 1,172 younger and 1,172 older participants, making a total sample of 2,344 participants. Thus for robust results, 1,154 younger participants and 1,136 older participants would need to participate.

For the Thai study, Wilcoxon Signed-Ranks test showed that there was significant difference on rating of difficulty of reading between serif font and sans serif font (Z = 4.33, p < .001, r

=.72). Participants found the serif font (*Mdn* = 2.00, *IQR* = 1.54) less difficult to read than the sans serif font (*Mdn* = 4.00, *IQR* = 2.17).

Friedman test showed that there was a significant difference in rating of difficulty of reading between the three font sizes (χ^2 = 10.49, *df* = 2, *p* < .01). Wilcoxon Signed-Ranks test showed that there was significant difference either between 18 point size and 14 point size (*Z* = 2.39, *p* < .05, *r* = .40). Participants found that 18 point text (*Mdn* = 2.88, *IQR* = 1.31) was less difficulty to read than 14 point text (*Mdn* = 3.25, *IQR* = 1.81). The median of rating of difficulty of reading for three font sizes are illustrated in Figure 4.11.

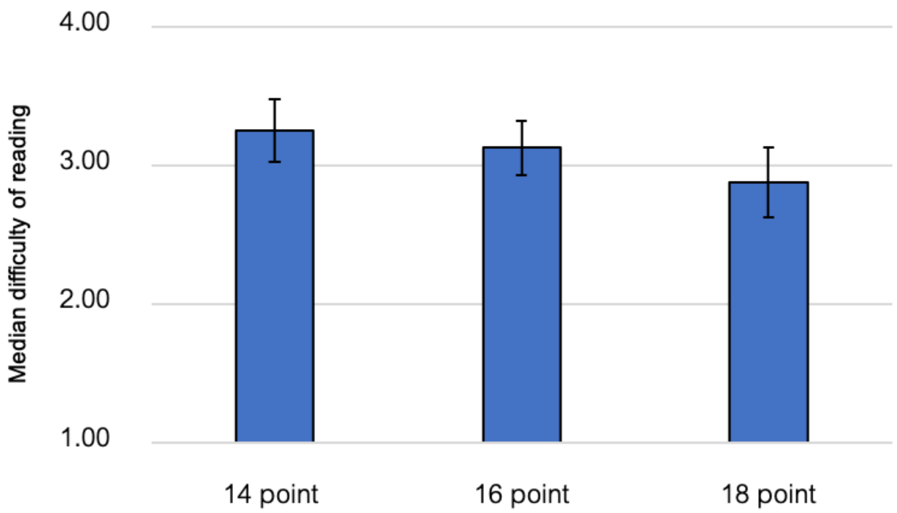


Figure 4.11 Median rating of difficulty of reading of Thai participants for each font size

To investigate the interaction between font type and font size, the Wilcoxon Signed-Ranks test revealed that there was significant difference in difficulty of reading between serif font and sans serif font at 14 point size (*Z* = 3.83, *p* < .001, *r* = .64), 16 point size (*Z* = 4.41, *p* < .001, *r* = .74) and 18 point size (*Z* = 3.69, *p* < .001, *r* = .62). Participants found that serif font (*Mdn* = 2.00, *IQR* = 2.00) was significantly less difficult to read than sans serif font at 14 point (*Mdn* = 4.00, *IQR* = 2.50). Participants found that serif font (*Mdn* = 1.75, *IQR* = 1.13) was significantly less difficult to read than sans serif font at 16 point (*Mdn* = 4.50, *IQR* = 2.50) and they also found that serif font (*Mdn* = 1.50, *IQR* = 1.50) was significantly less difficult to read than sans serif font at 18 point (*Mdn* = 4.00, *IQR* = 2.63).

To investigate the difference in rating of difficulty of reading for the different font type and font size by younger and older participants, Mann-Whitney U tests showed that there was no significant difference on rating of difficulty of reading between younger and older participants on either serif font (*U* = 140.00, *p* = .49, *r* = .12) or sans serif font (*U* = 124.50, *p* = .24, *r* = .20). There was also no significant difference on rating of difficulty of reading between younger and older participants in font size at 14 point size (*U* = 114.00, *p* = .13, *r* = .25), 16 point size (*U* = 129.50, *p* = . 30, *r* = .17) and 18 point size (*U* = 149.00, *p* = .68, *r*

= .07). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 511 younger and 511 older participants, making a total sample of 1,022 participants. Thus for robust results, 493 more younger participants and 493 more older participants would need to participate.

Overall, the results of the rating of difficulty of reading showed that 18 point text was the the least difficult to read both for UK and Thai participants. In addition, serif font was less difficult to read than sans serif font for Thai participants while sans serif font was less difficult to read than serif font for UK participants. Moreover, there was no significant difference in the rating of difficulty of reading between two age groups in both countries.

4.5.4 Preferences for combinations of font type and font size

For the UK study, participants were asked which of all the combinations of font type and font size they preferred. Their choices are summarized in Table 4.3.

A chi-square test showed the overall difference in preferences for combinations of font type and font size between older and younger participants was not significant ($\chi^2 = 9.88$, $df = 5$, *n.s.*). However, the difference in preferences for font type between the two age groups was significant ($\chi^2 = 4.34$, $df = 1$, $p < 0.01$), with older participants more likely to choose sans serif than younger participants. On the other hand, there was no significant difference in preference for font size between older and younger participants ($\chi^2 = 3.19$, $df = 2$, *n.s.*).

The power calculation indicated that there is an 80% chance of correctly detecting the differences in preferences with 81 younger and 81 older participants, making a total sample of 162 participants. Thus for robust results, 63 more younger participants and 45 more older participants would need to participate

Taking younger and older participants separately, and the distribution of younger participants preferences in font size was not a significantly different ($\chi^2 = 1.33$, $df = 2$, *n.s.*) while the distribution of older participants preferences in font size was a significantly different ($\chi^2 = 21.5$, $df = 2$, $p < 0.01$). For font type, the distribution of younger participants was not a significantly different ($\chi^2 = 0.89$, $df = 1$, *n.s.*) while the distribution of older participants was a significantly different ($\chi^2 = 18.78$, $df = 1$, $p < 0.01$).

The power calculation indicated that there is an 80% chance of correctly detecting the differences in preferences with 71 younger and 71 older participants, making a total sample of 142 participants. Thus for robust results, 53 more younger participants and 35 more older participants would need to participate.

Overall, the most popular choice was 18 point sans serif, chosen by nearly half (44.4%) the participants. For the older participants, this was also the most popular choice, chosen by

55.6% of the older participants. The sans serif choices in total accounted for 86.1% of choices by older participants, with only 13.9% choosing serif (and all at 18 point). For the younger participants, with approximately a quarter of younger participants choosing each of 16 and 18 point sans serif (27.8% and 22.2% respectively) and 18 point serif (22.2%).

Table 4.3 Preferences of all UK participants and younger and older participants separately for each combinations of font type and font size (% and number of participants)

Combinations (Font type / Font size)		Older (N = 36)	Younger (N = 18)	All (N = 54)
Serif	14 point	0.0 % (0)	11.1 % (2)	3.7 % (2)
	16 point	0.0 (0)	5.6 (1)	1.9 (1)
	18 point	13.9 (5)	22.2 (4)	16.7 (9)
Sans serif	14 point	11.1 (4)	11.1 (2)	11.1 (6)
	16 point	19.4 (7)	27.8 (5)	22.2 (12)
	18 point	55.6 (20)	22.2 (4)	44.4 (24)

Moreover, some participants gave reasons for choosing of combination of font type and font size. For participants who chose 18 point sans serif, some older participants found that the 18 point sans serif is comfortable size and clear font and it does not strain their eyes. They also found that sans serif font looks clean and 18 point was not too small and less pressure for their eyes to adjust. In addition, younger participants said that this combination kept their attention the best and also easy to read without staining. One younger participant said that it was easier skim reading otherwise it was straining to focus at speed.

In contrast, participants who chose sans serif at 16 point found that font size at 16 point was not too large and too small, easy to read and the sans serif font (as a plain font) was clean and clear to read. One older participant commented that a simple font (e.g. Arial) is easier to read than an old-fashioned font (e.g. Times New Roman) and medium size is better than small which is a bit of a strain to read or large which involved moving down the page too quickly.

Two older participants found that the 14 point sans serif seemed easier to read in a relaxed way and was a clear font. Moreover, another older participant did not notice the font size were different while she was reading the texts in the experiment. In addition, one older participant found that with the larger fonts (16 and 18 point) it was more difficult to grasp the overall meaning of a sentence. Two younger participants found that the 14 point sans serif was more aesthetically pleasing, and the font size was neither too big or too small and one of them stated that 14 point size was perfect for where she like to rest her head in relation to distance from the screen without needing to find next words.

Both younger and older participants found that the 18 point serif was clear and easy to read without too much effort for their reading. One younger participant commented that the serif font made his reading easier than sans serif. In contrast, only one younger participant chose 16 point serif and that participant found that serif font was better to read the sans serif font, and 16 point was a good font size for reading. Another two younger participants found the 14 point serif was a good format text and least tiring to read.

However, from all the participants' comments about why they chose that combination of font type and font size, most participants mentioned and commented about font sizes much more than they commented about font types.

For the Thai study, Thai participants were asked which of all the combinations of font type and font size they preferred. Their choices are summarized in Table 4.4.

A chi-square test showed the overall difference in preferences for combinations of font type and font size between older and younger participants was significant ($\chi^2 = 17.27$, $df = 5$, $p < .05$). In addition, there also was a significant difference in preferences for font size between older and younger participants ($\chi^2 =14.76$, $df = 2$, $p < 0.05$). However, there was no significant difference in preferences for the font type between the two age groups ($\chi^2 = 3.27$, $df = 1$, *n.s.*).

Taking younger and older participants separately, and the distribution of younger participants preferences in font size was not a significantly different ($\chi^2 = 0.33$, $df = 2$, *n.s.*) while the distribution of older participants preferences in font size was a significantly different ($\chi^2 = 14.22$, $df = 1$, $p < .001$). For font type, the distribution of younger participants was a significantly different ($\chi^2 = 8.00$, $df = 2$, $p < .05$) while the chi-square test cannot be performed for distribution of older participants preferences in font size. Since all eighteen older Thai participants chose only serif font for their preference and this was so clear that older preferred serif font the most.

The power calculation indicated that there is an 80% chance of correctly detecting the differences in preferences with 54 younger and 54 older participants, making a total sample of 108 participants. Thus for robust results, 36 more younger participants and 36 more older participants would need to participate.

Overall, the most popular choice was 18 point serif, chosen by more than half (61.1%) the participants. For the older participants, this was the most popular choice, chosen by 94.0%

of the older participants. For younger participants, serif was also the most popular choice, with approximately a quarter of them choosing each of 14, 16 and 18 point serif. Thus, the serif font type was the most popular choice for all Thai older participants (100.0%) and younger participants (83.3%). In contrast, sans serif was not chosen at all by older participants, and by only 5.6% of younger participants.

Table 4.4 Preferences of all Thai participants and younger and older participants separately for each combination of font type and size (% and number of participants)

Combinations (Font type / Font size)		Younger (N=18)	Older (N = 18)	All (N = 36)
Thai Serif	14 point	22.2% (4)	0.0% (0)	11.1% (4)
	16 point	33.3 (6)	5.6 (1)	19.4 (7)
	18 point	27.8 (5)	94.0 (17)	61.1 (22)
Thai Sans serif	14 point	5.6 (1)	0.0 (0)	2.8 (1)
	16 point	5.6 (1)	0.0 (0)	2.8 (1)
	18 point	5.6 (1)	0.0 (0)	2.8 (1)

Some Thai Participants also gave reasons for their preference of the combination of font type and size. Participants who chose 18 point Thai serif found that this combination was clear and easy to read for them. Some participants, both younger and older, said that the they were familiar with the Thai serif font. This font type has a circle on the beginning of Thai characters which made it clear and easy to read and also this font at 18 point was big and made them feel comfortable to read.

However, some younger participants and one older participant found that 16 point Thai serif was easy to read and font size was big enough to read but another four younger participants found that 14 point Thai serif was easy to read as it was not too big or too small for reading, and they were not confused in reading.

Only one younger participant mentioned that 18 point Thai sans serif was clear. Another one found that 16 point sans serif was easy to read and big enough for reading. In contrast, one younger participant also found 14 point sans serif was easy to read and he felt there were not too many words for reading.

4.6 Discussion

This study investigated the effects of font and font size on a range of objective and subjective measures of reading from tablet computers for older and younger people in Thailand and the UK. A number of interesting findings emerged.

Older participants read significantly more slowly than the younger participants both in the UK and Thailand, although age did not interact with font type or font size in affecting reading times. However, font size had a significant effect on reading time for all participants in both countries. For both UK and Thai participants reading the 18 point text was significantly quicker than either the 14 or 16 point. This result agrees with the study by Rello et al. (2015) in which participants read on a PC screen with varied font sizes in Arial font from 10 to 26 points. These researchers recommended using at least 18 point text, as does the present study. These conclusions are very different from earlier research which explored smaller text sizes on digital devices (Asawasakulsorn and Chatrangsan, 2014; Kamollimsakul, 2014; Zaphiris et al., 2006; 2005; Darroch et al., 2005; Bernard et al., 2003; 2001).

In addition, there was an interaction between font and font size in reading time for Thai participants. These participants read 18 sans serif significantly quicker than either 14 or 16 point while there were no significant differences in reading speed for different font sizes in the serif font type. This result may be because Thai participants are very familiar with reading the TH sarabun serif font which is a traditional font type in Thailand and this font type has been used for many decades (although the same argument could be made for Times New Roman for English, but the same effect did not emerge in the UK data).

For the reading comprehension scores, older Thai participants answered fewer questions correctly than younger Thai participants, while there was no significant difference on this variable between UK age groups. This difference may have been because older Thai participants were less familiar with the general ideas of the materials in the texts and possibly found them less interesting. Although I attempted to find texts which would be of universal interest but unfamiliar to participants, the texts may have been on topics less familiar and interesting to older Thai participants. Overall, both UK and Thai participants answered more questions correctly in the serif font than in the sans serif font. This result differs from previous research (Kamollimsakul, 2014; Darroch et al., 2005; Bernard et al., 2003; 2001) that did not find the difference in term of accuracy between serif and sans serif. Moreover, both UK and Thai participants answered more questions correctly in the serif font than in the sans serif font at 14 point size, but not for 16 and 18 point size. However, the results also found that overall, participants answered more questions correctly in the 18 point size font than 14 point for the UK and Thai participants.

With regard to the ratings of difficulty of reading, UK participants rated the sans serif font less difficult to read than the serif font at either each font size or the overall rating whereas Thai participants rated the serif font less difficult to read than sans serif font type at either each font size or the overall rating. As mentioned above, this may be because the Thai participants are much more familiar with the traditional serif font. In addition, ratings of difficulty of reading did not differ in font type or font size between younger and older participants. Again, all participants in both countries rated the 18 point size font as less difficult to read than the smaller sizes.

In term of overall preferences, there was a difference in preference for combinations of font type and font size between the two Thai age groups while there was no difference between two UK age groups. In addition, there was a significant difference in preference for font type between the two UK age groups while no difference for font type between the two Thai age groups. In contrast, there was a significant difference in preference for font size between two Thai age groups whereas no difference for those between two the UK age groups.

Older UK participants preferred 18 point sans serif whereas the younger participants were equally split between 16 and 18 point sans serif and 18 point serif. For Thai participants, the older participants preferred 18 point serif whereas the younger participants were split between 14, 16 and 18 serif, with only a few preferring sans serif. These results agree with Kamollimsakul (2014) which investigated reading from laptop screens and in both English and Thai and found that UK participants preferred the English Sans serif and Thai participants preferred Thai Serif font.

However, the experiment has several limitations which need to be taken into consideration. As mentioned in the method, the effects of the particular text might have been better eliminated by using a Latin Square design in which different participants read different texts with each combination of font type and font size. However, such a design does not allow investigation of all the interactions between the variables. We did control as much as possible for the effect of the text by very careful matching of the readability of the texts on a number of measures and by matching the difficulty of the questions with empirical testing.

The researcher did not attempt to tightly control the distance at which the participant viewed the tablet screen nor the exact way in which the table was held, as we wanted to create a reasonably ecologically valid scenario. However, the researcher did ask the participants to place the tablet on the table to create an approximately similar distance (around 35 to 45 centimetres). In real life, people may be more likely to hold the tablet in their hands when reading. The researcher deliberately used the skim reading task, again because this is ecologically valid, but different results may arise from different reading tasks such as in-depth reading or scanning the text for typographical errors. Finally, although the sample of older participants was quite diverse, all the younger participants were university students and should therefore be good readers. A more diverse sample of younger people may yield different results, although one would predict that this would decrease any differences between the age groups rather than increase them.

4.7 Conclusion

This study focused on the effects of font type and font size on the reading performance and preferences on tablet computers for younger and older people both in Thailand and the UK. There were fewer differences in the results from the two countries than might have been expected, given the very different orthographic systems and the life experiences, particularly of the older participants. The clearest result was that 18 point text was the best in reading performance and the 18 point text was also rated less difficult to read for all participants in both countries. Moreover, in both countries older participants showed a clear preference for 18 point text whereas younger participants showed no definite preference. Thus based on all the research, the researcher would recommend using 18 point text on all digital devices whenever possible, be the desktops, laptops or tablets. This will create a good objective and subjective experience for all users.

Conclusions on font type are less clear and differ between the two countries. In the UK font type did not affect reading time, although it affected text comprehension, with more questions answered correctly in serif font type. However, sans serif was rated less difficult to read for UK participants and older UK participants in particular preferred sans serif. In Thailand although there was no overall effect of font type on reading time, there was an interaction with font size, with 18 point sans serif being the quickest to read. However, comprehension was better with serif font. Participants also rated serif less difficult to read than sans serif and preferred the serif font.

Overall on the basis of the results of this study, the researcher recommends font size at 18 points was recommended for presentation in both English and Thai. On font type, Thai Serif font was recommended for both younger and older Thai readers. Although the results of English font type were not clear about reading performance, but English Sans serif was recommended for UK readers in term of rating of difficulty of reading and preference.

Chapter 5

Study 3: The effect of text and background colours on reading text on tablet computer for younger and older people in Thailand and the UK

5.1 Introduction

The most commonly used colour combination for text colour on websites background colour is black text on a white background, based on the tradition of print publications. Apart from this colour combination, there are many options for text/background combinations for digital presentations, whether on websites or other documents (e.g. PDFs, PPTs) which can be presented on different devices (e.g. laptops, smartphones, dedicated electronic book devices such as Kindles). Other common combinations include black text on a buff background, yellow text on a black background and white text on a grey or black background. In addition, as discussed in Chapter 3, some older people still have problems with the use of colour when using the tablet including text and background not having enough contrast.

In my literature review, I found four studies focused on text and background colour for digital presentation in English for older people (Loureiro and Rodrigues, 2014; Kamollimsakul, 2014; Zaphiris, Kurniawan and Ghiawadwala, 2006; 2005) and also some studies for younger people (Gradisar, Humar and Turk, 2007; Greco et al., 2008). A number of studies also investigated other languages: two studies focused on text colour combinations for Japanese people, both young and old (Yamazaki and Eto, 2015; 2014), one focused those variables for Chinese people, again both young and old (Huang, Bai and Ou, 2013) and one focused on Thai people, both young and old (Kamollimsakul, 2014).

Although, only two of those studies (Huang et al., 2013; Yamazaki and Eto, 2015) were conducted on tablet devices, and their tasks were not reading tasks. Another source of information (Loureiro and Rodrigues, 2014) about colour combinations for digital presentations on a touchscreen device is guidelines about web design for older people.

To summarize the research of text and background colour for digital presentations, the next paragraph will present the results of previous research which investigated the effect of text and background colour on reading texts via computer screens.

For text colour, Gradisar et al (2007) investigated the impact of text and background colour combinations on the legibility of web pages for younger people. They found a lighter text (such as white) on a darker background (such as black) colour produced comprehension scores lower than a dark text on a light background. Moreover, they also found black text produced a comprehension score higher than white text (see more detail in Chapter 2, 2.9.6). In addition, Greco et al. (2008) investigated the effect of the combination of text and background colour on the legibility of text. They found that dark text colours (such as black and blue text) were the most pleasant text colour and also found that a dark text colour on a light background colour was rated as the most legible.

For background colour, Yamazaki et al. (2014) investigated the effect of white and light blue background on comprehension of the English test on computer screens for younger Japanese people. They found that younger participants performed better with black text on light blue. In 2015, Yamazaki and Eto (2015) investigated the effect of different background colours on tablet computer screens on the attention of older Japanese people, aged 65 years and above. They found that older participants were able to concentrate most and felt least tired when they responded to the light blue background. Yamazaki and Eto (2015) also stated that white background may not be the best choice for older people.

Kamollimsakul (2014) investigated the effect of text and background colour on reading texts on laptop screens for younger and older people in Thailand and the UK. He found that the combination of text and background colour had no significant effect on reading time and comprehension scores. On preferences, younger and older participants preferred black text on white background colour and younger participants also preferred sepia text on off-white background colour in both Thailand and the UK.

In addition, some web design guidelines (Loureiro and Rodrigues, 2014; Zaphiris et al., 2006; 2005; Dunn, 2006; Setting Priorities for Retirement Years Foundation (SPRY), 1999) found that blue tones should be avoided on websites and the background screens should not be a pure white colour. But these guidelines are now outdated as their recommendations probably relate to desktop computers whose screens lacked the colour palettes and fine resolution of current devices, in particular tablet screens.

Nevertheless, the effect of these variables may vary between languages using different orthographic systems and between user groups of different ages. In addition, there is as yet no specific evidence for recommendations of combinations of text and background colours for tablet computers for the English and Thai language for readers, in particular, for older readers.

Therefore, this study investigated the effects of text and background colour on reading performance, comprehension and preferences for younger and older readers in both English and Thai. The text and background colours were selected from the findings of research discussed in the literature review (see Chapter 2, Section 2.9).

The research questions for this study are:

1. Do text colour and background colour make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
2. Do Thai and English make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
3. Do younger and older people differ in reading time, reading comprehension, rating of reading and preferences for text and background colour when reading on a tablet computer?

In addition, there may also be interactions between text and background colour, age and language.

5.2 Method

5.2.1 Design

The study was undertaken in both Thailand and the United Kingdom. However, data from each country were analysed separately as was mentioned in Chapter 4, Section 4.2. 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 (two levels: younger and older participants). The within-participants variable was Colour Combinations (five levels: Black text on White background, White on Black, Black on Buff, Sepia on Buff and Black on Light Blue). The choice of colour combinations was made on the basis of two factors: that there be good contrast between text and background (see Appendix S); and the colour combinations had been previously recommended or researched for older participants (see Chapter 2, section 2.9.6).

Each participant was asked to skim read five short texts presented on a tablet, one with each combination of text and background colours. Skim reading was chosen as the task, as explained in Chapter 4, section 4.2.1. The order of presentation of the texts and the colour combinations were also counterbalanced using the Latin square technique to avoid practice and fatigue effects. However, it is vital that the sequence of reading texts does not interact with the colour combinations when using the Latin square design to counterbalance for presentation order (Cardinal and Aitken, 2006). Therefore, the researcher used the sequence of reading texts as a variable in the Latin square analysis in order to be able to investigate this possibility.

Four dependent variables were measured: reading time, number of correct answers on comprehension questions, ratings of reading and the overall preference for the combinations of text and background.

5.2.2 Participants

100 participants took part in the study, 40 participants in Thailand and 60 participants in the UK. The inclusion criteria of participants in both countries were discussed in Chapter 4, section 4.2.2.

In the UK, 60 participants took part in the study, 30 older and 30 younger participants. The older participants comprised 13 men and 17 women, their ages ranged from 65 to 85 years, with a mean age of 71.2 years. All older participants were native English speakers. Four participants were still working and twenty-six were retired. Twenty-two older participants wore glasses for reading, one wore contact lenses. Two participants had participated in both Study 1 and 2, and twenty-two participants had participated in Study 2.

Twenty-nine older participants had experience in using the web, from 3 to 25 years (*M* = 15.69, *SD* = 4.89). In addition, they rated their level of experience and expertise in using the web at an average of 4.83 (*SD* = 1.14) and 4.10 (*SD* = 1.26), respectively (on a scale from 1: not at all to 7: extensive). Twenty-four participants had experience in using tablets, from 2 to 10.08 years (*M* = 5.40, *SD* = 2.65) and they rated their level of experience and expertise in using tablets at an average of 4.50 (*SD* = 1.22) and 4.08 (*SD* = 1.38), respectively (1: not at all to 7: extensive). One older participant did not have any experience in using the web and six participants did not have any experience in using tablets. However, this lack of experience would not affect with the reading tasks.

The older participants were recruited from a participant pool of older people who work with the HCI Research Group at the University of York and a local social networking site.

The younger participants comprised 13 men and 17 women, their ages ranged from 18 to 23 years, with a mean age of 19.7 years. All younger participants were native English speakers. Twenty-eight participants were undergraduate students, one was a master's student and one was a member of staff at the University of York. Six younger participants wore glasses for reading, and two wore contact lenses. 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). There were ten participants who had participated in Study 2.

All 30 younger participants had experience in using the web, from 7 to 16 years (*M* = 11.77, *SD* = 2.42). In addition, they rated their level of experience and expertise in using the web at an average of 5.93 (*SD* = 0.87) and 5.60 (*SD* = 1.04), respectively. Nineteen participants had experience in using tablets, from 0.08 to 10 years (*M* = 4.40, *SD* = 2.59) and they rated their level of experience and expertise in using tablets at an average of 4.50 (*SD* = 1.22) and 4.08 (*SD* = 1.38), respectively (1: not at all to 7: extensive). Seventeen participants did not have any experience in using tablets.

The younger participants were recruited from posting advertisements, put the flyers at the college receptions around the University of York and also from emailed advertisements to undergraduate students who participated in the Study 2.

In Thailand, 40 participants took part in the study, 20 younger and 20 older participants. The older participants comprised 5 men and 15 women, their ages ranged from 60 to 71 years, with a mean age of 64.9 years. All older participants were native Thai speakers. Half (10) of the older participants were still working and another half (10) were retired. Sixteen older participants wore glasses for reading. Eleven older participants had participated in previous studies. Two participants had participated in both Study 1 and 2, and nine participants participated in only in Study 2.

Eighteen older participants had experience in using the web, from 1 to 15 years (*M* = 6.36, *SD* = 3.83). In addition, they rated their level of experience and expertise in using the web at an average of 3.67 (*SD* = 1.14) and 3.39 (*SD* = 1.20), respectively. Ten participants had experience in using tablets, from 1 to 6.25 years (*M* = 3.63, *SD* = 1.93) and they rated their level of experience and expertise in using tablets at an average of 4.30 (*SD* = 1.06) and 4.30 (*SD* = 0.95), respectively. Two older participants did not have any experience in using the web and ten participants did not have any experience in using the tablet.

The older participants were recruited from a local social community at a temple and by snowballing recruitment, particularly people who were known by the parents of the researcher.

The younger participants comprised 7 men and 13 women, their ages ranged from 20 to 23 years, with a mean age of 21.7 years. All younger participants were native Thai speakers and they were undergraduate students at Naresuan University, Phitsanulok, Thailand. Four younger participants wore glasses for reading, one wore contact lenses. No participant had any colour vision deficiency problems. There were four participants who had participated in Study 2.

All Twenty younger participants had experience in using the web, from 7 to 18 years (*M* = 10.75, *SD* = 2.45). In addition, they rated their level of experience and expertise in using the web at an average of 5.05 (*SD* = 1.05) and 4.85 (*SD* = 1.14), respectively. Seven participants had experience in using tablets from 0.16 to 7 years (*M* = 3.57, *SD* = 2.55) and they rated their level of experience and expertise in using tablets at an average of 4.57 (*SD* = 1.51). Thirteen participants did not have any experience in using the tablet.

The younger participants were recruited from the Division of Student Affairs at Naresuan University by snowballing recruitment.

To thank them for their participation, a gift voucher value at £25 or 500 Baht was offered to older participants in the UK and Thailand, respectively. A gift voucher value at £10 or 100 Baht was offered to younger participants. For an explanation of the difference in values of the vouchers, see Chapter 4, section 4.2.2.

5.2.3 Equipment and materials

The equipment and materials were the same as used in the Study 2, as explained in Chapter 4, section 4.2.3.

A new 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 5.1 and the full set of combination of colours and the contrast between text and background colours in Appendix S).

The five texts were adapted from Wikipedia articles: Maple syrup, Taj Mahal, Peafowl, the Dead Sea and Brownies (see Appendix O). The practice text was Durian text (as used in Study 2 in Chapter 4).

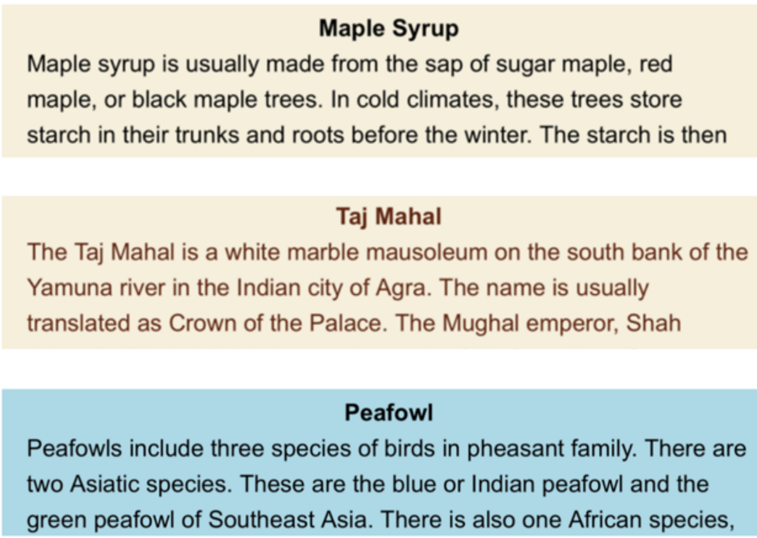


Figure 5.1 Examples of text and background colour combinations (Black/Buff, Sepia/Buff, Black/Light Blue)

For the English texts, each text comprised approximately 228 - 235 words in 15-17 sentences arranged in three paragraphs. The text length was chosen to fit on a tablet screen without the need to scroll to read the text which was discussed in Chapter 4. The texts were adjusted to have very similar readability levels using a number of measures. Table 5.1 shows the measures used, in each case texts were within +/-10% of the mean on all of these measures.

For the Thai texts, each Thai text also had three paragraphs and comprised approximately 261 - 262 words in 16 – 17 sentences (see procedure of translation from English for the Thai texts in Appendix N).

The texts were presented on the tablet in Arial font for the English texts and in TH Sarabun font (see Figure 4.1) for the Thai texts. For both languages, texts were presented in 18 point with 1.5 line spacing and left justification, as recommended by a number of researchers (Rello et al., 2015; Petrie, Kamollimsakul and Power, 2013) and also as recommended by the results of Study 2.

Table 5.1 Measures for matching the objective readability levels of the texts

Measure	Mean	+/- 10% range
Flesch-Kincaid Score	61.1	54.6 – 66.1
Gunning Fog Index	10.3	8.8 – 11.7
Sentences > 20 syllables (%)	39.0	33 – 44
Words > 12 letters	0	0
Passive sentences	3.3	2 - 5

Three multiple choice questions were developed for each text. As in study 2 (see Chapter 4, section 4.2.3), a four-set of questions was initially created for each text and their level of difficulty was assessed. Five participants read each text and answered the questions for it and rated for the difficulty of each question in two different ways.

From this data, three questions were selected for each text with the following criteria:

- no participant knew beforehand (so the researcher considered they were not likely to be common knowledge)
- ratings of 6.0 – 7.0 for the basic difficulty rating
- rating of 6.8 – 7.7 on the difficulty in the text rating

5.3 Procedure

The timeline for the procedure of the study is shown in Figure 4.4.

The study was conducted in Thailand and the UK, using a very similar procedure as had been used in Study 2 (see Chapter 4, section 4.3). The order of reading the five texts in the text and background colours was counterbalanced between participants to minimize practice and fatigue effects and used a Latin Square design to control nuisance factors (in this case the different experiment texts).

5.4 Data analysis

A 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 (Field, 2013; Cressie and Hawkins, 1980). 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 applied for analysis this variable.

In addition, the non-parametric statistical tests were also applied for the ratings of ease, how tiring and difficulty reading was, as above.

The explanation of how to apply each method of analysis to each variable were presented in Chapter 4, section 4.4.

5.5 Results

This section presents the effect of text and background colour on reading time, reading comprehension, ratings of ease, tiring and difficulty for reading on each combination and participants' preference of the combination of text and background colour. As discussed in Chapter 3, section 3.5, the power calculations were reported for non-significant results.

5.5.1 Reading time

For the UK study, 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 ($F_{(4,224)} = 6.34$, $p < .05$, $\eta_p^2 = .10$). Older participants took significantly longer to read the texts ($M = 67.5$ seconds, $SD = 24.57$) than younger participants ($M = 54.90$, $SD = 17.10$). 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. However, there was no significant effect of the text/background colour variable, nor any interaction between this variable and Age Group.

For the Thai study, the mixed model ANOVA on reading times also showed that 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 ($M = 114.37$, $SD = 46.59$) than younger participants ($M = 85.79$, $SD = 31.82$). However, there was no significant main effect for either for colour combination of text/background.

There was a significant interaction between age group and sequence of reading ($F_{(4,143)} = 2.58$, $p < .05$, $\eta_p^2 = .07$). Figure 5.2 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 to answer questions about the texts 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.

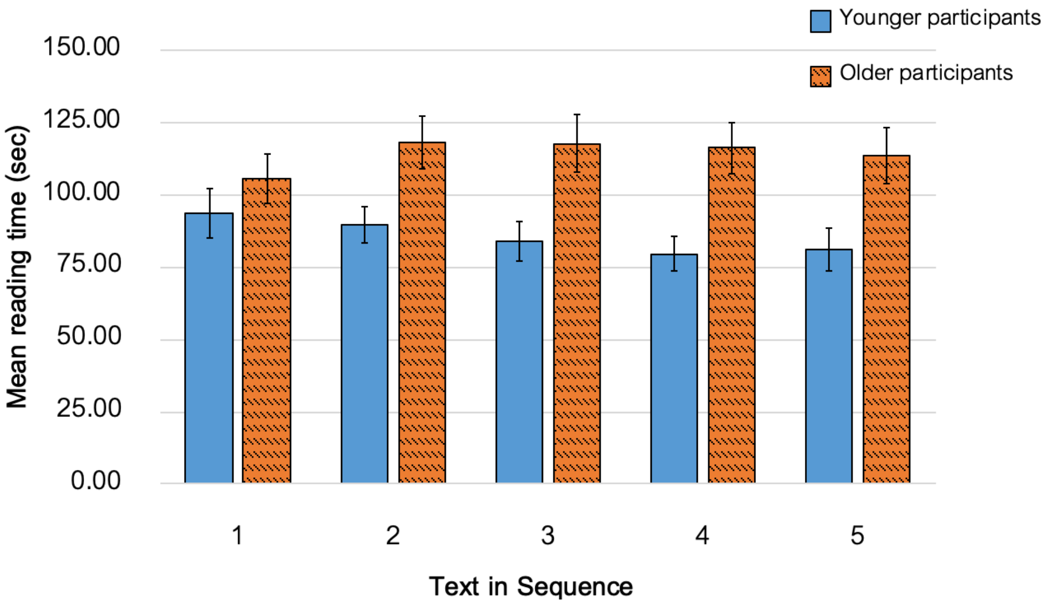


Figure 5.2 Mean reading time for each text in the sequence for younger and older Thai participants

Overall, the results of reading time showed that there was no significant effect of text and background colour for both Thai and the UK participants. However, Age groups had effect on reading time for both countries. Older participants took longer time to read the texts than younger participants. Moreover, the sequence of reading had main effect on reading time in the UK while there was significant interaction between age group and the sequence of reading in Thailand.

5.5.2 Comprehension of texts

For the UK study, Friedman tests showed that there was no significant difference in comprehension scores between the different text and background combinations ($\chi^2 = 1.45$, *df* = 4, *n.s.*) nor in the sequence of reading the texts ($\chi^2 = 1.92$, *df* = 4, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 252 younger and 252 older participants, making a total sample of 504 participants. Thus for the robust results, 222 more younger participants and 222 more older participants would need to participate.

A Mann-Whitney U test also found that there was no significant difference in comprehension scores between younger and older participants ($U = 430.50$, $p = .77$, $r = .38$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 184 younger and 184 older participants, making a total sample of 368 participants. Thus for robust results, 154 more younger participants and 154 more older participants would need to participate.

For the Thai study, Friedman tests showed that there was no significant difference in comprehension scores between the different text and background colour combinations ($\chi^2 = 2.24$, *df* = 4, *n.s.*) nor in the sequence of reading the texts ($\chi^2 = 1.68$, *df* = 4, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 110 younger and 110 older participants, making a total sample of 220 participants. Thus for robust results, 90 more younger participants and 90 more older participants would need to participate.

However, a Mann-Whitney U test found that there was a significant difference in comprehension scores for Age Group ($U = 83.50$, $p < .005$, $r = .50$). The older participants answered significantly fewer questions correctly (*Mdn* = 1.00 correct out of 3, *IQR* = 1) than younger participants (*Mdn* = 2.00, *IQR* = 1.75).

5.5.3 Participants ratings of ease of tiring and how tiring it was to read

Participants rated the ease of reading and how tiring it was to read for each combination of text and background colour on 7-point Likert items. Lower scores mean greater ease or less tiring as discussed in Chapter 4, section 4.5.3.

To investigate the relationship between the ratings of ease of reading and how tiring it was to read for each combination of text colour and background colour, a Spearman's Rank-Order Correlation was calculated for these two ratings of reading. There was a significant positive relationship found between the two ratings of reading for both UK and Thai participants for each combination of text colour and background colour. Thus, the rating of ease of reading positively related to the rating of how tiring it was to read for each colour combination in both countries. Table 5.2 illustrates the results of Spearman's Rank-order correlation (r) test for each combination of text colour and background colour.

Table 5.2 The result of Spearman's Rank-Order Correlation test on median of rating ease of reading and how tiring it was to read of UK and Thai participants for each colour combination

Text colour on Background colour	UK (ratings of ease of reading and how tiring reading was)	Thai (rating of ease of reading and how tiring reading was)
Black on White	r = .73*	r = .76*
White on Black	r = .76*	r = .76*
Black on Buff	r = .44*	r = .64*
Sepia on Buff	r = .62*	r = .64*
Black on Light Blue	r =.72*	r = .51*

Note: * correlation is significant at the 0.01 level (2-tailed)

As discussed in the study 2, the rating of difficulty of reading was produced by taking the mean of the rating of ease of reading and the rating of how tiring it was to read of each participant (see Chapter 4, section 4.5.3).

For the UK study, the Friedman test showed that there was significant difference in ratings of difficulty of reading of the five combinations of text and background colour (χ^2 = 16.06, *df* =4, *p* < .005). The median ratings of difficulty of reading for the five colour combinations are illustrated in Figure 5.3 and Table 5.3 which showed that participants found the combination of white text on black background colour was the most difficult to read.

Wilcoxon Matched-Pairs Signed Ranks test was conducted to compare on each pair of text and background colour. The results are presented in Table 5.4.

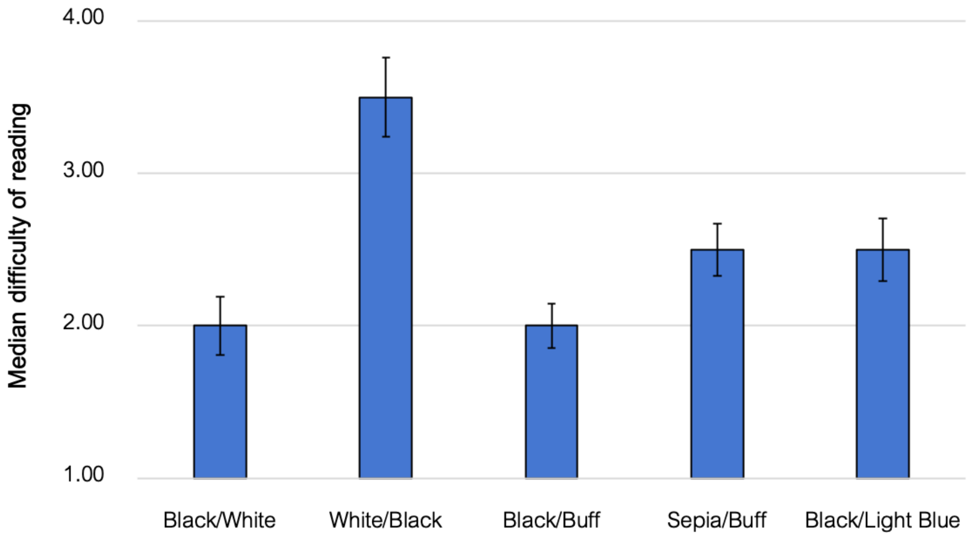


Figure 5.3 Median rating of difficulty of reading of UK participants for each colour combination (Text colour / background colour)

Table 5.3 The median and interquartile range of rating of difficulty of reading of UK participants for each colour combination

Text colour on background colour	Mdn	IQR
Black on White	2.00	1.50
White on Black	3.50	2.50
Black on Buff	2.00	1.00
Sepia on Buff	2.50	1.50
Black on Light Blue	2.50	2.00

Table 5.4 The result of Wilcoxon Match-Pairs Signed Ranks text on median rating difficulty of reading of UK participants for each pair of colour combination (Text colour on background colour)

Colour combination 1	Rating	Colour combination 2	Statistical test
White on Black	more difficult	Black on White	Z = 3.22, p < .005, r = .42
		Black on Buff	Z = 4.00, p < .001, r = .52

Colour combination 1	Rating	Colour combination 2	Statistical test
White on Black	more difficult	Sepia on Buff	Z = 2.18, $p < .05$, $r = .28$
Sepia on Buff	more difficult	Black on Buff	Z = 3.28, $p < .005$, $r = .42$
Black on Light Blue	more difficult	Black on Buff	Z = 3.02, $p < .005$, $r = .39$

To investigate the differences in rating of difficulty of reading for the different colour combinations the ratings by younger and older participants. The Mann-Whitney U tests were conducted. The medians and interquartile range are presented in Table 5.5. The tests showed there was a significant difference in ratings between younger and older participants in Black on White background ($U = 237.00$, $p < .005$, $r = .41$) and White on Black background ($U = 297.00$, $p < .05$, $r = .29$). However, there was no significant difference in ratings between younger and older participants of difficulty of reading in Black on Buff background ($U = 440.00$, $p = .88$, $r = .02$), Sepia on Buff background ($U = 359.50$, $p = .18$, $r = .17$) and Black on Light Blue background ($U = 411.00$, $p = .56$, $r = .07$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 104 younger and 104 older participants, making a total sample of 208 participants with the medium effect size. Thus for the robust results, 74 more younger participants and 74 more older participants would need to participate.

Table 5.5 The median and interquartile range of rating of difficulty of reading for each colour combination between younger and older UK participants

Text colour on Background colour	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
Black on White*	3.00	1.88	2.00	1.00
White on Black*	3.50	1.88	2.50	2.38
Black on Buff	2.00	0.88	2.00	1.38
Sepia on Buff	2.50	1.50	2.50	1.50
Black on Light Blue	2.50	2.00	2.00	1.00

Note: * significant difference

For the Thai study, the Friedman test showed that there was significant difference in rating of difficulty of reading of Thai participants between the five combinations of text and background colour (χ^2 = 20.91, df = 4, p < .001). The median ratings of difficulty of reading for the five colour combinations are illustrated in Figure 5.4 and Table 5.6 which showed that participants found the combination of white text on black background colour was the most difficult to read.

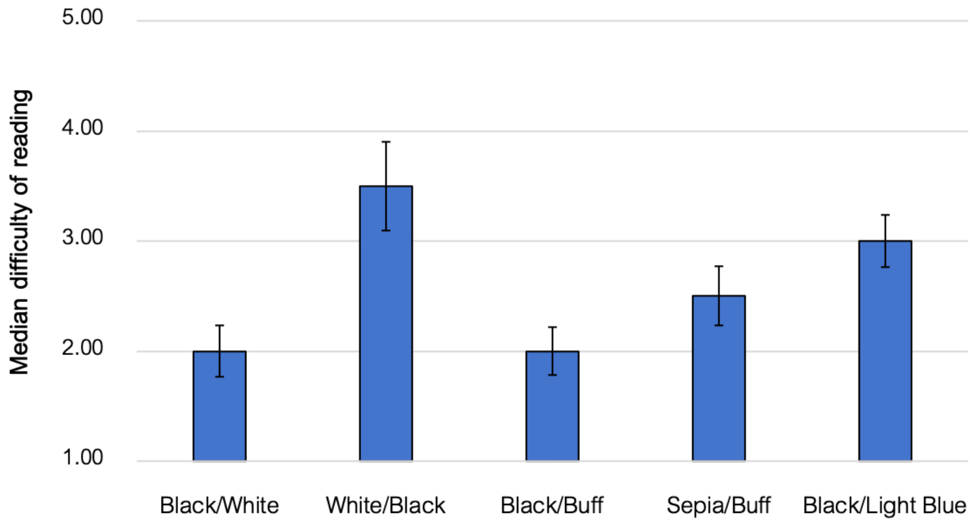


Figure 5.4 Median rating of difficulty of reading of Thai participants for each colour combination (Text colour / background colour)

Table 5.6 The median and interquartile range of the rating of difficulty of reading of Thai participants for each colour combination

Text colour on background colour	Mdn	IQR
Black on White	2.00	2.00
White on Black	3.50	3.13
Black on Buff	2.00	1.50
Sepia on Buff	2.50	2.00
Black on Light Blue	3.00	1.63

Wilcoxon Matched-Pairs Signed Ranks tests were conducted to compare on each pair of text and background colour. The results are presented in Table 5.7.

Table 5.7 The results of Wilcoxon Matched-Pairs Signed Ranks test on median rating of difficulty of reading of Thai participants for each pair of colour combination (Text colour on background colour)

Colour combination 1	Rating	Colour combination 2	Statistical test
White on Black	more difficult	Black on White	$Z = 3.61$, $p < .001$, $r = .57$
		Black on Buff	$Z = 3.45$, $p < .005$, $r = .55$
		Sepia on Buff	$Z = 2.56$, $p < .05$, $r = .41$
		Black on Light Blue	$Z = 2.65$, $p < .01$, $r = .42$
Black on Light Blue	more difficult	Black on White	$Z = 2.83$, $p < .01$, $r = .45$
		Black on Buff	Z = 2.86, $p < .005$, $r = .45$

To investigate the differences in rating of difficulty of reading for the different colour combinations the ratings by younger and older participants were compared using Mann-Whitney U tests. The median and interquartile range are presented in Table 5.8. The tests showed there was a significant difference in ratings between younger and older participants in Black on Light Blue background (U = 106.00, $p < .05$, $r = .40$). However, there was no significant difference in ratings between younger and older participants of difficulty of reading in Black on White background (U = 142.00, $p = .11$, $r = .25$), White on Black background (U = 163.50, $p = .32$, $r = .16$), Black on Buff background (U = 133.50, $p = .07$, $r = .30$) and Sepia on Buff background (U = 140.00, $p = .10$, $r = .30$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 164 younger and 164 older participants, making a total sample of 368 participants with the medium effect size. Thus for robust results, 144 more younger participants and 144 more older participants would need to participate.

Table 5.8 The median and interquartile range of rating of difficulty of reading for each colour combination between younger and older Thai participants

Text colour on Background colour	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
Black on White	2.00	2.00	1.75	1.50

Text colour on Background colour	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
White on Black	3.50	3.13	3.75	3.63
Black on Buff	2.75	2.00	2.00	1.50
Sepia on Buff	2.75	2.63	2.00	1.00
Black on Light Blue*	3.50	1.13	2.00	1.13

Note: * significant difference

Overall, the results of rating of ease of reading and how tiring reading was showed that white text on black background was the most difficult to read both for UK and Thai participants. Moreover, black text on white or buff background colour was less difficult to read than black text on light blue background for Thai participants. In addition, black text on buff background colour was also less difficult than black text on light blue for UK participants.

5.5.4 Preferences for combinations of text and background colour

For the UK study, participants were asked which of all the combinations of text and background colour they preferred. The choices are summarized in Table 5.9.

A chi-square test showed that the distribution of preferences for text/background combinations between the two age groups and colour combinations was significantly different from random ($\chi^2 = 12.82$, $df = 4$, $p < .05$). However, there was a significant difference between preference for the colour combinations when younger and older participants were considered together ($\chi^2 = 4.5$, $df = 4$, $p < .05$).

Taking older and younger participants separately, the distribution of older participants' preferences was not significantly different from random ($\chi^2 = 6.34$, $df = 4$, *n.s.)*. The distribution of younger participants' preferences was significantly different from random ($\chi^2 = 11.67$, $df = 4$, $p < .05$).

The power calculation indicated that there is an 80% chance of correctly detecting the difference in preferences with 66 younger and 66 older participants, making a total sample of 132 participants. Thus for robust results, approximately 36 more younger participants and 36 more older participants would need to participate.

However, overall the most popular choice was Black text on Buff background, chosen by 26.7% of the participants. For the older participants, Black text on White background colour and White text on Black background colour were the most popular choice, chosen by 30.0% of the older participants. For the younger participants, Black text on Light blue background colour was the most popular choice, chosen by 36.7% of younger participants. 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.

Table 5.9 Preferences of all UK participants and younger and older participants separately for each combinations of text and background colours
(% and number of participants)

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

Some UK participants gave reasons for their preference of the combination of text and background. For Black text on Buff background colour, six older participants found that with this combination it was easy to concentrate on the text, easy on the eyes and clear. Younger participants found that the buff background with black text was less bright than the pure white background and also found that the contrast between black text and buff background made the text clear and easy to read without getting tired. In addition, one younger participant found that there was a clear difference between words and the background that making it quicker to identify words and skim read.

For White text on Black background, some older participants found that a black background made the words stand out well and was clear to read and one older participant said that it was more a bit relaxing for reading. Younger participants found that this combination was easy to read since there was less white light reflecting into the eyes when reading. One of them said that the sepia text on buff background blended into each other.

For Black text on Light Blue background, one older participant found that the combination was so easy on the eyes and relaxing to read. Younger participants found that the light blue background was not intrusive and not too bright and easy to read and there was enough contrast between black text and light blue background colour. One of them found that the light blue background was easy on the eyes and not harsh at all and the black text also stand out well enough to read.

However, some older participants found that the Black text and White background colour was more familiar, clear and easy to read. They also found that this colour combination was a good contrast without glare. One older participant found that this colour combination was resembled colour use in a physical book or newspaper. One older participant found that this colour combination seemed to remain clearest while she was reading, whereas the Black background seemed to make the text bounce around while reading. In addition, she stated that the other three colour combinations (Black on Buff, Black on Light Blue and Sepia on Buff) were also all reasonable for her. In contrast, some younger and older participants found that the buff background with sepia text was easy to read. One of the older participants stated that the buff background was easier than the plain white background which can be glaring.

For the Thai study, participants were asked which of all the combinations of text and background colour they preferred. The choices are summarized in Table 5.10.

A chi-square test showed that the distribution of preferences between the age groups and the colour combinations was not significantly different from random ($\chi^2 = 1.92$, $df = 4$, n.s). Nor was there a significant difference between preferences for the colour combinations when younger and older participants were considered together ($\chi^2 = 3.25$, $df = 4$, n.s).

Taking older and younger participants separately, the distribution of older participants' preferences was not significantly different from random ($\chi^2 = 3.50$, $df = 4$, *n.s.)*. The distribution of younger participants' preferences was significantly different from random ($\chi^2 = 1.50$, $df = 4$, *n.s.*).

The power calculation indicated that there is an 80% chance of correctly detecting the differences in preferences with 66 younger and 66 older participants, making a total sample of 132 participants. Thus for robust results, 46 more younger participants and 46 more older participants would need to participate.

Overall, the most popular choice was Black text on White background, chosen by 30% of participants. This colour combination was also the most popular choice for younger and older participants, chosen by a quarter of the younger participants (25.0%) and more quarter of the older participants (35.0%). However, White text on Black background colour was also the most popular choice for younger participants, with a quarter of them choosing (25.0%).

Table 5.10 Preferences of all Thai participants and younger and older participants separately for each combination of text and background colours (% and number of participants)

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

Thai participants also gave reasons for their preference of the combination of text and background colours. Older and younger Thai participants who chose Black text on White background found that this combination of colours was clear and easy to read. In addition, they also said that it felt similar to reading a book or newspapers and the contrast between text and background colours was very good. They felt comfortable while they were reading.

For Black text on Buff background, older participants found that this colour combination was clear to read and made them feel comfortable while reading. One older participant said that this combination made him feel relaxed and enjoy reading. He also felt it was not like reading an academic book. In addition, younger participants found that this colour combination was easy to read without straining their eyes.

For White text on Black background, older participants found that the contrast of this combination was good and made it clear to read. Younger participants also found that it was clear to read and one of them said that she could focused the text well.

A few older participants and four younger participants found that Sepia text on Buff background was comfortable for their eyes for reading because the contrast of this colour combination was not too great. In contrast, a few younger participants and four older participants found that the Black text and Light Blue background colour was easy to read and comfortable for their eyes when reading due to the light blue background being a cool tone colour.

5.6 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 than Thai younger participants. However, the colour combinations of text and background had no effect on reading time for either age group 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, although he had people read on a laptop rather than on a tablet.

On comprehension scores, the older Thai participants answered significantly fewer 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 addition, the text and background colour had no effect on the comprehension score for younger and older in both countries. The result of younger participants contrasts with Cradisar et al.(2007) who found that a white background resulted in a lower mean number of correctly answered questions than a black background for younger participants.

In term of participants' ratings of reading, rating of ease of reading positively related to rating of how tiring reading was for each colour combination for both the UK and Thai participants. In addition, ratings of difficulty of reading between younger and older Thai participants did not differ for four colour combinations of text and background, only differ for black on light blue whereas older UK participants found black on white or white on black less difficult to read than younger UK participants. In addition, older Thai participants found that black text on light blue less difficult to read than Thai younger participants while older UK participants found that both black text on white background colour and white text on black background colour less difficult to read than younger UK participants.

However, both UK and Thai participants found that the white text on black background the most difficult to read in comparison to the other colour combinations. Moreover, UK and Thai participants also found that black text on light blue background colour more difficult than black text on white or buff background colours. The black text on light blue background colour was difficult to read for participants. That agrees with previous research and guidelines (Loureiro and Rodrigues, 2014; Zaphiris, Kurniawan and Ghiawadwala, 2007;

Kurniawan and Zaphiris, 2005; Setting Priorities for Retirement Years Foundation (SPRY), 1999) that the blue tone should be avoided for websites (although it is not clear whether they are referring to text or background).

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, it is similar to Yamazaki and Eto's (2014; 2015) work which found that younger and 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, 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 my 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. Moreover, Kurniawan and Zaphiris (2005) and Dunn (2006) also recommend avoiding white backgrounds, but this was the most popular choice for older Thai participants (35.0%) and equally 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 preferred 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%). Moreover, UK and Thai participants found that the white text on black background was the most difficult and tiring to read as discussed above.

However, the study had several limitations apart from the small sample size for the preference question, which need to be considered. The researcher did not attempt to control the distance at which the participants viewed the tablet screen. 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. Moreover, 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, as all discussed in the Chapter 4.

5.7 Conclusions

This study focused on the effects of colour combinations of text and background for reading on a tablet computer, investigating aspects of reading performance and participant preferences for younger and older participants in both Thailand and the UK. Overall, the colour combination of text and background no effect on reading time and comprehension scores. However, the combination of white text and black background colours was considered the most difficult to read in comparison to a range of other colour combinations for participants in both countries.

For participants' preferences for colour combinations, only younger participants in the UK showed a significantly pattern of responses, although the number of participants may have been too small to show clear patterns in preferences.

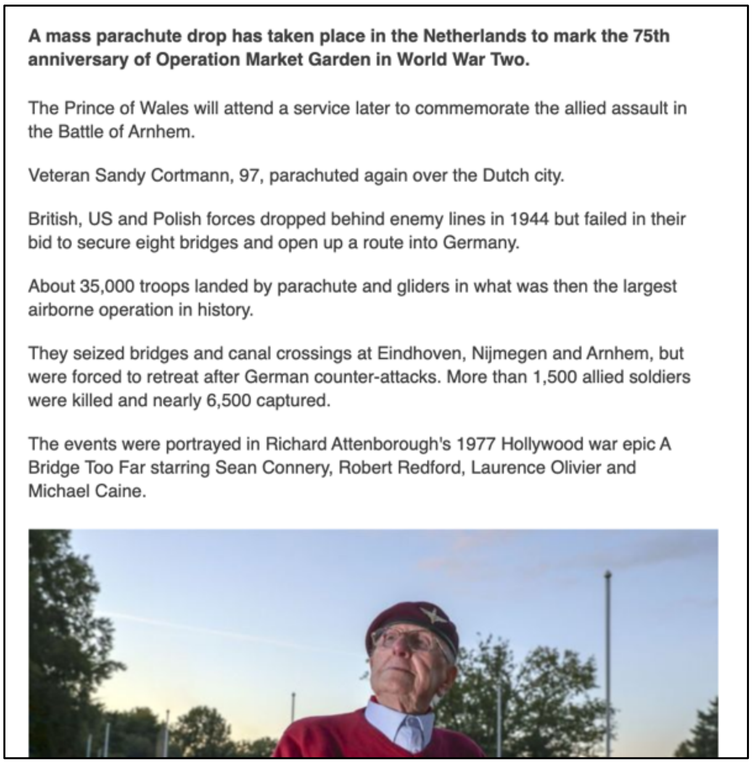
Overall, on the basis of results of this study, the researcher provisionally recommends using black text on white background for presenting text on tablets for both older and younger readers in both Thailand and the UK. However, black text on black text on pale background (Buff and Light Blue) can be recommended for younger readers in the UK. This recommendation is based on participants' subjective views, as the colour combinations did not have any effect on their reading performance.

Chapter 6

Study 4: The effect of column format and text justification on reading text on a tablet computer for younger and older people in Thailand and the UK

6.1 Introduction

There are a variety of layout formats for text in print and online contexts. Two of the important variables are the number of columns and whether the text is justified or not. For example, bbc.com typically uses a single column, left-justified presentation for its main articles (see Figure 6.1). On the other hand, many academic papers use two columns, fully justified (i.e. both left and right justified) presentation (see Figure 6.2).



A mass parachute drop has taken place in the Netherlands to mark the 75th anniversary of Operation Market Garden in World War Two.

The Prince of Wales will attend a service later to commemorate the allied assault in the Battle of Arnhem.

Veteran Sandy Cortmann, 97, parachuted again over the Dutch city.

British, US and Polish forces dropped behind enemy lines in 1944 but failed in their bid to secure eight bridges and open up a route into Germany.

About 35,000 troops landed by parachute and gliders in what was then the largest airborne operation in history.

They seized bridges and canal crossings at Eindhoven, Nijmegen and Arnhem, but were forced to retreat after German counter-attacks. More than 1,500 allied soldiers were killed and nearly 6,500 captured.

The events were portrayed in Richard Attenborough's 1977 Hollywood war epic A Bridge Too Far starring Sean Connery, Robert Redford, Laurence Olivier and Michael Caine.

Figure 6.1 A web page of BBC.com (A format of one column with left-justified)

Figure 6.2 Examples of a series of column formants and text justification on academic papers or journals

In Thailand, texts are normally presented with left–right justified for official papers and online documents such as memoranda, contracts and students' theses (see Figure 6.3).

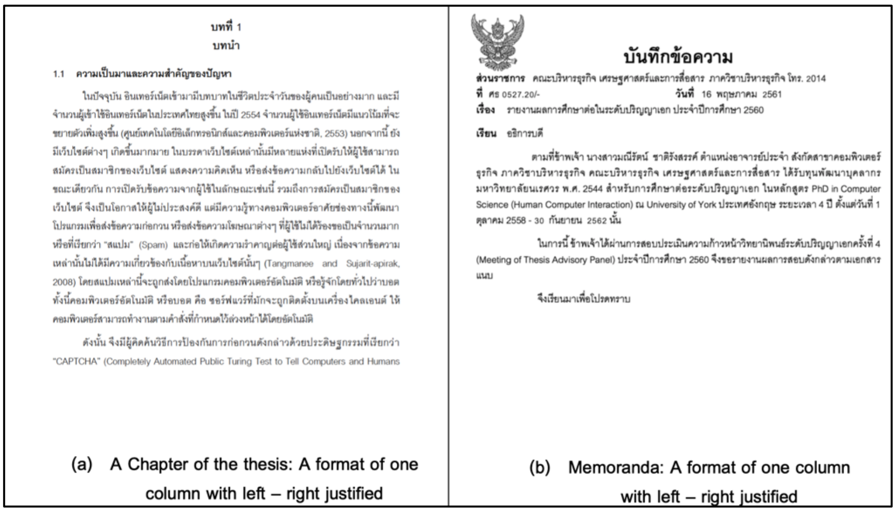


Figure 6.3 Examples of Thai official documents

The literature review (see Chapter 2, section 2.9) found a small number of studies of the effects of column format and text justification on reading performance and reader preferences. The researcher found four studies which focused on column format presentation in English on computer screen for younger and middle-age participants (Yi, Park and Cho, 2011; Baker, 2005; Zaphiris and Kurniawan, 2001; Dyson and Kipping, 1997). One study (Yi et al., 2011) was conducted with Korean participants, but used English material for their study. Only one study (Kuhna, Kivelä and Oittinen, 2012) focused on the effect of column format in English text presented on a tablet screen was found, but it did not use a reading task, but a task of browsing with the different layouts of text and rating the readability of the layouts. For text justification, the researcher found one study (Baker, 2005) which focused on text justification in English text presented on a desktop computer screen for younger people and one study (Kamollimsakul, 2014) which focused on text justification in both English and Thai when reading on a laptop computer screen for younger and older people.

To outline the research on the number of columns and text justification for digital presentations, the next paragraph presents the results of previous research on the effect of a number of columns and text justification on reading text on a computer screen.

In relation to number of columns, Dyson and Kipping (1997) found that English text in one column was read significantly faster by young to middle-aged participants (aged 14 – 44 years) than text in three columns, but the participants found the three columns was easy to read and they preferred three columns. Zaphiris and Kurniawan (2001) investigated the effect of different column formats (one, two and three columns) on reading speed on paper and screen presentations for English text with three age groups (young: 18 – 40 years, middle-aged: 40 – 45 years and seniors: 65 years and above). They found that there was no significant difference between the three different column formats on reading speed and preferences of the participants.

Baker (2005) investigated the effect of three column formats and text justification (left and left-right justified) in English text on reading performance and satisfaction with undergraduate students. The column formats were one column (approximately 90 characters per lines - CPL), two columns (approximately 45 CPL) and three columns (approximately 30 CPL). Column format and text justification had no main effect on reading performance and satisfaction. However, he found that participants read two columns with left-right justification significantly faster than one column with left-right justification. In addition, participants read one column with left justification faster than with left-right justification or three columns with left-right justification.

Yi et al. (2011) investigated the effect of column formats (one and two columns) on reading speed, comprehension and satisfaction with undergraduate students in Korea although they used English materials for the experiment. They found that the column formats had no effect on reading speed and comprehension, but a format of one column was significantly preferred by participants. In addition, Kuhna, Kivelä and Oittinen (2012) investigated the usability of three prototypes of online magazines on a iPad for younger users. The three prototypes were called Manual, Automatic and Responsive and the text layouts on the three prototypes were different. They found that the responsive prototype which presented the text in one column was rated the highest for readability by younger readers (see more in Chapter 2, section 2.9.3).

However, in the latest research, Sahito et al. (2015) examined the readability of four different line lengths (30, 60, 90 and 120 CPL) on a tablet screen in English with four different age groups (20-25 years, 25 to 30 years, 30 to 35 years and 35 to 40 years) but only reported participants' preferences not about their reading performance. Overall, they found that the two younger age groups (20 - 25 years and 25 - 30 years) preferred longer line lengths (90 and 120 CPL), while the two older age groups (30 - 35 years and 35 - 40 years) preferred shorter line lengths (30 and 60 CPL). They also mentioned that the long lines on a tablet computer were difficult to read for the older age group (35 – 40 years). However, they recommended that 90 CPL (approximately the number of characters in one column format) as preferable for general online readers as this reflects the majority of participants' preferences.

In relation to text justification, as discussed above, Baker (2005) found that the text justification had no effect on reading performance and satisfaction although column format did have an effect. In addition, Ling and van Schaik (2007) examined the effect of line spacing and text justification on reading performance and preferences with undergraduate students aged 25 years and under and people aged 26 to 50, but the majority of the participants were undergraduate students. They found that left-justified text produced better performance than left-right justified text. However, participants preferred left-right justified over left-justified.

Apart from this study which investigated the effects of justification in English, Kamollimsakul (2014) studied the effect of line spacing and text justification on reading performance in English and Thai. He found that there was no significant difference between left justification and left–right justification on reading time, reading comprehension and participants' preferences when reading from a laptop. On overall preferences, both UK and Thai participants preferred left–right justification. However, there was significant difference between left and left–right justification on reading experience scores (the mean of ease, pleasantness and speed of reading) for Thai participants, but there was no significant difference for UK participants.

Moreover, a number of web design guidelines (Loureiro and Rodrigues, 2014; Zaphiris et al., 2006, 2005; Setting Priorities for Retirement Years Foundation (SPRY), 1999) recommend that left-justified text should be used to present the text for older readers.

It can be seen that there is only a small amount of research on the effects of the number of columns and text justification on reading from computer screens, whether they are desktop, laptop or tablets. In addition, there has been very little research on the effects of these variables in languages other than English, so there is a need for research on a broader range of languages, to understand how the effects that columns and justification might have in languages with orthographies different from English. Finally, the effects of these variables on readers of different ages, who may be more or less familiar with reading from a screen, have not been explored.

Therefore, this study investigated the effects of column number and justification on reading performance, comprehension and preferences for younger and older readers in both English and Thai.

The research questions for this study are:

1. Do formats of one column, two columns and three columns make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
2. Do Left justification and Left-Right justification make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
3. Do Thai and English make a difference to reading time, reading comprehension, rating of reading and preference when reading on a tablet computer?
4. Do younger and older people differ in reading time, reading comprehension, rating of reading and preferences for column format and text justification when reading on a tablet computer?

In addition, there may also be interactions between the four variables of column format and text justification, age and language.

6.2 Method

6.2.1 Design

The study was undertaken in both Thailand and the United Kingdom. However, data from each country was analysed separately as was explained in Chapter 4, section 4.2.1. A random-complete block (RCB) factorial design (in which every block gets all possible combination of two factors) was used with three independent variables: two within–participants variables and one between–participants variable (see Appendix T). A Latin square design was not suitable to use in this study due to the two within–participants variables having two and three levels which could not be ordered into a Latin square. The two within–participants variables were Column Format (three levels: one, two and three columns) and Text Justification (two levels: left justification and left–right justification). The between– participants variable was Age Group (two levels: younger and older participants).

Each participant was asked to skim read six short texts presented on a tablet computer, one with each combination of column format and text justification. The order of presentation of the texts and the column format and text justification combination were counterbalanced to avoid practice and fatigue effects. Skim reading was chosen as the task, as explained in Chapter 4, section 4.2.1.

Four dependent variables were: reading time, number of correct answers on comprehension questions, rating of reading and the preferences of participants for the combinations of column format and text justification.

6.2.2 Participants

144 participants took part in the study, 72 participants in Thailand and 72 participants in the UK. The inclusion criteria of participants in both countries were discussed in Chapter 4, section 4.2.2.

In the UK, 72 participants took part in the study, 36 older and 36 younger participants. The older participants comprised 15 men and 21 women, their ages ranged from 65 to 82 years, with a mean age of 71.1 years. All older participants were native English speakers. Twenty-eight older participants wore glasses for reading. Seven participants were still working and twenty-nine were retired. There were twenty-four older participants who had participated in previous studies. Two participants had participated in all previous studies (Studies 1, 2 and 3), nineteen participants had participated in Studies 2 and 3, and three participants had participated only in Study 2.

All thirty-six older participants had experience in using the web, from 2 to 42 years[8] (M = 17.14, SD = 8.14). In addition, they rated their level of experience and expertise in using the web at an average of 4.56 (SD = 1.27) and 4.17 (SD = 1.32), respectively (on a scale from 1: not at all to 7: extensive). Thirty-one participants had experience in using tablets, from 2 to 15 years (M = 6.30, SD = 3.48) and they rated their level of experience and expertise in using the tablet at an average of 4.42 (SD = 1.36) and 4.23 (SD = 1.36), respectively (1: not at all to 7: extensive). Five older participants did not have any experience

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[8] The results are those provided by the participants themselves. Clearly having used the Web for 42 years is not possible, as the Web has only existed for approximately 30 years. One participant probably confused the length of his experience with the Web with his experience of using computers in his answer.

in using tablets, but this would not affect their performance on the reading tasks.

The older participants were recruited from a participant pool of older people who work with the HCI Research Group at the University of York and a local social networking site.

The younger participants comprised 15 men and 21 women, their ages ranged from 18 to 24 years, with a mean age of 19.8 years. All younger participants were native English speakers. Thirty-five participants were undergraduate students and one was a masters student. Six younger participants wore glasses for reading, and four wore contact lenses. Three of the younger participants had mild red-green colour vision deficiency (this would not affect their perception of the column and justification combinations in the study). Twenty-one younger participants had participated in previous studies. Six participants had participated in both Studies 2 and 3, and fifteen participants had participated only in Study 3.

All thirty-six younger participants had experience in using the web, from 4 to 18 years (M = 12.39, SD = 2.97). In addition, they rated their level of experience and expertise in using the web at an average of 6.44 (SD = 0.69) and 5.69 (SD = 0.98), respectively. Twenty-seven participants had experience in using tablets, from 1 to 10 years (M = 5.20, SD = 2.54) and they rated their level of experience and expertise in using tablets at an average of 5.03 (SD = 1.16) and 5.00 (SD = 1.11), respectively. Nine participants did not have any experience in using tablets.

The younger participants were recruited from posting advertisements, putting flyers at the college receptions around the University of York and also from emailed advertisements to undergraduate students who participated in Studies 2 and 3.

In Thailand, 72 participants took part in the study, 36 younger and 36 older participants. The older participants comprised 6 men and 30 women, their ages ranged from 60 to 73 years, with a mean age of 64.9 years. All older participants were native Thai speakers. Twenty-eight older participants wore glasses for reading. Fourteen of older participants were still working and twenty-two were retired. Thirteen older participants had participated in previous studies. Two participants had participated in all the previous studies (Studies 1, 2 and 3), one participant had participated in Studies 1 and 2, five participants had participated in Studies 2 and 3 and five participants had participated only in Study 3.

Thirty-two older participants had experience in using the web, from 0.25 to 15 years (M = 6.48, SD = 4.30). In addition, they rated their level of experience and expertise in using the web at an average of 3.94 (SD = 1.08) and 3.53 (SD = 1.02), respectively. Seven participants had experience in the tablets, from 0.5 to 4.4 years (M = 2.27, SD = 1.19) and they rated their level of experience and expertise in using tablets at an average of 3.29 (SD

= 1.38) and 2.86 (*SD* = 1.07), respectively. Four participants did not have any experience in using the web and twenty-nine did not have any experience in using tablets.

The older participants were recruited from a local social community at a temple and by snowball recruitment, particularly people who were known by the parents of the researcher.

The younger participants comprised 11 men and 25 women, their ages ranged from 19 to 23 years, with a mean age of 20.6 years. All younger participants were native Thai speakers and were undergraduate students at Naresuan University, Phistsanulok, Thailand. Six younger participants wore glasses for reading. No younger participant had any colour vision deficiency. Twenty participants had not used tablets before. Four younger participants had participated in previous studies. One participant had participated in all the previous studies (Studies 2 and 3), and three participants had participated only in Study 3.

All thirty-six younger participants had experience in using the web, from 3 to 16 years (*M* = 10.17, *SD* = 2.95). In addition, they rated their level of experience and expertise in using the web at an average of 5.00 (*SD* = 0.68) and 4.86 (*SD* = 0.64). Sixteen participants had experience in using tablets, from 0.25 to 11 years (*M* = 4.25, *SD* = 2.84) and they rated their level of experience and expertise in using tablets at an average of 4.50 (*SD* = 1.10) and 4.38 (*SD* = 0.89), respectively. Twenty participants did not have any experience in using tablets.

The younger participants were recruited from the Division of Student Affairs at Naresuan University by snowballing recruitment.

To thank them for their participation, a gift voucher value for £25 or 500 Baht was offered to older participants in the UK and Thailand, respectively. A gift voucher value at £10 or 100 Baht was offered to younger participants. For explanation of the difference in values of the vouchers, see Chapter 4, section 4.2.2.

6.2.3 Equipment and materials

The equipment and materials were the same as used in Study 2, as explained in Chapter 4, section 4.2.3.

The texts were adapted from Wikipedia articles: Fondue, Banff, Lamington, Florianopolis, Echidnas and the Flamingo (the last was also used in Study 2 in Chapter 4). The practice text was the Durian text (as used in Study 2). See all of the experimental texts in Appendix O.

For the English texts, each text comprised approximately 225 - 228 words in 14-17 sentences. The text length was to fit on a tablet screen without the need to scroll to read the text, as discussed in Chapter 4, section 4.2.3. Texts were presented in Arial typeface, 18 point (pt) black text on white background with 1.5 line spacing. This presentation configuration is recommended by a number of researchers (Rello et al., 2015; Petrie et al.,

2013) and also by the results of Studies 2 and 3, presented in Chapter 4 and Chapter 5, respectively. The texts were adjusted to have very similar readability levels on a number of measures (see Table 6.1).

For the Thai texts, each text comprised approximately 263 - 264 words in 15 – 16 sentences. The Thai texts were presented in TH Sarabun font (see Chapter 4, section 4.2.3). As for the English texts, the Thai texts were presented in 18 pt black text on a white background with 1.5 line spacing. Figure 6.4 shows examples of the combinations of column format and text justification in English and Thai language for the study.

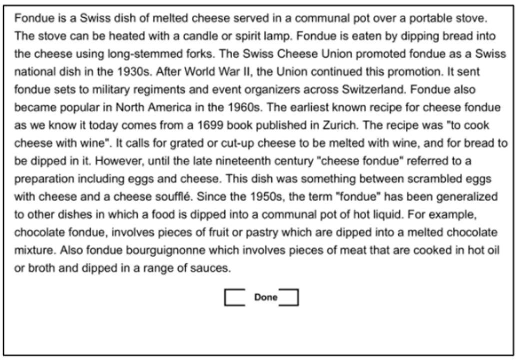
Table 6.1 Objective readability levels for the English texts

Measure	Mean	+/- 10% range
Flesch-Kincaid Score	55.10	36.5 – 63.3
Gunning Fog Index	11.1	9.9 – 11.7
Sentences > 20 syllables (%)	47.5	35 – 60
Words > 12 letters	0	0
Passive sentences	2.83	2 - 4

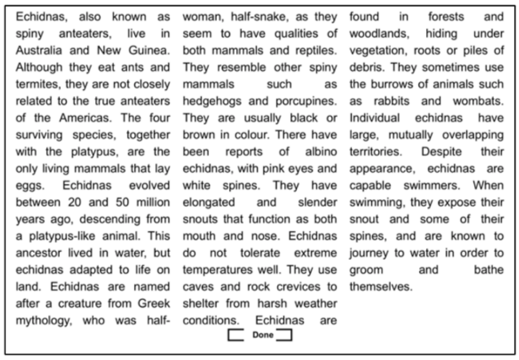
Three multiple choice questions were developed for each text. As in the previous studies (see Chapter 4, section 4.2.3), a larger set of questions were initially created for each text and their level of difficulty was assessed. Five participants read each text and answered the questions for it and rated for the difficulty of each question in two different ways.

Three questions were selected for each text with the following criteria:

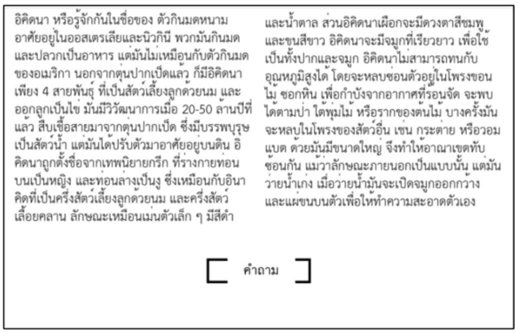
- no participant knew beforehand (the researcher considered they were not likely to be common knowledge)
- ratings of 5.0 – 7.0 for the basic difficulty rating
- ratings of 6.7 – 8.0 on the difficulty in text rating.



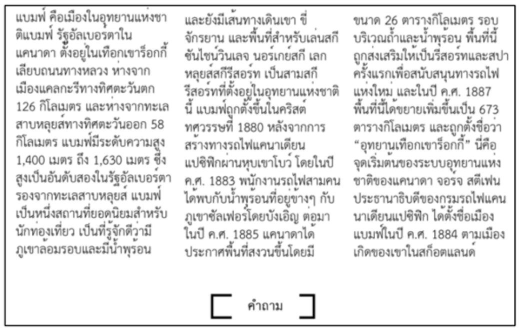
(a) English text in one column with left justification



(b) English text in three columns with left – right justification



(c) Thai text in two columns with left justification



(d) Thai text in three columns with left justification

Figure 6.4 Examples of the combinations of column format and text justification in English and Thai

6.3 Procedure

The study was conducted in Thailand and the UK, using a very similar procedure, as used in Study 2 (see Chapter 4, section 4.3). However, in this study participants were asked to skim read the six texts in landscape view on the tablet screen. The order of the column format and text justification conditions were counterbalanced between participants to minimize practice and fatigue effects. The timeline for the procedure of the study is shown in Figure 4.4 in Chapter 4, section 4.3.

6.4 Data analysis

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 (Field, 2013; Cressie and Hawkins, 1980). 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. Aggregate scores were created by summing the scores for the left justification texts and the left-right justification texts separately (3 texts each, so scores range from 0 – 9) and the three column formats (2 texts each, so scores range from 0 – 6) and also total scores (6 texts each, so scores range from 0 – 18). Then, non-parametric statistical tests were applied for analysis of this data.

In addition, the non-parametric statistical tests were also applied for the ratings of ease, how tiring and difficulty reading was, as above.

The explanation of how to apply each method of analysis to each variable were presented in the Chapter 4, section 4.4.

6.5 Results

This section presents the effect of column format and text justification on reading time, reading comprehension and participants' ratings and preferences of the combination of column format and text justification. As discussed in Chapter 3, section 3.5, the power calculations were reported for non-significant results.

6.5.1 Reading time

For the UK study, a mixed model ANOVA on reading times (Age Group x Column Format x Text Justification) showed there was a significant main effect for Age Group with a large effect size[9] ($F_{(1,70)} = 19.53$, $p < .05$, $\eta_p^2 = .22$). Older participants took significantly longer to read the texts (M = 74.76 seconds, SD = 27.43) than younger participants (M = 53.49, SD = 16.68). However, there was no significant effect of neither the Column Format with a medium effect size ($\eta_p^2 = .04$) and Text Justification with a small effect size ($\eta_p^2 = .02$) variables, nor any interaction between these variables and age group. The power calculation indicated that there is an 80% chance of correctly detecting the difference with 65 younger and 65 older participants, making a total sample of 130 participants. Thus for robust results, 29 more younger participants and 29 more older participants would need to participate.

For the Thai study, the mixed model ANOVA on reading times also showed that there was a significant main effect for Age Group ($F_{(1,70)} = 19.59$, $p < .05$, $\eta_p^2 = .22$). Older participants took significantly longer time to read the texts (M = 126.00, SD = 46.32) than younger participants (M = 90.58, SD = 35.95). However, there was no significant main effect for either the Column Format or Text Justification with a small effect size ($\eta_p^2 = .04$).

There was a significant three interaction between Age Group, Column Format and Text Justification ($F_{(2,140)} = 3.44$, $p < .05$, $\eta_p^2 = .05$). Figure 6.5 and Figure 6.6 shows the mean interaction of Column Format and Text Justification for younger and older Thai participants.

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[9] In term of effect size: partial eta-squared (η_p^2) ≥ .01 indicates a small effect size, η_p^2 ≥ .06 indicates a medium effect size η_p^2 ≥ .14 indicates a large effect size (source: Rules of thumb on magnitudes of effect sizes, University of Cambridge, from http://imaging.mrc-cbu.cam.ac.uk/statswiki/FAQ/effectSize)

However, Bonferroni post-hoc comparisons failed to show that there was a significant interaction between column format and text justification for either younger or older participants. This may be because the effect size of this interaction was small.

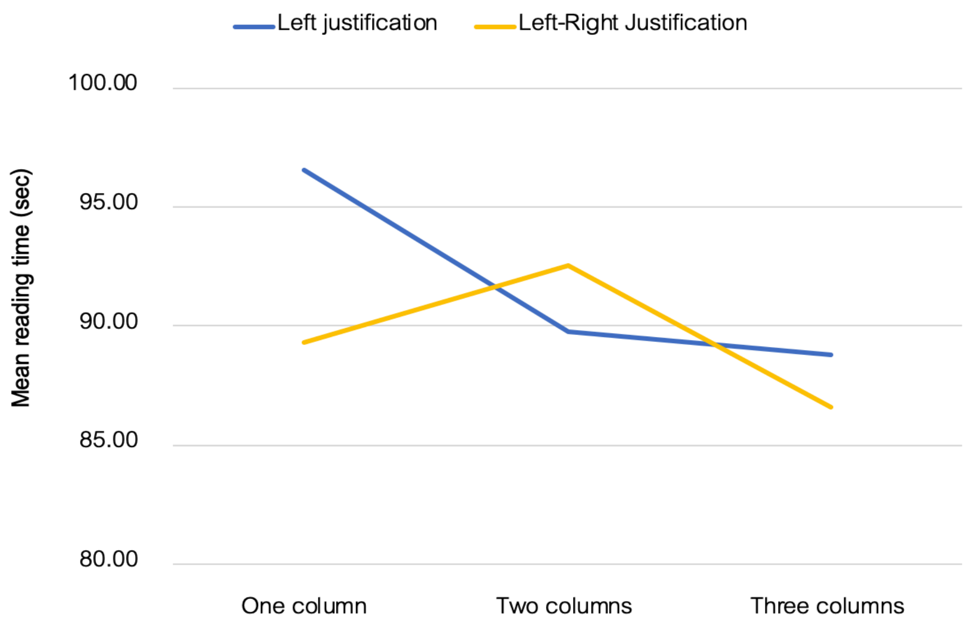


Figure 6.5 Mean reading time for each combination of column formats and text justification (L: Left justification and LR: Left – Right justification) for younger Thai participants

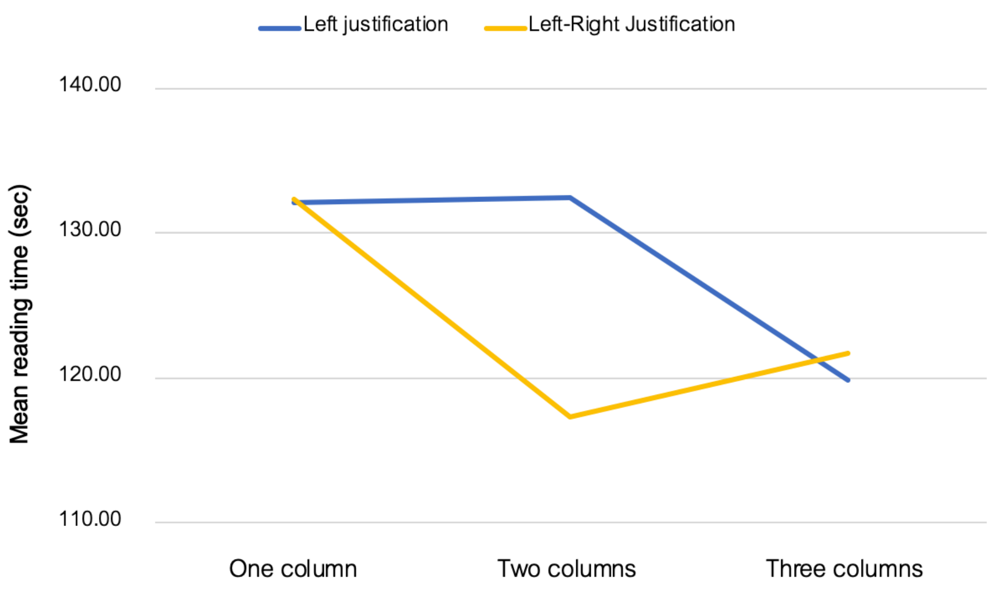


Figure 6.6 Mean reading time for each combination of column formats and text justification (L: Left justification and LR: Left – Right justification) for older Thai participants

Overall, older took longer time to read the texts than younger participants in both Thailand and the UK. However, column format and text justification had no effect in reading time for both Thai and UK participants. In addition, there was no three interactions between column format, text justification and UK age group. Although there was a significant three interaction between column format, text justification and Thai age group, the result of those comparisons revealed that there was no significance between column format and text justification for younger and older Thai participants.

6.5.2 Comprehension of texts

For the UK study, on the effect of Column Format on comprehension of the texts, a Friedman test showed that there was no a significant difference between one, two and three column formats ($\chi^2 = 2.11$, *df* = 2, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 87 younger and 87 older participants, making a total sample of 174 participants. Thus for robust results, 51 more younger participants and 51 more older participants would need to participate.

For Text Justification, a Wilcoxon Signed Ranks test showed that there was also no significant difference in comprehension scores between left and left–right justifications ($Z = 1.95$, $p = .05$, $r = .23$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 64 younger and 64 older participants, making a total sample of 128 participants. Thus for robust results, 28 more younger participants and 28 more older participants would need to participate.

Mann-Whitney U test found that there was no significant difference in comprehension scores overall between younger and older participants ($U = 639.0$, $p = .92$, $r = .01$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 2,630 younger and 2,630 older participants, making a total sample of 5,260 participants. Thus for robust results, 2,594 more younger participants and 2,594 more older participants would need to participate.

For the Thai study, Friedman test showed that there was no significant difference in comprehension scores between the three column formats ($\chi^2 = 0.33$, *df* = 2, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 643 younger and 643 older participants, making a total sample of 1,286 participants. Thus for robust results, 607 more younger participants and 607 more older participants would need to participate.

For text justification, a Wilcoxon Signed Ranks test showed that there was also no significance difference between left and left–right justifications ($Z = 0.9$, $p = .93$, $r = .12$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 15,759 younger and 15,759 older participants, making a total sample of

31,518 participants. Thus for the robust results, 15,723 more younger participants and 15,723 more older participants would need to participate.

However, Mann-Whitney U test found that there was a significant difference in comprehension scores between the age groups (U = 248.0, p < .001, r = .53). The older participants answered significantly fewer questions correctly (*Mdn* = 1.00 correct out of 3, *IQR* = 1.00) than younger participants (*Mdn* = 2.00, *IQR* = 1.00).

6.5.3 Participants' ratings of ease of reading and how tiring it was to read the texts

Participants rated the ease of reading and how tiring it was to read for each combination of column format and text justification on 7-point Likert items. Lower scores mean greater ease or less tiring as discussed in Chapter 4, section 4.5.3.

To investigate the relationship between the rating ease of reading and how tiring it was to read for each combination of text and background colour, a Spearman's Rank-Order Correlation was applied for the two ratings of reading. There was a significant relationship found between the two ratings of reading of both UK and Thai participants for each combination of text and background colour. Therefore, the rating of ease of reading related to the rating of how tiring it was to read for each combination of column format and text justification in both countries. Table 6.2 illustrated the results of Rank-order correlation text for each combination of column format and text justification.

Table 6.2 The results of Spearman's Rank-Order Correlation test on Median of rating ease of reading and how tiring it was to read of UK and Thai participants for each combination of column format and text justification

Combinations (column format / text justification)		UK (ratings of ease of reading and how tiring reading was)	Thai (ratings of ease of reading and how tiring reading was)
One column	Left justification	r = .69*	r = .75*
	Left – Right justification	r = .65*	r = .71*
Two columns	Left justification	r = .65*	r = .68*
	Left – Right justification	r = .69*	r = .74*

Combinations (column format / text justification)		UK (ratings of ease of reading and how tiring reading was)	Thai (ratings of ease of reading and how tiring reading was)
Three columns	Left justification	r = .76*	r = .68*
	Left – Right Justification	r = .72*	r = .71*

Note: *correlation is significant at the 0.01 level (2-tailed)

As discussed in the study 2, the rating of difficulty of reading was produced by the mean of the rating of ease of reading and the rating of how tiring it was to read of each participant (see Chapter 4, section 4.5.3)

For the UK study, the Friedman test showed that there was a significant difference in rating of difficulty of reading between the three column formats ($\chi^2 = 30.12$, $df = 2$, $p < .001$). In comparing each pair of column formats, the Wilcoxon Matched-Pairs Signed-Ranks test showed there was a significant difference between one and three columns formats ($Z = 3.25$, $p < .005$, $r = .38$) and a significant difference between two and three columns formats ($Z = 4.97$, $p < .001$, $r = .59$). Participants found that one column format (*Mdn* = 2.13, *IQR* = 1.31) and two columns format (*Mdn* = 2.50, *IQR* = 1.56) less difficult to read than three columns format (*Mdn* = 3.13, *IQR* = 2.50).

The median ratings of difficulty of reading for each column format are presented in Figure 6.7 which showed that participants found the format of three columns was the most difficult to read.

For text justification, the Wilcoxon Signed-Ranks test showed there was no significant difference in rating of difficulty of reading between the left justification and left-right justification ($Z = 1.95$, $p = .05$, $r = .23$). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 48 younger and 48 older participants, making a total sample of 96 participants. Thus for robust results, 12 more younger participants and 12 more older participants would need to participate.

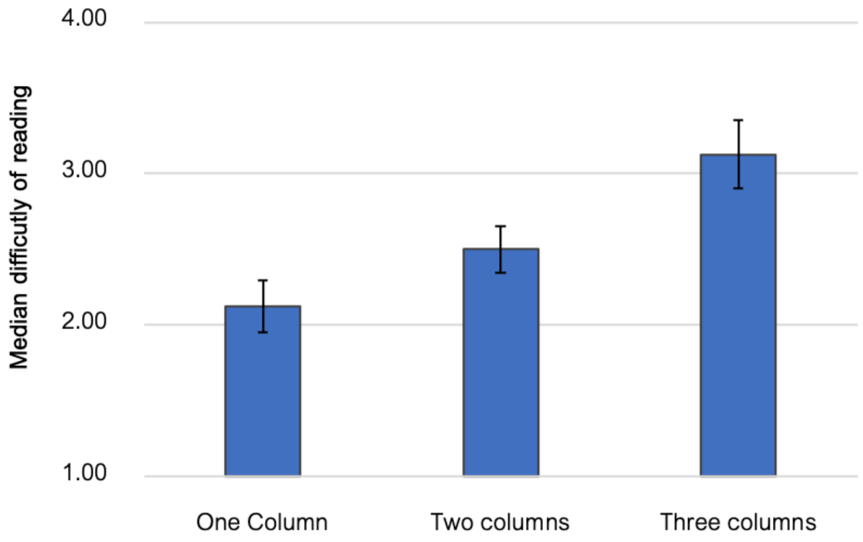


Figure 6.7 Median rating of difficulty of reading of UK participants for each column format

To investigate the interaction between column format and text justification in ratings of ease of reading, the Wilcoxon Signed-Ranks tests revealed that there was a significant difference in rating of difficulty of reading between left justification and left-right justification in a format of two (Z = 2.32, p < .05, r =.27) and three columns (Z = 2.04, p < .05, r =.24).

In addition, to investigate the differences in the rating of difficulty of reading for the different column formats rating by younger and older participants. Mann-Whitney U tests were conducted. The tests showed that there was significant difference in the ratings between younger and older participants for a format of one column (U = 469.00, p < .05, r =.24), two columns (U = 413.50, p < .01, r =.31) and three columns (U = 427.50, p < .05, r =.29). The median and interquartile are shown in Table 6.3. Older participants found a format of one, two and three columns less difficult than younger participants.

Table 6.3 The median and interquartile range of ratings of difficulty of reading for each column format between younger and older UK participants

A format of column	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
One column*	2.63	1.63	2.00	1.25
Two column*	2.75	1.00	2.00	1.13
Three columns*	3.50	1.94	2.63	1.75

Note: * significant difference

However, Mann-Whitney U test were also conducted the differences in ratings of difficulty of reading for different text justification ratings by younger and older participants. The tests showed that there was a significant difference in the ratings between younger and older participants for left-right justification (U = 338.50, p < .001, r =.41) but no significant difference for left justification (U = 477.50, p = .05, r =.23). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 91 younger and 91 older participants, making a total sample of 182 participants. Thus for robust results, 55 more younger participants and 55 more older participants would need to participate.

The median and interquartile are shown in Table 6.4. Older participants found that left-right justification less difficult than younger participants.

Table 6.4 The median and interquartile range of ratings of difficulty of reading for each text justification between younger and older UK participants

Text justification	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
Left justification	3.00	1.33	2.33	1.58
Left – Right justification*	3.42	1.37	2.33	1.42

Note: * significant difference

For the Thai study, the Friedman test showed that there was significant difference in ratings of difficulty of reading between one, two and three columns (χ^2 = 12.10, df = 2, p < .005). The Wilcoxon Match-Pairs Signed Ranks tests showed that there was a significant difference between one and two columns (Z = 2.70, p < .01, r = .32). There was also a significant difference between two and three columns (Z = 3.35, p < .005, r = .39). Participants found that the two columns format (Mdn = 2.75, IQR = 1.50) was significantly less difficult to read than one column (Mdn = 3.25, IQR = 2.25) and three columns (Mdn = 3.13, IQR = 2.50).

The median ratings of difficulty of reading for each columns format are shown in Figure 6.8 which shows that participants found the one and three were difficulty to read.

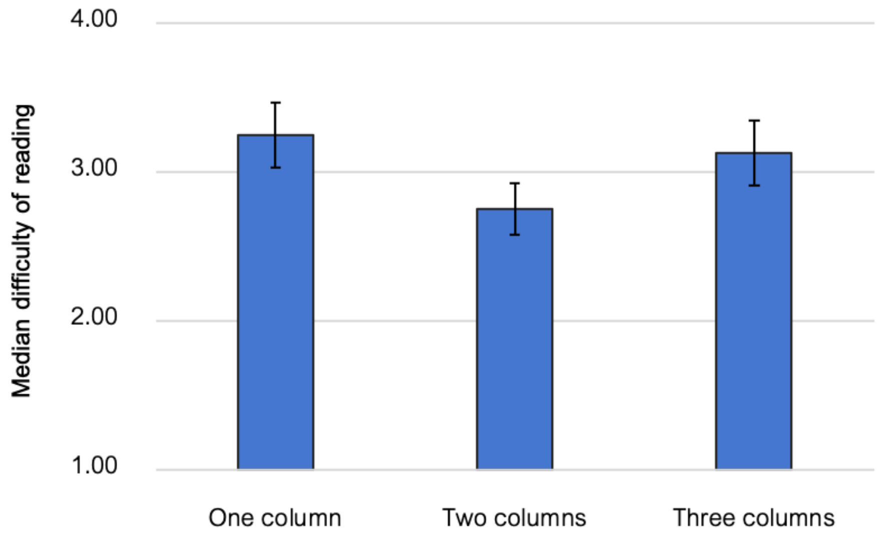


Figure 6.8 Median rating of difficulty of reading of Thai participants for each column format

For text justification, Wilcoxon Signed-Ranks test showed that there was a significant difference in rating of difficult of reading between left justification and left-right justification (Z = 2.27, p < .05, r = .27). Participants found that left justification (*Mdn* = 3.17, *IQR* = 1.50) was significantly less difficult to read than left-right justification (*Mdn* = 3.33, *IQR* = 1.37).

To investigate the interaction between column format and text justification in rating of how tiring reading was. Wilcoxon Signed Rank tests revealed that there was a significant difference in ratings between left justification and left-right justification in a format of two columns (Z = 2.22, p < .05, r = .26) and three columns (Z = 2.14, p < .05, r = .25).

To investigate the differences in the ratings of difficulty of reading was for the different column formats ratings by younger and older participants. Mann-Whitney U tests were conducted. The tests showed that there was significant difference in the ratings between younger and older participants for a format of two columns (U = 398.50, p < .01, r = .33) and three columns (U = 335.00, p < .001, r = .42) while there was no significance in the ratings for a format of one column (U = 510.50, p = .12, r = .18). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 131 younger and 131 older participants, making a total sample of 262 participants. Thus for robust results, 95 more younger participants and 95 more older participants would need to participate.

The median and interquartile range are shown in Table 6.5. Older participants found a format of two columns and three columns easier than younger participants.

Table 6.5 The median and interquartile range of ratings of difficulty of reading for each column format between younger and older Thai participants

A format of column	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
One column	3.75	1.88	3.00	2.13
Two column*	3.13	1.25	2.13	1.56
Three columns*	4.00	2.00	2.50	1.81

Note: * significant difference

Mann-Whitney U tests were also conducted the differences in the ratings of how tiring reading was for the different text justification ratings by younger and older participants. The tests showed that there was a significant difference in the ratings between younger and older participants for left justification (U = 328.50, p < .001, r = .42) and left-right justification (U = 317.00, p < .001, r = .44). The median and interquartile range are shown in Table 6.6Table 6.6. Older participants found that both left and left-right justification less difficult than younger participants.

Table 6.6 The median and interquartile range of difficulty of reading for each text justification between younger and older Thai participants

Text justification	Younger participants		Older participants	
	Mdn	IQR	Mdn	IQR
Left justification*	3.50	1.00	2.67	1.34
Left – Right justification*	3.83	1.00	2.67	1.20

Note: * significant difference

Overall, the results of rating of difficulty of reading showed that participants found the formats of one column and two columns were less difficult to read than three columns for UK participants. However, the format of two columns was less difficult to read than one and three columns for Thai participants. In addition, left justification was less difficult to read than left-right justification for both UK and Thai participants.

6.5.4 Preferences for combinations of column format and text justification

In the UK study, participants were asked which of all the combinations of column format and text justification they preferred. The choices are summarized in Table 6.7.

A chi-square test showed that the distribution of preferences for column format and text justification combinations between the two age groups and text layout combinations was not significant ($\chi^2 = 4.41$, $df = 5$, *n.s.*). In addition, there was no significant difference in preference between younger and older participants for either column formats ($\chi^2 = 2.25$, $df = 2$, *n.s.*) or text justification ($\chi^2 = 0.06$, $df = 1$, *n.s.*).

The power calculation indicated that there is an 80% chance of correctly detecting the difference with 81 younger and 81 older participants, making a total sample of 162 participants. Thus for robust results, approximately 45 more younger participants and 45 more older participants would need to participate.

Taking older and younger participants separately for preferences of column format, the distribution of younger preferences was not significantly different ($\chi^2 = 3.50$, $df = 2$, *n.s.)*. The distribution of older preferences was significantly different ($\chi^2 = 9.50$, $df = 2$, $p < .01$).

For preferences of text justification, the distribution of younger participants' preferences was not significantly different from random ($\chi^2 = 1.00$, $df = 1$, *n.s.)* and the distribution of older participants' preferences was also not significantly different from random ($\chi^2 = 0.44$, $df = 1$, *n.s.)*.

The power calculation indicated that there is an 80% chance of correctly detecting the difference with 71 younger and 71 older participants, making a total sample of 142 participants. Thus for robust results, approximately 35 more younger participants and 35 more older participants would need to participate.

However, overall the most popular choice was two columns with left text justification, chosen by 26.4% of the participants. For the older participants, the two columns with left text justification was also the most popular choice, chosen by 27.8% of the older participants. Followed by the two columns with left – right justification, chosen by a quarter of older participants (25.0%) while three columns with left – right justification was not chosen. Moreover, the two columns format was chosen by more than half (52.8%) of older participants while the one column was chosen by 36% of older participants and the three columns format was chosen by only 11.1% of them. In addition, the left text justification was chosen by more than a half of older participants (55.6%) while the left – right text justification was chosen by 44.4% of them.

For the younger participants, one column with left – right text justification and two columns with left text justification were the most popular choice, chosen by a quarter of younger participants (25.0%). Followed by one column with left text justification, chosen by 19.4%. Moreover, one column and two columns formats were chosen by more than quarter of younger participants (44.4% and 36.1%, respectively) while three columns format was chosen by only 19.4% of younger participants. In addition, the left text justification was chosen by more than a half of younger participants (58.3%) while the left – right text justification was chosen by 41.6% of them.

Some UK participants gave reasons for their preference of the combination of column format and text justification. However, the column formats were mentioned more than the text justifications. The reasons or comments from the UK participants are presented following below.

Table 6.7 Preferences of all UK participants and younger and older participants separately for each combination of column format and text justification (% and number of participants)

Combinations (column format / text justification)		Younger (N = 36)	Older (N = 36)	All (N = 72)
One column	Left justification	19.4% (7)	16.7% (6)	18.1% (13)
	Left – Right justification	25.0 (9)	19.4 (7)	22.2 (16)
Two columns	Left justification	25.0 (9)	27.8 (10)	26.4 (19)
	Left – Right justification	11.1 (4)	25.0 (9)	18.1 (13)
Three columns	Left justification	13.9 (5)	11.1 (4)	12.5 (9)
	Left – Right justification	5.6 (2)	0.0 (0)	2.8 (2)

Six older participants found that the combination of one column and left text justifications was clear, simple and familiar, and the longer lines were easier to read continuously. Five younger participants found that it was easier to read long lines of text or single column rather than having to move their eyes more frequently in reading short lines or multi-columns. Two of them stated that this combination had a natural flow and was the most familiar from reading books.

Seven older participants found that the one column with left-right justification was easy and clear to read and one of them mentioned that the three columns was more difficult to read.

Six of younger participants found that it was easy, clean and clear to read. One of them mentioned that this combination was similar to a paperback book.

In contrast, ten older participants found that the two columns format with left text justification was easy to read without the eyes having to jump to different paragraphs. Some of them stated that the shorter line length was easier than the long line length, as they found the one and three columns format was more tiring and confusing to read for either left justified text or left–right justified text. Seven younger participants found that two columns format was easier than having to read across the whole screen or too many columns, which were difficult to concentrate on in reading. They also found that left justified text made it easier to see where the column ended than left–right justified text.

Nine older participants found two columns with left–right justified text was neat, easy and clear to read. In addition, three of younger participants found this easy to read and the left–right justified text helped define the edges of each column. They mentioned that one column made them confused when reading the next line of the text, but it was not so tiring to read as three columns where their eyes have to constantly shift which line, they were reading.

Three older participants found that three columns with left justified text was easier to skim read than other formats. Four younger participants found that three columns provided not too much text per column and seem shorter and easier to read than one or two columns. In addition, with the left justified text it was easy to see the gaps between columns. One younger participant stated that this combination was laid out in a familiar newspaper style.

Only two younger participants found that the three columns with left-right justification was nicely structured text with the words separately well.

For the Thai study, participants were also asked which of all the combinations of column format and text justification they preferred. The choices are summarized in Table 6.8.

A chi-square test showed that the distribution of preferences for column format and text justification combinations between the two age groups and text layout combinations was not significantly different ($\chi^2 = 3.91$, $df = 5$, *n.s.*). The power calculation indicated that there is an 80% chance of correctly detecting the difference with 81 younger and 81 older participants, making a total sample of 162 participants. Thus for the robust results, approximately 45 more younger participants and 45 more older participants would need to participate.

In addition, there was no significant difference in preference between younger and older participants for either column formats ($\chi^2 = 2.57$, $df = 2$, *n.s.*) or text justification ($\chi^2 = 0.56$, $df = 1$, *n.s.*).

The power calculation indicated that there is an 80% chance of correctly detecting the difference with 61 younger and 61 older participants, making a total sample of 122 participants. Thus for the robust results, approximately 25 more younger participants and 25 more older participants would need to participate.

Taking older and younger participants separately, for preferences of column format, the distribution of younger participants preferences was not significantly different (χ^2 = 2.00, *df* = 2, *n.s.)* and the distribution of older participants' preferences was also not significantly different (χ^2 = 2.67, *df* = 2, *n.s.*). For preferences of text justification, the distribution of older participants' preference was not significantly different (χ^2 = 0.11, *df* = 1, *n.s.)* and the distribution of younger participants' preference was also not significantly different (χ^2 = 0.00, *df* = 1, *n.s.)*.

The power calculation indicated that there is an 80% chance of correctly detecting the difference with 71 younger and 71 older participants, making a total sample of 142 participants. Thus for the robust results, approximately 35 more younger participants and 35 more older participants would need to participate.

In addition, overall the most popular choice was two columns with left justification, chosen by 25% of participants. This combination was also the most popular choice for younger and older participants, chosen by 22.2% of the younger participants and more quarter of the older participants (27.8%). However, one column with both left justification and left-right justification was the second popular choice for younger participants, chosen by 19.4% of them. For older participants, three columns with left-right justification was the second popular choices, chosen by 19.4% of them. Interestingly, one column with left justification was the least popular choice for older participants (only 5.6%, choosing by them) while the three columns with left justification was the least popular choice for younger participants (only 8.3%, chosen by them).

Table 6.8 Preferences of all Thai participants and younger and older participants separately for each combination of column format and text justification (% and number of participants)

Combinations (Column format / Text justification)		Younger (N = 36)	Older (N = 36)	All (N = 72)
One column	Left justification	19.4% (7)	5.6% (2)	12.5% (9)
	Left – Right justification	19.4 (7)	16.7 (6)	18.1 (13)
Two columns	Left justification	22.2 (8)	27.8 (10)	25.0 (18)

Combinations (Column format / Text justification)		Younger (N = 36)	Older (N = 36)	All (N = 72)
	Left – Right justification	16.7 (6)	16.7 (6)	16.7 (12)
Three columns	Left justification	8.3 (3)	13.9 (5)	11.1 (8)
	Left – Right justification	13.9 (5)	19.4 (7)	16.7 (12)

Some Thai participants gave reasons for their preference of the combination column format and text justification. The column formats were mentioned more often than the text justifications the explanations. The reasons or comments of the Thai participants are presented following below.

Two older participants found that the one column with left justified text was easier to read due to not having to move their eyes so much while reading. They also mentioned that the longer lines made it easier to read continuously. Seven younger participants found this combination easy to read and one of them stated that this combination was similar to a book layout. These reasons were similar to UK participants' reasons.

Six older participants found that the one column with left–right justified text was easy to read, and the left-right justified text was neat for reading. Seven younger participants found that this combination was easy and clear to read. Some of them said that the one column was faster than either two or three columns.

In contrast, ten older participants found the two columns with left justification easy to read and understand because the long line length were not too long. Two of them mentioned that the gaps between words were not too big in the left justified text. Moreover, three of them also mentioned that in one column the line length was too long but in three columns the line length was too short for reading. They had to move their eyes up and down too frequently when reading the three columns. One of them also said that in the two columns format, there was a separate the texts as a similar to an appearance of a book. Six younger participants found that the two columns format provided not too dense text for reading and felt comfortable to read.

Six older participants found that the two columns with left–right justified text was easier to read than one column and three columns as they got lost and skipped lines of text while they were reading in one column. For three columns format, they got tired when reading because of too much eye movement. Six younger participants found that two columns provided good line length for reading and the text was not too crowded. Moreover, two of them mentioned that left-right justified text was a nice structure and clear for their eyes.

However, five older participants found the three columns with left justified text easier to read than one column because they did not skip lines of text while reading with the shorter line length. Moreover, the left justified text did not have too wide gaps between words. One of younger participants mentioned that the three columns made the line length shorter and this was easy to read and good for comprehension reading.

Seven older participants found that three columns with left-right justified text was easy and not tiring to read because of the short line length, and this did not strain their eyes. Moreover, three of them said that the text justification did not affect with their reading. Five younger participants found that this combination was compact and easy to read and understand

6.6 Discussion

This study investigated the effect of column format and text justification 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, there was no significant effect on reading time for neither the column format nor text justification variables, nor any interaction between this variable and age group in either countries. The result of text justification agrees with that of Kamollimsaku (2014) who also worked with younger and older participants in both Thailand and the UK and found that the text justifications had no effect on reading performance, although his participants read texts on a laptop computer screen. In addition, the result of column format has no effect on reading time that supports previous research about column layout on computer screen (Yi et al., 2011; Zaphiris and Kurniawan, 2001) which found no significant difference between different columns layouts in reading speed. However, there was no interaction between column format and text justification in reading time. This result contrasts with research by Baker (2005) who found that there was an interaction between column format and text justification in reading time on computer screen for younger participants.

For comprehension scores, there was no significant effect of neither the column format nor text justification variables in either countries. The result of UK (in term of younger participants) similar to the results of Baker (2005) who found that those two variables had no effect on reading comprehension on desktop computer for younger people. In addition, the older Thai participants answered significantly fewer questions correctly than younger Thai participants. In contrast, there was no significant difference on this variable between the older and younger UK participants. However, the texts in this study had more about animals which can be more interesting than previous studies for older participants.

In terms of participants' rating of difficulty of reading. UK participants did not find the difference in difficulty of reading between the left justification and left-right justification while

Thai participants found left justification significantly less difficult to read than left–right justification. In addition, UK participants found that the one and two columns formats were significantly less difficult to read than three columns format. However, Thai participants found that Thai texts presented in two columns format was significantly less difficult to read than one and three columns format. The differences may because Thai participants felt tired when reading one column with its long line, due to the fact that there is no full stop to indicate the end of a sentence and there is also no space between words in Thai texts.

In terms of preferences, overall UK and Thai participants show no significant preferences for particular combinations of column format and text justification. These results somewhat agree with those of Baker (2005), who found that the combination of column format and text justification had no effect on satisfaction of his participants, however he worked only with younger participants.

However, older UK participants showed a significant difference on preference of columns, with over half (52.8%) favouring two columns, although there was no difference for older Thai participants. The format of two columns was the most popular for them, chosen by 44.4% of older participants.

In addition, the preference for text justifications failed to show any significant difference in either country. The results on text justification was contrast somewhat to the research of Kamollimsakul (2014) who found that the text justifications (left and left–right justification) had an effect on preference for Thai participants but no effect for UK participants. This may because of using the different materials, Kamollimsakul's study used a laptop computer while the current study used a tablet computer. In addition, the two studies investigated different combination of variables on reading text. Kamollimsakul's study investigated the effect of line spacing and text justification whereas the current study investigated the effect of column format and text justification. Combining justification with column format may mean that readers notice the column differences more than the justification differences, whereas combining justification with line spacing highlights the justification differences more.

Nevertheless, the study had several limitations. The researcher did not attempt to control the distance at which the participants viewed the tablet screen, although participants were asked to place the tablet on the table to create an approximately similar distance. 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. In addition, the participants in both countries were quite well educated and therefore not representative of the whole population. Different results might have been found with less well-educated participants with lower literacy levels, as was discussed in Chapter 4 (section 4.6). Although only a landscape orientation of the tablet was used in this study, previous research has found that there were no differences between portrait and landscape orientation of tablets in productivity ratings;

however, the exactly meaning of productivity rating was not clearly explained (Pereira et al., 2013).

In addition, the researcher was able to compare reading the same text in landscape and portrait for the UK participants (both older and younger), as one of the texts (the Flamingo text) was used in Study 2 in portrait orientation and then used in Study 4 in landscape orientation. An analysis was therefore undertaken comparing reading time and comprehension scores for these two conditions (see Appendix U for further details). This showed that there was no significant difference in reading time between portrait and landscape orientation. However, the effect of the use of tablets in portrait and landscape orientations still needs further study.

A final limitation is that the English-speaking participants were all from the UK. Thus although the recommendation is for presentation of texts in English, it might be that participants from other English speaking countries, such as Australia, Canada or the USA, read the orthography differently, although this seems unlikely.

6.7 Conclusions

This study focused on the effects of combinations of column format and text justification for reading on a tablet computer, investigating aspects of reading performance and participants' preferences, for younger and older participants in both Thailand and the UK. Overall, the column format and text justification no effect on reading time and comprehension scores in either country. However, UK participants found the format of one column and two columns less difficult to read than three columns. In contrast Thai participants found the format of two columns was less difficult to read than one and three columns. In addition, Thai participants found that left justification less difficult to read than left-right justification, but UK participants did not find that there was difference between left justification and left – right justification for difficulty of reading.

Participants' preferences for text layout combinations did not show any difference in either country, and only older participants in the UK showed a significant difference in their preference for column formats. The format of two columns was the most popular choice for them.

Although there were no differences in the performance measures, given the differences in the ratings and preferences of the participants, the researcher recommends that the format of one or two columns with left justification are best for presentation of both English and Thai texts on tablet computers. It should be noted that these recommendations apply to text presented in landscape orientation of the tablet, as that was the orientation used by participants in reading in this study. Further investigation would be needed for portrait orientation.

Overall on the basis of the results of this study, the researcher recommends a format of two columns with left justification as best for the presentation of texts in landscape view on tablet computer screens for older readers in English. In addition, the format of either one or two columns with left justification best for Thai younger and older readers and also younger readers of English.

Chapter 7 Overall Discussion and Conclusions

7.1 Introduction

This chapter presents a discussion and the overall conclusions of the programme of research, Including the limitations of the research, the contributions made by the research and recommendations for future research.

7.2 Overall of the programme of research

As the older population increases worldwide, both the UK and Thailand have already become ageing societies. To help older people to live fulfilled lives for as long as possible, they are becoming increasingly involved in the use of technology. For example, tablet computers are now a very popular device for accessing the internet for older people in both the UK and Thailand (Electronic Transactions Development Agency (ETDA), 2015; 2016; Office for National Statistics, 2018a).

From the literature review, there are arguments both for and against the usability and acceptability of tablets for older people. In addition, one area of particular interest about the usability of tablet computers for older adults is the presentation of text on the tablet: how large the text should be and what fonts, font size, font and background colours, column formats and text justifications should be used. However, while there is much research about text presentation on personal computers, and some research on text presentation for older adults, most of the research is on the presentation of English. For example, no research on text presentation for Thai older people on tablet computers has been found.

The aims of this programme of research were to investigate the usability and acceptability of tablet computers for older people in Thailand and the United Kingdom. In addition, this programme investigated the presentation of text for reading on tablet computers for younger and older people in both English (with UK people) and Thai (with Thai people). The programme of research also developed recommendations for the presentation of text on tablet computers for both English and Thai.

There were four studies in the programme of research: the first exploratory study investigated general usability and accessibility of tablets for older people (see Study 1 in Chapter 3), and the other three studies were investigating the presentation of text both in English and Thai for both younger and older people. These three studies have allowed me to make recommendations about text presentation on tablets for younger and older people in both countries. The studies had participants skim read the texts. The three studies (Studies 2 to 4) investigated the effect of different text presentation variables on reading text: Study 2 investigated the effect of font type and font size (see Chapter 4), Study 3 investigated the effect of text colour and background colour (see Chapter 5), and Study 4 investigated the effect of column format and text justification (see Chapter 6).

7.3 Contributions of the programme of research

7.3.1 Problems encountered by older people in the UK and Thailand in using tablet computers

The first contribution of this programme of research is a greater understanding of the usability of tablet computers for older people in both the UK and Thailand. A number of problems were found by eighteen older participants, eight UK participants and ten Thai participants. Problems were categorised into four main problem areas: Physical presentation, Content, Information architecture and Interactivity (see Chapter 3).

Most problems were found in the area of interactivity, 17 in all by UK and Thai participants. For example, while participants were tapping on some controls, the controls did not work. Eleven physical presentation problems were found by four UK and ten Thai participants, including text or labels too small, and the text colour and background on some controls not having sufficient contrast. Three content problems were found by one UK and five Thai participants, including the website not showing information clearly enough. Only one information architecture problem was found, which was the website was not clear in which category to search for a product; this problem was found by only Thai participants. Finally, participants' lack of confidence and knowledge were also barriers in using the tablets.

7.3.2 Attitude of UK and Thai older people toward tablet computers

All the UK older participants found the tablet was easier and faster to use than a desktop computer. Apart from the problems above, some UK older participants found that some interaction with the tablet such as scrolling and zooming were easy for them, although two of them found zooming in made them lose orientation and some information on the screen. Some older participants had problems with tapping, they held the tap for too long. However, three of the four novice participants said they were tempted by the tablet after using it in the study.

In Thailand, some older Thai participants found that they are able to transfer some knowledge from using a desktop computer to using the tablet computer. One older participant said that the tablet computer would be useful for her when travelling and during her leisure time. Another participant found that the screen and keyboard of the tablet was too small for her and some participants had problems with tapping, similar to those of the UK participants. One novice participant thought that he would be able to work with a tablet very well if he used it for approximately one month.

Overall, UK and Thai older people have good attitudes toward using tablets. Although some of them had some problems for interaction with the tablet, overall they found that it easy and convenient to use (see Chapter 3).

7.3.3 The recommendations of text presentations on tablet computers for younger and older UK readers

There is a considerable amount of research which has developed recommendations for the presentation of text in English to be presented on digital devices. However, some of the recommendations are now outdated and did not focus on tablets or on the needs of older readers. Reading from a tablet is quite different from reading from the screen of a desktop computer, including screen size, viewing distance, and angle of view. Therefore, this programme of research developed empirical evidence to update and provide recommendations for the presentation of English text on tablets for both younger and older readers in the UK.

Based on the results of three studies which investigated English text presentation, 18 point sans serif font with black text on a white background is recommended for presenting the texts for both younger and older readers (see Chapter 4 and 5). However, black text on pale background (buff and light blue) can also be recommended for younger readers. In addition, from Study 4, a format of two columns with left justification is recommended for presenting texts for both younger and older readers when the tablet screen is oriented in landscape view for reading, however, a format of one column with left justification can also be recommended for younger readers (see Chapter 6). The recommendations for English text are summarized in Table 7.1.

Table 7.1 Recommendations for the presentation of English texts

Aspect of text presentation	Younger readers	Older readers
Font type	Sans serif font	Sans serif font
Font size	18 point	18 point
Combination of text and background colour	Black text on White background or Black text on Buff or Light Blue background	Black text on White background

Aspect of text presentation	Younger readers	Older readers
Column format (for landscape orientation)	One or Two columns	Two columns
Text justification (for landscape orientation)	Left justification	Left justification

Although the recommendations are for text presentations in English, all participants are native English speakers in the UK. Nonetheless, there may have been differences if participants had been native English speakers from other countries such as Australia, Canada or the United State as well as the countries, although this seems unlikely. Similarly, there may be differences for languages which use the same alphabet as English such as French and German.

7.3.4 Recommendations of text presentations on tablet computers for younger and older Thai readers

There has only been one programme of research which has investigated the presentation of text on digital devices in the Thai language for older readers (Kamollimsakul, 2014). However, that research investigated reading on a laptop computer not a tablet. In addition, the Thai older participants were somewhat younger than those in this programme of research, being aged 55 years and older. Currently, the healthy life expectancy in Thailand is become a little higher than in previous years so people who are 55 years is still in the middle-age group. Consequently, this programme of research provided empirical evidence to develop recommendations for the presentation of text in Thai on tablet screens for both younger and older readers.

Based on the results of the three studies which investigated Thai text presentation, 18 point serif font with black text on a white background is recommended for the presentation of the texts for both younger and older readers (see Chapter 4 and Chapter 5). In addition, a format of one or two columns with left justification is recommended for the layout presentation of the text for both younger and older readers when the tablet screen is oriented in landscape view for reading (see Chapter 6). The recommendations for Thai text are summarized in Table 7.2.

Table 7.2 The recommendations for the presentations of Thai texts

Aspect of text presentation	Younger readers	Older readers
Font type	Thai Serif font	Thai Serif font
Font size	18 point	18 point
Combination of text colour and background colour	Black text on White background	Black text on White background
Column format (for landscape orientation)	One or Two columns	One or Two columns
Text justification (for landscape orientation)	Left justification	Left justification

7.4 Limitations and future work

Each study in this programme of research had some limitations. The most important of these are the small sample sizes of younger and older people; in particular, this made the statistical analysis of the preference data in the text presentation studies difficult, which needs to be considered in interpreting the results. Other limitations are discussed below.

In Study 1, the number of websites in Thai on the topic areas chosen were limited. This was a concern as I wanted websites which participants had not used before. However, in the event, none of older Thai participants had used the websites before using them in the study.

In Studies 2 to 4, the three studies of text presentation, I did not attempt to control the distance at which the participants viewed the tablet screen, as I wanted to create a reasonably ecologically valid scenario. However, I did ask participants to place the tablet on the desk in front of them (rather than holding it in their hands), to create a similar viewing distance. 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 texts. However, there is no measure of readability for texts in Thai, so they could not be assessed for their readability once they had been translated into Thai. Thus, I cannot be sure that the texts were of equal readability in both languages.

In this current programme of research, the participants in both countries were quite well educated and therefore not completely representative of the whole population. Different results may be found with less-well-educated participants with lower literacy levels.

As discussed above, the Latin alphabet is used for many languages in Europe and other parts of the world, including some Asian countries such as Malaysia. The current research on English only used native speakers of English from the UK. So although it seems reasonable to generalize to the countries which use English, it is less clear whether these results would generalize to other languages with use the Latin alphabet. Thus, further research is needed to investigate the effect of text presentation in different languages that use the Latin alphabet.

Although Kamollimsakul (2014) developed recommendations the presentation of text on computer screen for younger and older readers in Thailand, the aspects of text presentation in his research were quite different from the aspects in the current programme of research. Thus the recommendations for the presentation of Thai texts developed in this programme of research were the first recommendations of certain aspects of text presentation on tablets for younger and older readers in Thailand. Further research is needed to investigate the effects of text presentation on other digital devices (for example smartphone), for different age groups and for people with disabilities.

Finally, the tablet orientation still needs to be considered. Although a supplementary analysis conducted with data from two studies in this programme of research found that tablet orientation did not affect in reading performance, the study only had a small number of participants. In addition, that analysis only included UK participants, so the result may differ for participants in other countries.

7.5 Conclusions

This programme of research provides empirical evidence about the problems and attitudes of older people in their use of tablet computers in the UK and Thailand. Overall, using tablets are not difficult for UK and Thai older people, but they still have some issues with using them such as text that is too small and cannot be resized or holding a tap for too long. However, older people in both countries have positive attitudes toward tablets and they are interested in using tablets in the future.

In addition, the research also provides recommendations for text presentation in English and Thai on tablet computer screens for both younger and older readers. On font type and font size, although font type did not affect in reading time in both countries, the majority of UK participants preferred the Sans Serif font while Thai participants preferred the Serif font. However, the results of font size were very clear for both UK and Thai participants. Font size of 18 point (which was the biggest font size used in this research) is the best for the presentation of texts for both younger and older readers in the UK and Thailand, based on both performance and preference measures. On text and background colour, black text on white background is the best combination for the presentation of text for both younger and older readers in both countries. On column format and text justification, a format of two columns with left-justified text is recommended for presentation of text layouts for both younger and older readers in the UK and Thailand when reading text in landscape orientation; however, a format of one column with left-justified text is recommended for younger and older readers in Thailand and also younger readers in the UK.

Appendices

Appendix A : Counterbalancing of protocols (CVP vs RVP and websites for Study 1)

Participants	First protocol			Second protocol		
	Protocol	Website	Task order	Protocol	Website	Task order
1	CVP	Website 1	1 then 2	RVP	Website 2	1 then 2
2	CVP	Website 2	1 then 2	RVP	Website 1	1 then 2
3	CVP	Website 1	2 then 1	RVP	Website 2	2 then 1
4	CVP	Website 2	2 then 1	RVP	Website 1	2 then 1
5	RVP	Website 1	1 then 2	CVP	Website 2	1 then 2
6	RVP	Website 2	1 then 2	CVP	Website 1	1 then 2
7	RVP	Website 1	2 then 1	CVP	Website 2	2 then 1
8	RVP	Website 2	2 then 1	CVP	Website 1	2 then 1

Appendix B : Initial Questionnaire for the study of the usability and acceptability of tablet computer

a) Initial Questionnaire in English

Part1 use of the web

1. Approximately how long have you been using the web?

   _______________ years

2. How did you learn to use the web (tick as many as are appropriate)?

   ❑ Taught myself ❑ From family members ❑ From friends

   ❑ From colleagues at work ❑ From reading a guide

   ❑ I took a course (if so, where_____________________________)

3. Approximately how often do you use the web in a typical week?

   _______________ hours

4. How do you access the web (tick as many as are appropriate)?

   ❑ Desktop computers ❑ Laptop computers ❑ Mobile phones

   ❑ Tablet computers ❑ Other………………………………..

5. How would you rate your level of **experience** using web (circle one of the crosses)?

   None at all Extensive

   + -------- + -------- + -------- + -------- + -------- + -------- +

6. How would you rate your level of expertise in using the web (circle one of the crosses)?

   None at all Extensive

   + -------- + -------- + -------- + -------- + -------- + -------- +

If you have used a tablet computer, please answer the questions in Part 2, otherwise go to Part3

Part 2 use of the tablet computers

1. Approximately how long have you been using the tablets?

   _________ months _________ years

2. How did you learn to use the tablets (tick more than one)?

❑ Taught myself ❑ From family members ❑ From friends

❑ From colleagues at work ❑ From reading a guide

❑ I took a course (if so, where_____________________________)

3. Approximately how often do you use the tablet in a typical week?

_______________ hours

4. How would you rate your level of **experience** of using tablet (circle one of the crosses)?

None at all Extensive

+ -------- + -------- + -------- + -------- + -------- + -------- +

5. How would you rate your level of **expertise** in using the tablet (circle one of the crosses)?

None at all Extensive

+ -------- + -------- + -------- + -------- + -------- + -------- +

Part 3 About you

Please answer the following general questions about yourself (this information is only for statistical purposes, and is confidential and anonymous)

1. Age: _________ years

2. Gender: ❑ Male ❑ Female

3. What is your current employment status?

❑ Working ❑ Not working or Retired

If you working, what is your job: ……………………………………………….

Thank you for taking the time to complete these questions

b) Initial Questionnaire in Thai

ส่วนที่ 1 การใช้งานเว็บไซต์ของท่าน

1. ท่านเข้าใช้งานเว็บไซต์มาโดยประมาณนานเท่าไร
   ________________ ปี
2. ท่านเรียนรู้การใช้งานเว็บไซต์ด้วยวิธีใด (เลือกได้มากกว่าหนึ่งข้อ)
   ❑ ด้วยตัวท่านเอง ❑ จากคนในครอบครัว ❑ จากเพื่อน
   ❑ จากเพื่อนร่วมงาน ❑ จากการอ่านคู่มือหรือคำแนะนำ
   ❑ ลงเรียนหรืออบรมคอร์สระยะสั้น (ถ้าลงเรียน ท่านลงเรียนที่ไหน ____________________)
3. ท่านเข้าใช้งานเว็บไซต์โดยประมาณเป็นระยะเวลาเท่าใดใน 1 สัปดาห์
   ________________ ชั่วโมง
4. ท่านเข้าใช้งานเว็บไซต์ด้วยอุปกรณ์ใด (เลือกได้มากกว่าหนึ่งข้อ)
   ❑ คอมพิวเตอร์แบบตั้งโต๊ะ ❑ คอมพิวเตอร์แบบพกพา ❑ โทรศัพท์มือถือ
   ❑ คอมพิวเตอร์แท็บเล็ต ❑ อื่น ๆ______________________________
5. ท่านคิดว่าประสบการณ์การเข้าใช้งานเว็บไซต์ของท่านอยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)
   ไม่มีประสบการณ์เลย มีประสบการณ์อย่างกว้างขวาง
   + ---------- + ---------- + ---------- + ---------- + ---------- + --------- +
6. ท่านคิดว่าตัวท่านมีความเชี่ยวชาญในการใช้งานเว็บไซต์อยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)
   ไม่มีความเชี่ยวชาญเลย มีความเชี่ยวชาญอย่างมาก
   + ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

ถ้าท่านเคยใช้คอมพิวเตอร์แท็บเล็ต กรุณาตอบคำถามในส่วนที่ 2 แต่สำหรับท่านที่ไม่เคยใช้คอมพิวเตอร์แท็บเล็ต กรุณาข้ามคำถามในส่วนที่ 2 ไป โดยไปตอบคำถามในส่วนที่ 3

ส่วนที่ 2 การใช้คอมพิวเตอร์แท็บเล็ตของท่าน

1. ท่านใช้งานคอมพิวเตอร์แท็บเล็ตมาโดยประมาณนานเท่าไร
   _________ เดือน _________ ปี

2. ท่านเรียนรู้การใช้งานคอมพิวเตอร์แท็บเล็ตด้วยวิธีใด (เลือกได้มากกว่าหนึ่งข้อ)

❑ ด้วยตัวท่านเอง ❑ จากคนในครอบครัว ❑ จากเพื่อน

❑ จากเพื่อนร่วมงาน ❑ จากการอ่านคู่มือหรือคำแนะนำ

❑ ลงเรียนหรืออบรม (ถ้าลงเรียน ลงเรียนที่ไหน ______________________________)

3. ท่านใช้งานคอมพิวเตอร์แท็บเล็ตโดยประมาณเป็นระยะเวลาเท่าใดใน 1 สัปดาห์

______________ ชั่วโมง

4. ท่านคิดว่าประสบการณ์ในการใช้คอมพิวเตอร์แท็บเล็ตของท่านอยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)

ไม่มีประสบการณ์เลย มีประสบการณ์อย่างกว้างขวาง

\+ ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

5. ท่านคิดว่าตัวท่านมีความเชี่ยวชาญในการใช้งานคอมพิวเตอร์แท็บเล็ตอยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)

ไม่มีความเชี่ยวชาญเลย มีความเชี่ยวชาญอย่างมาก

\+ ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

ส่วนที่ 3 เกี่ยวกับตัวท่าน

กรุณาตอบคำถามเกี่ยวกับข้อมูลส่วนตัวของท่าน (ข้อมูลนี้ใช้ในการวิเคราะห์ทางสถิติเท่านั้น และข้อมูลนี้จะถูกเก็บเป็นความลับและไม่มีการเปิดเผยตัวตนของท่าน)

1. อายุ: ________ ปี

2. เพศ: ❑ ชาย ❑ หญิง

3. ปัจจุบันท่าน

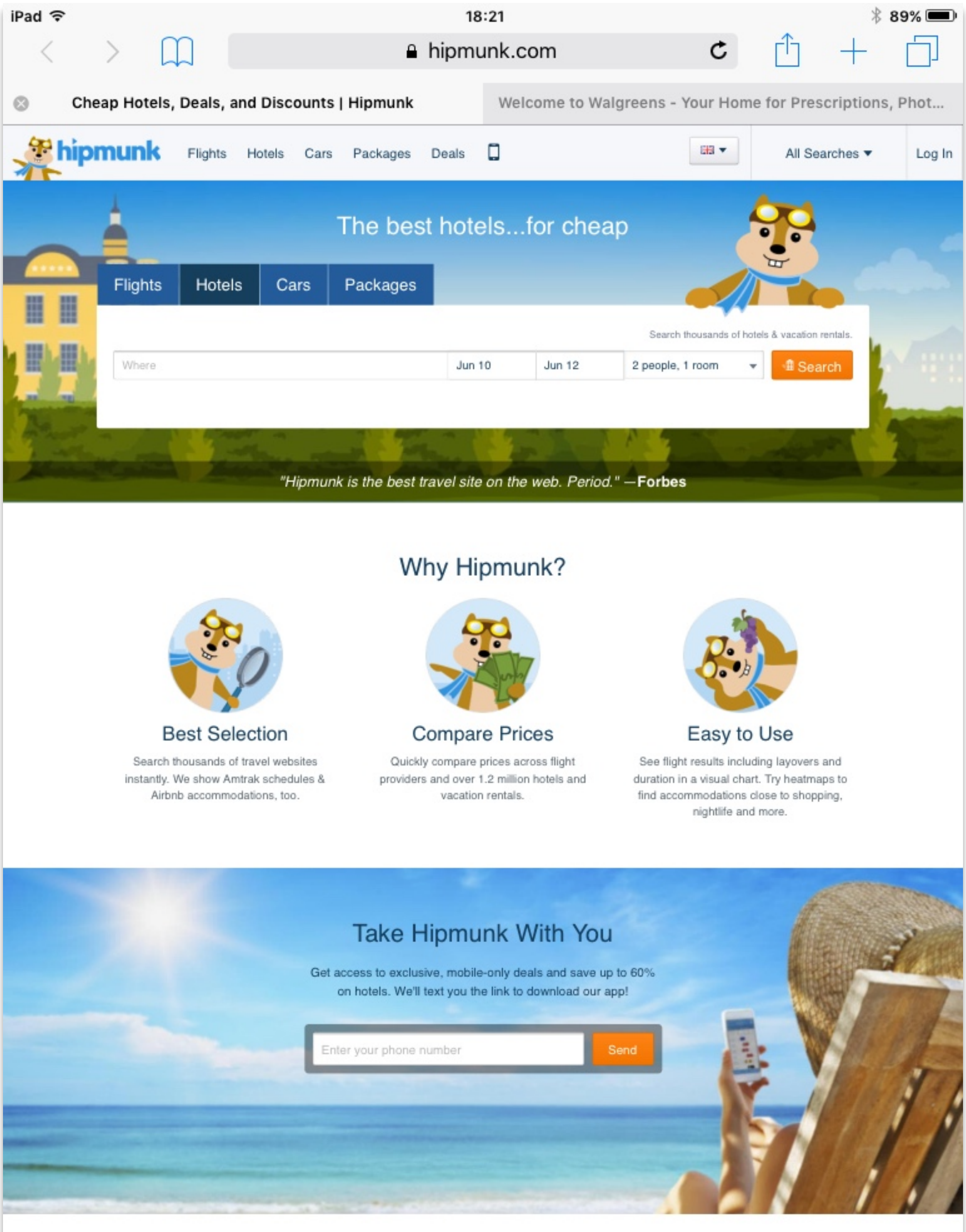
❑ ทำงาน ❑ ไม่ทำงาน หรือเกษียณอายุ

ถ้าท่านทำงาน ท่านทำอาชีพอะไร ________________________________

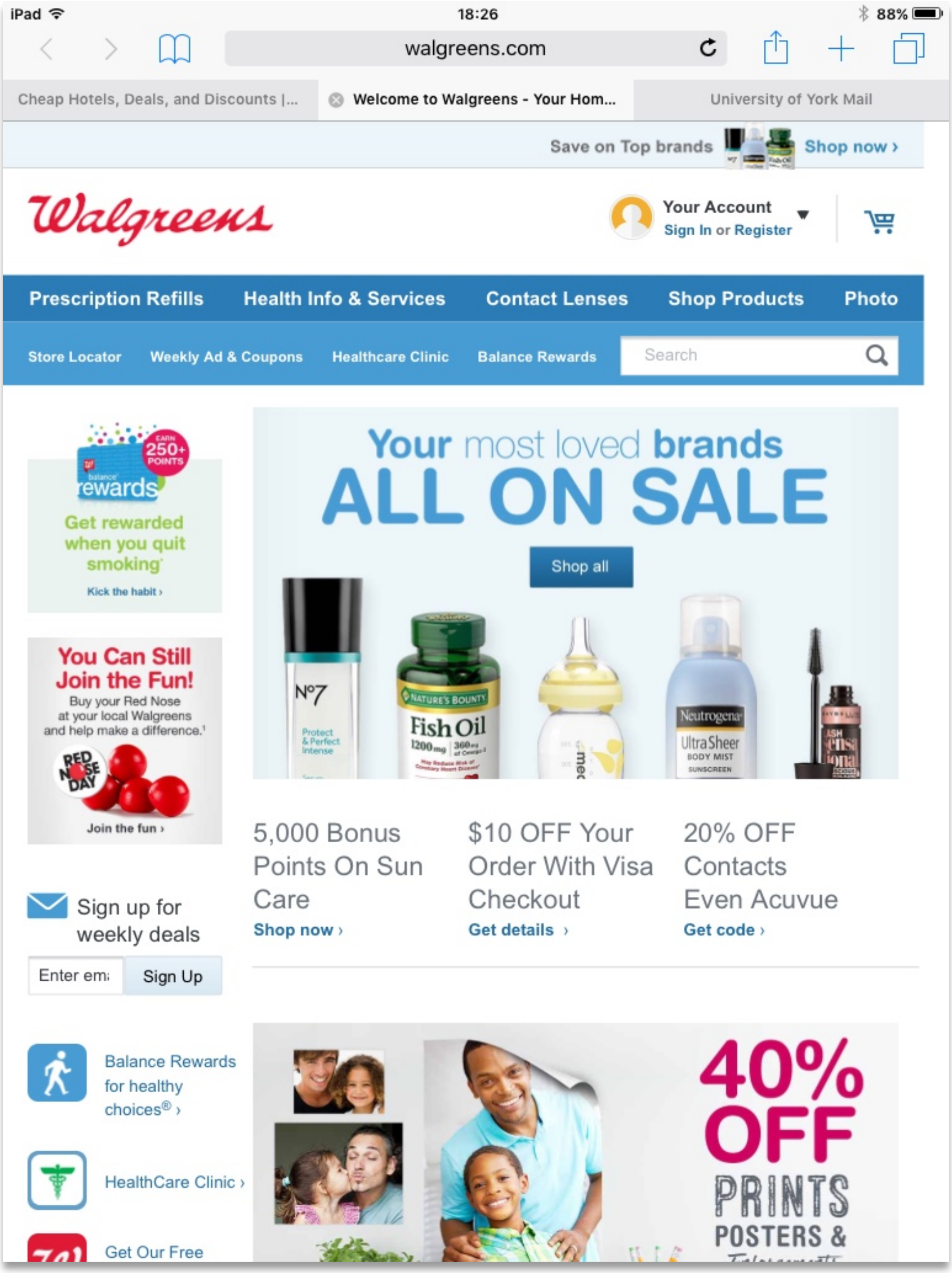
ขอขอบคุณท่านที่สละเวลาในการตอบคำถาม

Appendix C : Websites will use for the study of usability and acceptability of tablet computer for older people.

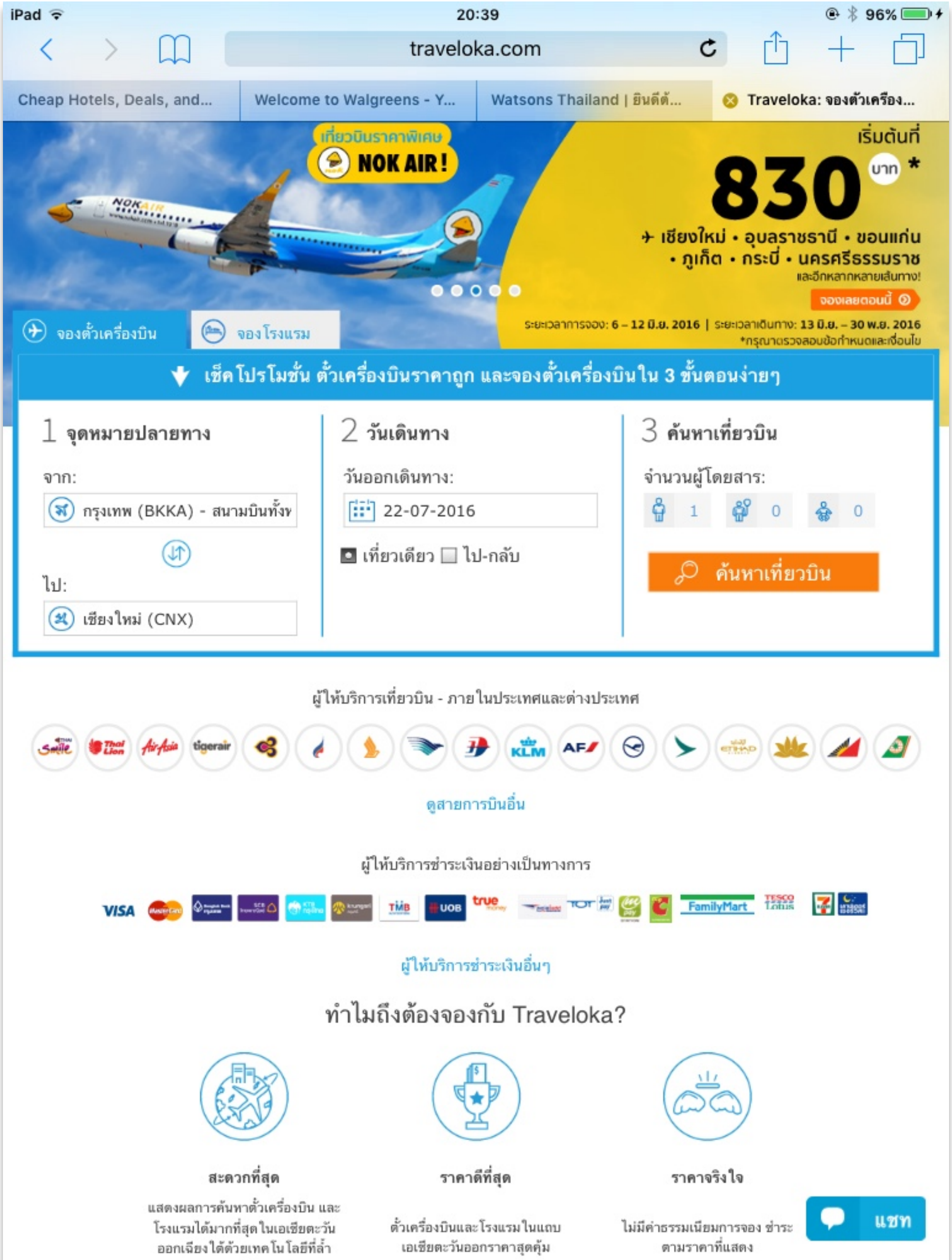
1) Hipmunk.com



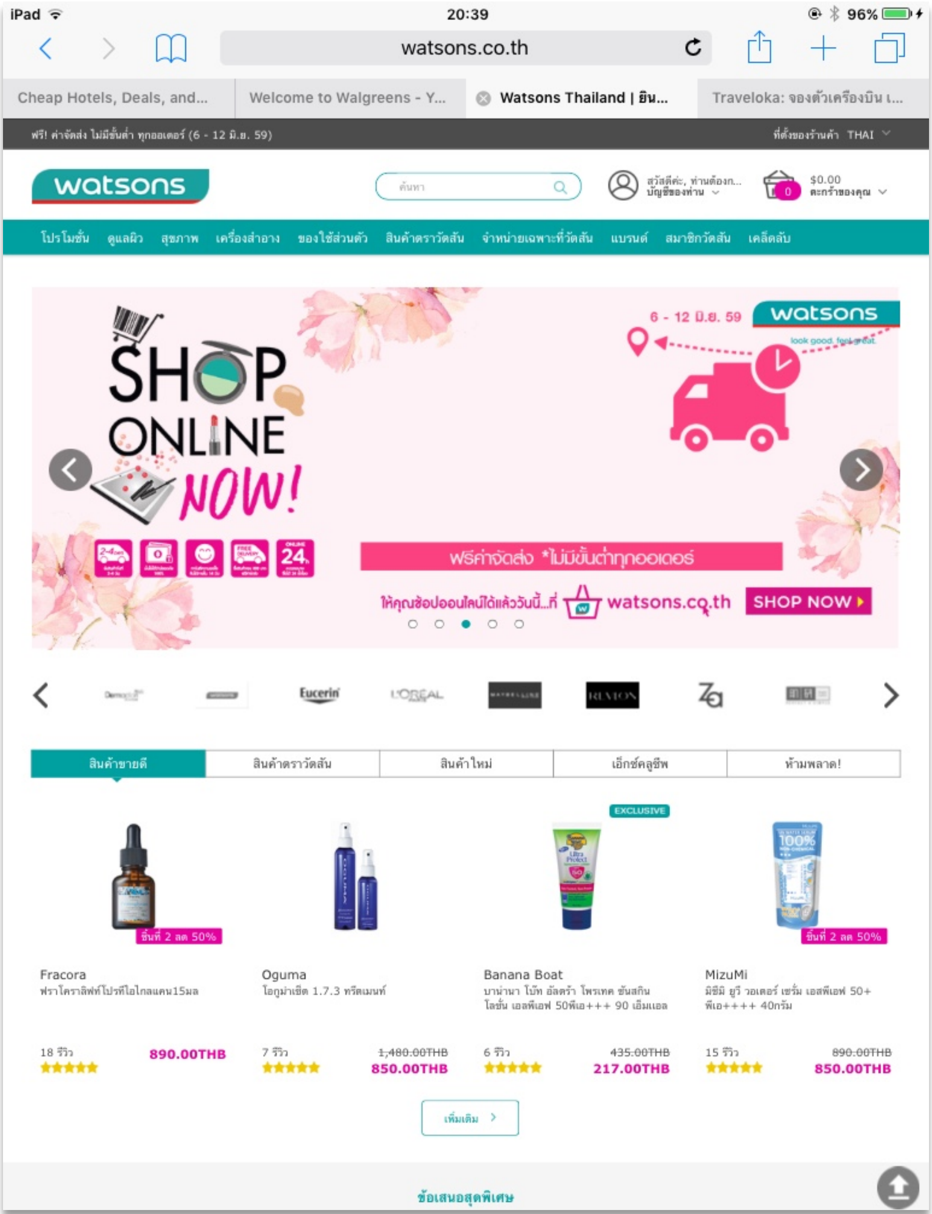
2) Walgreens.com



3) Traveloka.com



4) Watson.co.th



Appendix D: Pre-study brief for the study of usability and acceptability of tablet computer for older people

a) Pre-study brief in English

Thank you for your interest in this study.

Before starting the study, I will just tell you a bit about it.

There will be several parts: a short questionnaire, then a short interview, both about your use of computers. Then the main part of the study, doing some tasks on the web. These will be easy tasks, and we are definitely not "testing" you in any way, we are interested in what is easy on the web and what is tricky. We will do the tasks in two ways, one will be you will talk through what you are doing, in effect "thinking aloud". In the other, you will do the task and then we will play back a video of you doing the tasks and you can then describe what you are doing. We will have some practice of each way, so you get the hang of it. We are interested in which way is easiest for people and which way shows any problems on the websites most clearly. After doing the tasks each way, we will give you a rather odd exercise to measure how difficult you found it. It was developed by NASA to measure how difficult astronauts found different tasks they had to do on the moon missions, but it's now used a lot in measuring difficult of technology related tasks.

The session will take about one hour and you will be offered with a £ 25 gift voucher for your participation.

Do you have any questions?

After questions, get them to sign the informed consent form.

b) Pre-study brief in Thai

ขอขอบคุณสำหรับการเข้าร่วมการวิจัยในครั้งนี้

ก่อนที่จะเริ่มการวิจัย ผู้วิจัยจะชี้แจงรายละเอียดเกี่ยวกับการวิจัยในครั้งนี้คร่าว ๆ

กระบวนการการวิจัยจะแบ่งออกเป็นสามส่วน คือ แบบสอบถามสั้น ๆ และการสัมภาษณ์สั้น ๆ โดยคำถามจะเกี่ยวกับการใช้คอมพิวเตอร์ ในส่วนที่เป็นกระบวนหลักคือ การปฏิบัติงานบนเว็บไซต์ โดยงานที่จะให้ผู้เข้าร่วมวิจัยปฏิบัตินั้นจะเป็นงานง่าย ๆ และพวกเราจะไม่ได้ตรวจสอบที่ตัวท่านในการปฏิบัติงาน แต่จะเป็นการศึกษาการใช้งานของเว็บไซต์ว่ามีอะไรที่ใช้งานได้ง่ายหรือมีอะไรที่ทำให้ผู้ใช้สับสับ โดยงานที่ผู้เข้าร่วมวิจัยจะต้องทำตอนปฏิบัติงานเว็บไซต์มีสองวิธีด้วยกันก็คือ การคิดแบบออกเสียงขณะปฏิบัติงานบนเว็บไซต์ และการคิดแบบออกเสียงภายหลังปฏิบัติบนเว็บไซต์ โดยจะให้ดูวิดีโอตอนที่ท่านปฏิบัติงาน แล้วให้อธิบายว่าท่านกำลังทำอะไร แต่ก่อนที่จะเริ่มผู้วิจัยจะให้ท่านลองฝึกการคิดแบบออกเสียงทั้งสองแบบ โดยการวิจัยในครั้งจะมีจุดประสงค์ที่จะนำเสนอว่าวิธีการคิดแบบออกเสียงทั้งสองแบบนั้นวิธีไหนง่ายกว่ากัน และสามารถแสดงปัญหาได้ชัดเจนกว่ากัน หลังจากเสร็จสิ้นการปฏิบัติงานบนเว็บไซต์แล้ว ผู้วิจัยจะให้ท่านวัดความยากของงานที่ท่านปฏิบัติโดยใช้วิธีวัดของ NASA ที่ใช้วัดว่างานที่แตกต่างกันของนักบินอวกาศที่ปฏิบัติบนดวงจันทร์มีความยากอย่างไร เนื่องจากในปัจจุบันมีการนำวิธีวัดของ NASA นี้มาใช้ในการวัดความยากของงานที่เกี่ยวกับเทคโนโลยีอย่างมาก

การวิจัยนี้จะใช้เวลาประมาณ 1 ชั่วโมง และท่านจะได้รับบัตรกำนัลมูลค่า 500 บาท สำหรับการเข้าร่วมการวิจัยครั้งนี้

ท่านมีคำถามจะถามก่อนเริ่มการวิจัยหรือไม่

หลังจากนี้ ผู้วิจัยจะแจกหนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัย เพื่อให้ท่านได้ลงลายมือชื่อ

Appendix E : Informed consent form for the study of usability and acceptability of tablet computer

a) Informed consent form in English

Thank you for participating in this study. This study is investigating the experience that people in using tablet computers and this study is part of my PhD research programme at University of York. At the beginning of the session you will be asked to complete a short questionnaire about your use of the web and tablet computers and demographic information. Then, you will be asked to undertake a series of short tasks of to find information on websites using a tablet computer. Finally, when all of the tasks are complete, you will be briefly interviewed about how you found the tasks and about using tablet computers. Please feel free to ask questions about the study at any point. If you are uncomfortable at any point, please let us know and we will stop the study. This does not affect your right to receive a gift voucher for the study.

If you have any questions after the study, please send a message to Maneerut at mc1363@york.ac.uk and Professor Helen Petrie (her PhD supervisor) at helen.petrie@york.ac.uk.

All your information will be completely confidential and anonymous. Only Maneerut and Helen will see your detailed information. Information from the study will only be made public in an aggregated way, so that individuals cannot be identified.

Before participating in this study, please complete section A. Once study is completed and you have been debriefed, you will be asked to initial the three statements in Section B, to indicate your agreement

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Section A

I, ______________________________, voluntarily give my consent to participate in this study. I agree to perform the tasks on the web and answer questions about my experience of the web and tablet computers. I have been informed about and feel that I understand the basic nature and propose of this study. I understand that there are no known risks to participation in the study and that I may withdraw at any time during the study without prejudice. I understand that I will be compensated in the amount of £15 per hour regardless of whether I am able to complete the study or not.

I understand that all data gathered will be treated completely confidentially. I also understand that my data will only be available in its original from to Maneerut Chatrangsan and her research supervisor Professor Helen Petrie. I understand that I will not be identified when the data is shared described or interpreted.

_____________________________ _________________

Signature of Research Participant Date

Section B

Please initial each of the following statements when the study has been completed and you have been debriefed.

I have been adequately debriefed. Your signature: __________________________

I was not forced to complete the study. Your signature: __________________________

All my questions have been answered. Your signature: __________________________

b) Informed consent form in Thai

ขอบคุณท่านที่เข้าร่วมในการศึกษาครั้งนี้ การวิจัยนี้มุ่งสำรวจประสบการณ์และปัญหาในการใช้งานคอมพิวเตอร์แท็บเล็ตของผู้ใช้งาน และในการศึกษาครั้งนี้เป็นส่วนหนึ่งในการศึกษาระดับปริญญาเอก มหาวิทยาลัยยอร์ค ประเทศอังกฤษ เมื่อเริ่มต้นการวิจัย ท่านจะถูกขอให้กรอกแบบสอบถามสั้น ๆ เกี่ยวกับการใช้งานเว็บไซต์ การใช้งานแท็บเล็ตคอมพิวเตอร์ และข้อมูลส่วนบุคคล จากนั้นท่านจะถูกขอให้ค้นหาข้อมูลบนเว็บไซต์ตามใบงานผ่านแท็บเล็ตคอมพิวเตอร์ เมื่อท่านเสร็จสิ้นการค้นหาข้อมูลแล้ว ท่านจะถูกสัมภาษณ์สั้น ๆ เกี่ยวกับการที่ท่านค้นหาข้อมูลบนเว็บไซต์ และจากนั้นท่านสามารถสอบถามรายละเอียดที่ท่านต้องการเกี่ยวกับงานวิจัยในครั้งนี้

ถ้าท่านมีคำถามก่อนหรือหลังการเข้าร่วมการวิจัย ท่านสามารถถามคำถามได้โดยส่งอีเมลมาที่นางสาวมณีรัตน์ ชาติรังสรรค์ ที่ mc1363@york.ac.uk และศาสตราจารย์เฮเลน เพทรี (Professor Helen Petrie) ที่ helen.petrie@york.ac.uk

ท่านจะทราบเกี่ยวกับวัตถุประสงค์ของการศึกษาในครั้งนี้ก่อนการวิจัยจะเริ่มต้น และถูกขอให้กรอกข้อมูลในหนังสือแสดงการยินยอมในการเข้าร่วมการวิจัยในส่วนที่ 1 เกี่ยวกับการยินยอมเข้าร่วมการวิจัยและลงลายมือชื่อ และหลังจากการวิจัยในการครั้งนี้เสร็จสิ้นท่านถูกรับรองในหนังสือแสดงการยินยอมในส่วนที่ 2 ว่าไม่ได้ถูกบังคับและได้รับค่าตอบแทนในการเข้าร่วมการวิจัยที่ได้ตกลงกันไว้ พร้อมกับทราบรายละเอียดคร่าว ๆ เกี่ยวกับรายละเอียดการเก็บข้อมูลและการเผยแพร่ข้อมูลในการวิจัยครั้งนี้

ส่วนที่ 1

ข้าพเจ้า____ ขอแสดงความยินยอมอย่างสมัครใจในการเข้าร่วมการวิจัยเกี่ยวกับการใช้งานเว็บไซต์ และตอบคำถามเกี่ยวกับประสบการณ์การใช้เว็บไซต์และคอมพิวเตอร์แท็บเล็ต ข้าพเจ้าได้รับทราบและเข้าใจรายละเอียดเบื้องต้นและวัตถุประสงค์ของการวิจัยในครั้งนี้ ข้าพเจ้าเข้าใจว่าไม่ไม่ความเสี่ยงใด ๆ แก่ข้าพเจ้าในการวิจัยครั้งและสามารถถอนตัวจากการวิจัยได้ตลอดเวลาโดยไม่ต้องคืนค่าตอบแทนที่ได้ตกลงกันไว้ โดยข้าเจ้าทราบว่าจะได้รับค่าตอบแทนเป็นบัตรกำนัลของห้างโรบินสันเป็นจำนวน 400 บาท และข้าพเจ้ารับทราบว่าข้อมูลทั้งหมดจะเป็นความลับ และเข้าใจดีว่ามีเพียงนางสาวมณีรัตน์ ชาติรังสรรค์ และอาจารย์ที่ปรึกษา ศาสตราจารย์เฮเลน เพทรี (Professor Helen Petrie) เท่านั้นที่จะเข้าถึงข้อมูลดิบของข้าพเจ้าที่จากการวิจัย และทราบว่าในการเผยแพร่ข้อมูล รวมไปถึงการตีความจะไม่มีการระบุตัวตนของข้าพเจ้า

___________________________________ ________________________

ลายมือชื่อผู้เข้าร่วมการวิจัย วัน เดือน ปี

ส่วนที่ 2

กรุณารับรองว่าท่านได้ถูกปฏิบัติตามข้อความด้านล่างนี้ เมื่อเสร็จสิ้นการวิจัยและได้รับฟังรายละเอียดของการวิจัยในการครั้ง

ข้าพเจ้าถูกสอบถามรายละเอียดอย่างเพียงพอและเหมาะสม ลายมือชื่อ____________________

ข้าพเจ้าไม่ได้ถูกบังคับให้ทำการวิจัยในครั้งนี้ ลายมือชื่อ____________________

คำถามของข้าพเจ้าทุกคำถามได้ถูกตอบ ลายมือชื่อ____________________

Appendix F : NASA TLX Documents

a) NASA TLX Documents in English: Rating Scale definitions

Title	Endpoints	Description
MENTAL DEMAND	Low/High	How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching etc)? Was the task easy or demanding, simple or complex, exacting or forgiving
PHYSICAL DEMAND	Low/High	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating etc)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	Low/High	How much time pressure did you feel due to the rate or pace at which the tasks or task element occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	Good/Poor	How successful do you think you were in accomplishing the goals of the tasks set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	Low/High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION	Low/High	How insecure, discourages, irritated, stressed and annoyed versus secure, gratified, content relaxed and complacent did you feel during the task?

NASA TLX Pairwise Comparisons Sheet

Which was more important for the tasks (consider each pair separately):

Effort or Performance	Temporal Demand or Frustration	Frustration or Effort	Performance or Mental Demand
Temporal Demand or Effort	Physical Demand or Frustration	Performance or Temporal Demand	Mental Demand or Effort
Performance or Frustration	Physical Demand or Temporal Demand	Mental Demand or Physical Demand	Effort Or Physical Demand
Physical Demand or Performance	Temporal Demand or Mental Demand	Frustration or Mental Demand	

Individual Task Rating Scales

Participant No: ___________________________________

Website: ____ Protocol: CVP / RVP

Task: Task 1 / Task 2

MENTAL DEMAND How mentally demanding was the task?

Very low Very high

PHYSICAL DEMAND How physically demanding was the task?

Very low Very high

TEMPORAL DEMAND How hurried or rushed was the pace of the task?

Very low Very high

PERFORMANCE How successful were you in accomplishing what you were asked to do?

Perfect Failure

EFFORT How hard did you have to work to accomplish your level of performance?

Very little very hard

FRUSTRATION How insecure, discourage, irritated, stressed or annoyed were you?

Very little very much

NASA TLX

Weighted Task Workload Calculation Sheet

Participant No: ______________________________________

Website: _______________________________________ Protocol: CVP / RVP

Task: Task 1 / Task 2

Scale	Weight (from Pairwise Comparisons Sheet)	Raw Rating (from NASA Task Load Index Sheet)	Adjusted Rating (Weight x Raw)
Mental Demand			
Physical Demand			
Temporal Demand			
Performance			
Effort			
Frustration			
		Total of Adjusted Ratings:	
		OVERALL WORKLOAD Weighted Ratings (Total of Adjusted Ratings/15)	

b) NASA TLX Documents in Thai: **คำอธิบายระดับการให้คะแนน**

หัวข้อ	**ระดับ**	**คำอธิบาย**
ความต้องการทางจิตใจ (MENTAL DEMAND)	ต่ำ/สูง	ท่านคิดว่าระดับการใช้การรับรู้ทางความคิดและจิตใจอยู่ในดับใด (เช่น การคิด, การตัดสินใจ, การคิดคำนวณ, การจดจำ, การค้นหา ฯลฯ) งานที่ปฏิบัติเป็นงานที่ง่าย หรือมีความซับซ้อน ต้องการใช้สมาธิ หรือต้องการที่จะหยุดกระทำ
ความต้องการทางกายภาพ (PHYSICAL DEMAND)	ต่ำ/สูง	ท่านคิดว่าระดับความต้องการทางกายภาพอยู่ในระดับใด (เช่น การออกแรง หรือการควบคุม ฯลฯ) ลักษณะงานที่ปฏิบัติเป็นงานที่มีความง่าย หรือยาก, ช้า หรือเร็ว, ไม่ต้องออกแรงหรือต้องออกแรงมาก หรือเป็นงานที่ผ่อนคลาย
ความต้องการชั่วขณะ (TEMPORAL DEMAND)	ต่ำ/สูง	ท่านคิดว่าระดับความกดดันในเรื่องของระยะเวลาในการปฏิบัติงาน สามารถทำได้อย่างค่อยเป็นค่อยไป สบายๆ หรือมีความเร่งรีบในการทำ
ประสิทธิภาพ (PERFORMANCE)	ดี/แย่	ท่านคิดว่าระดับความประสบผลสำเร็จตามเป้าหมายที่ตั้งไว้ รวมไปถึงความพึงพอใจในประสิทธิภาพการปฏิบัติงานของท่านตรงตามเป้าหมายที่ตั้งไว้อยู่ในระดับใด
ความพยายาม (EFFORT)	ต่ำ/สูง	ท่านคิดว่าระดับความยากของงานที่ท่านต้องใช้ความพยายามในการบรรลุตามระดับประสิทธิภาพของท่าน (กำลังกายและกำลังใจ) อยู่ในระดับใด
ความขัดแย้ง (FRUSTRATION)	ต่ำ/สูง	ท่านคิดว่าระดับความไม่ปลอดภัย ความเครียด ความย่อท้อ และความรำคาญ เมื่อเทียบกับความปลอดภัย ความผ่อนคลาย ความพึงพอใจระหว่างการปฏิบัติงานของท่านอยู่ในระดับใด

หัวข้อไหนสำคัญในการปฏิบัติงานของท่าน (พิจารณาเป็นรายคู่)

ความพยายาม หรือ ประสิทธิภาพ	ความต้องการชั่วขณะ หรือ ความขัดแย้ง	ความขัดแย้ง หรือ ความพยายาม	ประสิทธิภาพ หรือ ความต้องการทางจิตใจ
ความต้องการชั่วขณะ หรือ ความพยายาม	ความต้องการทางกายภาพ หรือ ความขัดแย้ง	ประสิทธิภาพ หรือ ความต้องการชั่วขณะ	ความต้องการทางจิตใจ หรือ ความพยายาม
ประสิทธิภาพ หรือ ความขัดแย้ง	ความต้องการทางกายภาพ หรือ ความต้องการชั่วขณะ	ความต้องการทางจิตใจ หรือ ความต้องการทางกายภาพ	ความพยายาม หรือ ความต้องการทางกายภาพ
ความต้องการทางกายภาพ หรือ ประสิทธิภาพ	ความต้องการชั่วขณะ หรือ ความต้องการทางจิตใจ	ความขัดแย้ง หรือ ความต้องการทางจิตใจ	

ระดับการให้คะแนนของการประเมินการปฏิบัติงาน

หมายเลขของผู้เข้าร่วมวิจัย: ____________________ **เว็บไซต์:** ____________________

เทคนิค: การคิดออกเสียงขณะปฏิบัติงาน (CVP) / การคิดออกเสียงภายหลังปฏิบัติงาน (RVP)

ความต้องการทางจิตใจ **ระดับทางจิตใจเป็นอย่างไรตอนปฏิบัติงาน**

ต่ำที่สุด **สูงที่สุด**

ความต้องการทางกายภาพ **ระดับทางกายภาพเป็นอย่างไรตอนปฏิบัติงาน**

ต่ำที่สุด **สูงที่สุด**

ความต้องการเกี่ยวกับชั่วขณะ **ระดับความเร่งรีบอย่างไรตอนปฏิบัติงาน**

ต่ำที่สุด **สูงที่สุด**

ประสิทธิภาพ **ระดับความสำเร็จในการปฏิบัติงานของท่านบรรลุผลสำเร็จตามที่ได้รับ**

ดีที่สุด **แย่ที่สุด**

ความพยายาม **ระดับความยากของการปฏิบัติงานเพื่อให้บรรลุผลสำเร็จ**

น้อยที่สุด **มากที่สุด**

ความขัดแย้ง **ระดับความตึงเครียด ความไม่สบายตอนปฏิบัติงาน**

น้อยที่สุด **มากที่สุด**

การคำนวณการประเมินการปฏิบัติงานของ NASA TLX

หมายเลขของผู้เข้าร่วมวิจัย: ___________________________________

เว็บไซต์: ___________________________________

เทคนิค: การคิดออกเสียงขณะปฏิบัติงาน / การคิดออกเสียงภายหลังปฏิบัติงาน

งาน: งาน 1 / งาน 2

การวัด	**น้ำหนัก** **(จากการเปรียบเทียบเป็นรายคู่)**	**คะแนนดิบ** **(จากการให้ประเมินการปฏิบัติงาน)**	**การคำนวณ** **(น้ำหนัก x คะแนนดิบ)**
ความต้องการทางจิตใจ (Mental Demand)			
ความต้องการทางกายภาพ (Physical Demand)			
ความต้องการชั่วขณะ (Temporal Demand)			
ประสิทธิภาพ (Performance)			
ความพยายาม (Effort)			
ความขัดแย้ง (Frustration)			
		คะแนนรวม:	
		คะแนนประเมินโดยรวม แบบถ่วงน้ำหนัก (คะแนนรวม/15)	

Appendix G: Post-study debriefs for the study of usability and acceptability of tablet computer

a) Post-study debrief in English

Thank you for helping me with this study. In this study I was interested in two things

(1) whether tablet computers present particular problems for older users that we should be publicizing to developers of programs for tablets for older users (and also what older people think about tablets, as a lot of people are promoting them as a good computer for older people, but without much real evidence)

and

(2) whether concurrent think aloud or retrospective think aloud is better at finding problems about programmes on tablets and which people find easier to do, particularly older people

That's why we asked you to do tasks with both think aloud methods and measured how hard it was for you with the rather complicated NASA measure.

Would you like a short report about the results of this study – we can send that to you in a couple of months.

Do you have any questions?

Could you please complete Part B of the informed consent form for me?

Thank you very much for your participation.

b) Post-study debrief in Thai

ขอบคุณสำหรับการเข้าร่วมการวิจัยในครั้งนี้ ในการศึกษาการวิจัยครั้งนี้ผู้วิจัยสนใจอยู่สองอย่างคือ

(1) นำเสนอถึงปัญหาของการใช้งานคอมพิวเตอร์แท็บเล็ต โดยเฉพาะอย่างยิ่งสำหรับผู้สูงอายุ เพื่อเผยแพร่ให้กับผู้พัฒนาโปรแกรมบนคอมพิวเตอร์แท็บเล็ตสำหรับผู้สูงอายุ (และยังนำเสนอเกี่ยวกับความคิดของผู้สูงอายุที่ต่อคอมพิวเตอร์แท็บเล็ต เนื่องจากคนส่วนใหญ่คิดว่าการใช้คอมพิวเตอร์แท็บเล็ตนั้นดีและเหมาะสมสำหรับผู้สูงอายุ แต่ไม่มีหลักฐานที่ใช้อ้างอิงได้ว่าเหมาะสมจริง)

และ

(2) การใช้เทคนิคการคิดออกเสียงขณะปฏิบัติงาน และการคิดออกเสียงภายหลังปฏิบัติงาน ซึ่งแบบไหนจะใช้ในการหาปัญหาเกี่ยวกับโปรแกรมบนคอมพิวเตอร์แท็บเล็ตได้ดีกว่า และแบบไหนที่ผู้สูงอายุจะปฏิบัติได้ง่ายกว่า

ดังนั้น ผู้วิจัยจึงให้ท่านทำงานบนคอมพิวเตอร์แท็บเล็ต โดยใช้ทั้งสองเทคนิคการคิดออกเสียง และวัดว่าเทคนิคไหนยากสำหรับท่านโดยใช้วิธีของ NASA

ท่านต้องการสรุปผลการทดลองหรือไม่ ผู้วิจัยสามารถส่งไปให้ท่านได้ ภายหลังจากการเสร็จสิ้นการทดลองนี้ โดยประมาณสองถึงสามเดือนค่ะ

ท่านมีคำถามหรือข้อสงสัยจะถามหรือไม่

ขอความกรุณาท่านช่วยเซ็นลายมือชื่อในหนังสือเจตนายินยอมเข้าร่วมการวิจัย ในส่วนที่ 2 ด้วยค่ะ

ขอขอบคุณอย่างมากสำหรับการเข้าร่วมการวิจัยในครั้งนี้

Appendix H: Post-Study Interview Questions for the study of usability and acceptability of tablet computer

a) Post-Study Interview Questions in English

A. Reviewing CVP and RVP

1. Just reviewing the two ways of doing the tasks on the websites (CVP and RVP), which technique was easier to mention your thoughts about what you were doing and any problems you were encountering with the task and the website?

2. Which technique of think aloud (CVP or RVP) did you find easier overall? [prompt: Could you give reasons why?]

3. Were there any particular problems with the websites that you want to highlight?

4. Were there any particular issues with using the tablet computer that you want to highlight?

5. How did you find doing the NASA TLX?

B. Use of and Attitudes towards tablet computers

In the Pre-Study Questionnaire, you said that you have used tablets before.

If participant has used tablets before, continue with these questions, otherwise go to Question 16

6. Yes, what brand your tablet have you used?

7. Do you still use it?

8. What do/did you use the tablet for? (prompts: reading, watching, sending emails, and so on)

9. Do/did you find read on the tablets easy? Why/why not?

10. Do/did you find using the controls on the tablet easy to use?

11. Have you encountered the “picker” / “spinner” on a tablet (demonstrate for them)?

12. If yes to 11, do you find it easy? Would you prefer something else?

13. If you used a PC before the tablet, did you find it confusing to transfer?

14. Do you think tablets are a good choice for older users? (easy to use, useful, light to hold, versatile and so on)

15. Would you recommend a tablet to a friend of your age who has not used a computer before as their first purchase?

The tablet in this study

16. How did you find using the tablet in this study?

17. Was it easy to use the controls (prompts: buttons, scrolling)?

18. Was it easy to read the text?

For those who have not used tablets only

19. Is there any particular reason why you haven’t tried a tablet?

20. After today’s experience are you tempted? Why/why not?

b) Post-Study Interview Questions in Thai

A. การทบทวนของเทคนิคการคิดออกเสียงขณะปฏิบัติงานและภายหลังปฏิบัติงาน

1. ระหว่างเทคนิคการคิดออกเสียงขณะปฏิบัติงาน และการคิดออกเสียงขณะภายหลังปฏิบัติงาน เทคนิคไหนง่ายต่อการคิดของท่านเกี่ยวกับปัญหาที่ท่านพบตอนปฏิบัติงานบนเว็บไซต์

2. โดยภาพรวมเทคนิคการคิดออกเสียงขณะปฏิบัติงาน และการคิดออกเสียงขณะภายหลั ปฏิบัติงาน เทคนิคไหนง่ายกว่ากัน

3. ท่านต้องการที่จะเน้นถึงปัญหาเกี่ยวกับการใช้งานเว็บไซต์หรือไม่

4. ท่านต้องการที่จะเน้นถึงปัญหาสำหรับการใช้งานคอมพิวเตอร์แท็บเล็ตหรือไม่

5. ท่านรู้สึกอย่างไรในการทำแบบสอบถามของ NASA TLX

B. การใช้และทัศนคติที่มีต่อคอมพิวเตอร์แท็บเล็ต

ในแบบสอบถามก่อนการวิจัย ท่านพูดว่าท่านเคยใช้คอมพิวเตอร์แท็บเล็ตมาก่อน

ถ้าผู้เข้าร่วมวิจัยเคยใช้คอมพิวเตอร์แท็บเล็ตมาก่อน ให้ถามคำถามตั้งแต่ข้อที่ 6 แต่ถ้าผู้เข้าร่วมวิจัยไม่เคยใช้คอมพิวเตอร์แท็บเล็ตมาก่อน ให้ถามคำถามตั้งแต่ข้อที่ 16

6. ถ้าผู้เข้าร่วมวิจัยตอบ. “ใช่” ท่านเคยใช้แท็บเล็ตของยี่ห้ออะไร

7. แล้วท่านยังใช้แท็บเล็ตนั้นอยู่หรือไม่

8. ท่านใช้แท็บเล็ตเพื่ออะไร (ตัวอย่าง: อ่านหนังสือ, ดูละคร, ส่งอีเมล ฯลฯ)

9. ท่านว่าการอ่านหนังสือหรืออ่านข้อความบนแท็บเล็ตง่ายหรือไม่ ทำไมง่าย/ทำไมไม่ง่าย

10. ท่านคิดว่าการใช้งานแท็บเล็ตง่ายหรือไม่

11. ท่านเคยเลื่อน หรือเลือกวัตถุ บนแท็บเล็ตหรือไม่

12. ถ้าผู้เข้าร่วมวิจัยตอบว่าเคยในข้อ 11 ท่านคิดว่ามันง่ายหรือไม่ ท่านเคยมีประสบการณ์อย่างอื่นหรือไม่

13. ถ้าท่านเคยใช้คอมพิวเตอร์ตั้งโต๊ะมาก่อนแท็บเล็ต ท่านคิดว่าจะทำให้ท่านสับสนในการใช้แท็บเล็ตหรือไม่

14. ท่านคิดว่าแท็บเล็ตเป็นอุปกรณ์ที่ดีสำหรับผู้สูงอายุหรือไม่ (ง่ายต่อการใช้, มีประโยชน์, เบาต่อการถือ, อเนกประสงค์ ฯลฯ)

15. ท่านต้องการที่จะแนะนำคนที่อายุรุ่นเดียวกับท่านที่ไม่เคยใช้คอมพิวเตอร์มาก่อนให้ใช้แท็บเล็ตหรือไม่

เกี่ยวกับแท็บเล็ตที่ใช้ในการวิจัยครั้งนี้

16. ท่านคิดว่าการใช้แท็บเล็ตในการวิจัยครั้งงนี้เป็นอย่างไร

17. การควบคุมใช้งานแท็บเล็ตง่ายหรือไม่ (ตัวอย่าง: ปุ่มต่างๆ, การเลื่อนขึ้นเลื่อนลง)

18. การอ่านข้อความบนแท็บเล็ตนี้ง่ายหรือไม่

สำหรับผู้เข้าร่วมที่ไม่เคยใช้แท็บเล็ตมาก่อน

19. ทำไมท่านถึงไม่ลองใช้แท็บเล็ต

20. หลังจากเสร็จสิ้นการวิจัยครั้งนี้ ท่านคิดว่าจะจูงใจให้ท่านใช้แท็บเล็ตหรือไม่ ทำไม/ทำไมไม่

Appendix I : Categorisation of usability problems encountered during the tasks

Major category	Specific problems	CVP		RVP	
		The UK (problems)	Thailand (problems)	The UK (problems)	Thailand (problems)
Physical presentation	The button was too small (H)	2	-	-	-
	The text on the menu bar was too small (W2, T)	-	1	-	4
	Text on the label was too small (T, W2)	-	2	-	1
	Text on the web was too small (H, W2, T)	-	4	1	4
	Text box was too small for typing into (H)	-	-	1	-
	Icons were too small (W, T)	-	-	-	2
	Could not see the whole information of the webpage when zooming in (H, T, W)	2	2	1	2

Major category	Specific problems	CVP		RVP	
		The UK (problems)	Thailand (problems)	The UK (problems)	Thailand (problems)
Physical presentation	Size of the tablet was too small which made it easy to make an error (W1)	-	-	1	-
	Colour of tab which was chosen from a menu was not sufficiently different in colour from the other tabs (H, T)	-	-	1	1
	Colour of stars rating on product did not contrast sufficiently with the background. One of participant said that should be red. (W2)	-	-	-	2
	Text and Background colours did not contrast well enough (T)	-	1	-	-
	Submenu should have different colour from main menu (W2)	-	-	-	1

Major category	Specific problems	CVP		RVP	
		The UK (problems)	Thailand (problems)	The UK (problems)	Thailand (problems)
Content	The photo of the product was not clear enough (W2)	-	-	-	2
	Webpage did not show information clearly (H, W2)	-	-	1	-
	Meaning of some words that on the web were not clear and did not make sense (T)	-	1	-	2
Information architecture:	Not clear what category from the menu to search in for a particular product (W2)	-	2	-	3
Interactivity:	Unclear how to recover from errors when the website is highly interactive (H)	-	-	1	-
	I did not know that the website was loading (W1, H)	1	-	1	-

Major category	Specific problems	CVP		RVP	
		The UK (problems)	Thailand (problems)	The UK (problems)	Thailand (problems)
Interactivity:	The page had two areas which scrolled separately, this was confusing in itself and unclear how to scroll each area (H)	1	-	-	-
	I had to fill in all information again when I pressed back button in the browser (H)	-	-	1	-
	It was not clear how to use a control for ranking the price of the hotel (H)	-	-	2	-
	Symbols which represent to passengers were not clear (T)	-	-	-	2
	It was not clear where I should tap on (the label, picture, some text or check box) (T, W2)	-	5	-	2

Major category	Specific problems	CVP		RVP	
		The UK (problems)	Thailand (problems)	The UK (problems)	Thailand (problems)
Interactivity:	Search button for the flight search did not look like a button (T)	-	-	-	1
	The initial or previous text in the textbox did not clear when a new search was initiated (H, T)	1	2	-	2
	The total price of the hotel was not given, and I had to calculate by myself (T)	-	-	-	1
	It was not clear how to use the calendar (H, T)	1	1	-	1
	The sign for non-stop flight was not clear (H)	-	-	1	-
	The button did not work when tapped (H, T)	1	1	-	1
	The calendar on the web was not responsive when tapped (H)	1	-	1	-

Major category	Specific problems	CVP		RVP	
		The UK (problems)	Thailand (problems)	The UK (problems)	Thailand (problems)
Interactivity:	Interaction was “weird” and not responsive when tapping on the textbox (H)	1	-	-	-
	The tablet was too responsive, easy to activate things without meaning (H, T, W)	-	1	2	3
	Confused as to how to move the cursor (H, T)	-	-	1	1

Note: H is Hipmunk.com; W1 is Walgreens.com; W2 is Watson.co.th; T is Traveloka.com

Appendix J : Counterbalancing of font types and font sizes

Order/ Participant No.	**1**	**2**	**3**	**4**	**5**	**6**
Participants 1	Serif 14 point	Serif 16 point	Serif 18 point	Sans serif 14 point	Sans serif 16 point	Sans serif 18 point
Participants 2	Sans serif 18 point	Serif 14 point	Serif 16 point	Serif 18 point	Sans serif 14 point	Sans serif 16 point
Participants 3	Sans serif 16 point	Sans serif 18 point	Serif 14 point	Serif 16 point	Serif 18 point	Sans serif 14 point
Participants 4	Sans serif 14 point	Sans serif 16 point	Sans serif 18 point	Serif 14 point	Serif 16 point	Serif 18 point
Participants 5	Serif 18 point	Sans serif 14 point	Sans serif 16 point	Sans serif 18 point	Serif 14 point	Serif 16 point
Participants 6	Serif 16 point	Serif 18 point	Sans serif 14 point	Sans serif 16 point	Sans serif 18 point	Serif 14 point

Appendix K : Pre-study brief for the study of the effect of text presentation on reading text on tablet computer

a) Pre-study brief in English

Thank you for your interest in this study.

Before starting the study, I will just tell you a bit about it. There will be several parts: a short questionnaire, then the main part of the study, doing short tasks of reading texts on a website. After that answering around four multiple choices questions per text. These will be easy tasks, and we are definitely not "testing" you in any way, I am interested in what is easy for reading on the web and what is tricky.

The session will take about one hour and you will be offered with a £25 (older participants) / £15 (younger participants) gift voucher for your participation.

Do you have any questions?

After questions, get them to sign the informed consent form.

b) Pre-study brief in Thai

ขอบคุณสำหรับความสนใจในการศึกษานี้ของท่าน

ก่อนที่จะเริ่มการศึกษา ผู้วิจัยจะบอกถึงภาพรวมในการศึกษาครั้งนี้ สำหรับในกาศึกษานี้จะมีแบบสอบถามสั้น ๆ จากนั้น จะเป็นการศึกษาหลักคือ การอ่านข้อความบนเว็บไซต์ หลังจากนั้นจะเป็นการตอบคำถามเกี่ยวกับบทความนั้น ๆ โดยการศึกษาทั้งหมดนี้จะไม่ได้เป็นการทดสอบตัวท่านไม่ว่าจะทางด้านใดก็ตาม ผู้วิจัยเพียงสนใจในการอ่านบนเว็บไซต์ว่ามีความยากง่ายหรือมีความยุ่งยากต่อผู้อ่านหรือไม่

การศึกษานี้จะใช้เวลาโดยประมาณ 1 ชั่วโมง และท่านจะได้รับบัตรกำนัลจำนวน 500 บาท (ผู้สูงอายุ) /100 (นิสิต / นักศึกษา) บาทสำหรับการเข้าร่วมในการศึกษานี้

ท่านมีคำถามหรือไม่

หลังจากคำถาม ให้ผู้เข้าร่วมลงลายมือชื่อในแบบฟอร์มการยินยอมการเข้าร่วมวิจัย

Appendix L : Informed consent form for the study of the effect of text presentations on reading text on tablet computers

a) Informed consent in English

Informed Consent Form

Thank you for participating in this study. This study is investigating the experience that people in using tablet computers and this study is part of my PhD research programme at University of York. At the beginning of the session you will be asked to complete a short questionnaire about your use of the web and tablet computers and demographic information. Then, you will be asked to undertake a series of short tasks of reading texts about articles of animals and places on tablet computer. After that answer questions from texts. Finally, when all of the tasks are complete, you will be completed a questionnaire about how you feel about reading on tablet computers. Please feel free to ask questions about the study at any point. If you are uncomfortable at any point, please let us know and we will stop the study. This does not affect your right to receive a gift voucher for the study.

If you have any questions after the study, please send a message to Maneerut at mc1363@york.ac.uk and Professor Helen Petrie (her PhD supervisor) at helen.petrie@york.ac.uk.

All your information will be completely confidential and anonymous. Only Maneerut and Helen will see your detailed information. Information from the study will only be made public in an aggregated way, so that individuals cannot be identified.

Before participating in this study, please complete section A. Once study is completed and you have been debriefed, you will be asked to initial the three statements in Section B, to indicate your agreement.

Section A

I, ________________________, voluntarily give my consent to participate in this study. I agree to perform the tasks on the web and answer questions about my experience of the web and tablet computers. I have been informed about and feel that I understand the basic nature and propose of this study. I understand that there are no known risks to participation in the study and that I may withdraw at any time during the study without prejudice. I understand that I will be compensated in the amount of £25 per hour regardless of whether I am able to complete the study or not.

I understand that all data gathered will be treated completely confidentially. I also understand that my data will only be available in its original from to Maneerut Chatrangsan and her research supervisor Professor Helen Petrie. I understand that I will not be identified when the data is shared described or interpreted.

____________________________ ______________

Signature of Research Participant Date

Section B

Please initial each of the following statements when the study has been completed and you have been debriefed.

I have been adequately debriefed. signature: ______________

I was not forced to complete the study. signature: ______________

All my questions have been answered. signature: ______________

b) Informed consent in Thai

หนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัย (Informed Consent Form)

ขอบคุณท่านที่เข้าร่วมในการศึกษาครั้งนี้ การวิจัยนี้มุ่งสำรวจประสบการณ์และปัญหาในการใช้งานคอมพิวเตอร์แท็บเล็ตของผู้ใช้งาน และในการศึกษาครั้งนี้เป็นส่วนหนึ่งในการศึกษาระดับปริญญาเอก มหาวิทยาลัยยอร์ค ประเทศอังกฤษ เมื่อเริ่มต้นการวิจัย ท่านจะถูกขอให้ตอบแบบสอบถามสั้น ๆ เกี่ยวกับการใช้งานเว็บไซต์ การใช้งานแท็บเล็ตคอมพิวเตอร์ และข้อมูลส่วนบุคคล จากนั้นท่านจะถูกขอให้อ่านบทความสั้นๆ เกี่ยวกับสัตว์ และสถานที่ต่างๆ บนเว็บไซต์ผ่านแท็บเล็ตคอมพิวเตอร์ หลังจากท่านอ่านแต่ละบทความเสร็จ ท่านจะต้องตอบคำถามเกี่ยวกับบทความนั้น ๆ ในตอนสุดท้ายท่านจะถูกถามเกี่ยวกับความรู้สึกในการอ่านบทความ และจากนั้นท่านสามารถสอบถามรายละเอียดที่ท่านต้องการทราบเกี่ยวกับงานวิจัยในครั้งนี้ และถ้าท่านรู้สึกไม่สบายใจและต้องการหยุดเข้าร่วมในการศึกษาครั้งนี้ ท่านสามารถแจ้งกับผู้วิจัยได้ทันที โดยจะท่านยังจะได้รับบัตรกำนัลสำหรับการเข้าร่วมในการศึกษานี้

ถ้าท่านมีคำถามก่อนหรือหลังการเข้าร่วมการวิจัย ท่านสามารถถามคำถามได้โดยส่งอีเมลมาที่ นางสาวมณีรัตน์ ชาติรังสรรค์ (mc1363@york.ac.uk) และศาสตราจารย์เฮเลน เพทรี (Professor Helen Petrie) ที่ helen.petrie@york.ac.uk

ข้อมูลทั้งหมดของท่านจะเป็นความลับ โดยจะมีแค่นางสาวมณีรัตน์ ชาติรังสรรค์ และอาจารย์ที่ปรึกษา ศาสตราจารย์เฮเลน เพทรี (Professor Helen Petrie) เท่านั้นที่จะเข้าถึงข้อมูลของท่านโดยละเอียดสำหรับในการวิจัยครั้งนี้ ข้อมูลโดยรวมจะถูกเผยแพร่ต่อสาธารณชน และจะไม่สามารถระบุตัวตนของผู้เข้าร่วมการวิจัยครั้งนี้

ก่อนเริ่มการศึกษา ขอความกรุณาท่านกรอกข้อมูลและลงลายมือชื่อในหนังสือแสดงการยินยอมในการเข้าร่วมการวิจัยในส่วนที่ 1 หลังจากการศึกษานี้เสร็จสิ้น ท่านจะทราบเกี่ยวกับวัตถุประสงค์ของการศึกษาในครั้งนี้ และหลังจากการวิจัยในการครั้งนี้เสร็จสิ้น ขอความกรุณาท่านลงลายมือชื่อรับรองในส่วนที่ 2 เพื่อตอบรับตามข้อตกลงที่ได้แจ้งท่านไว้ว่าเป็นความจริง

ส่วนที่ 1

ข้าพเจ้า____ ขอแสดงความยินยอมอย่างสมัครใจในการเข้าร่วมการศึกษาครั้งนี้ ฉันตกลงที่จะปฏิบัติงานบนเว็บไซต์ และตอบคำถามเกี่ยวกับประสบการณ์การใช้เว็บไซต์และคอมพิวเตอร์แท็บเล็ต ข้าพเจ้าได้รับทราบและเข้าใจรายละเอียดเบื้องต้นและวัตถุประสงค์ของการวิจัยในครั้งนี้ ข้าพเจ้าเข้าใจว่าไม่มีความเสี่ยงใด ๆ แก่ข้าพเจ้าในการวิจัยครั้ง และสามารถถอนตัวจากการวิจัยได้ตลอดเวลาโดยไม่ต้องคืนค่าตอบแทนที่ได้ตกลงกันไว้ โดยข้าพเจ้าทราบว่าจะได้รับค่าตอบแทนเป็นบัตรกำนัลจำนวน 500 บาท และข้าพเจ้ารับทราบว่าข้อมูลทั้งหมดจะเป็นความลับ

ข้าพเจ้าเข้าใจดีว่าข้อมูลทั้งหมดของข้าพเจ้าจะถูกเก็บรักษาเป็นความลับ มีเพียงนางสาวมณีรัตน์ ชาติรังสรรค์ และอาจารย์ที่ปรึกษา ศาสตราจารย์เฮเลน เพทรี (Professor Helen Petrie) เท่านั้นที่จะเข้าถึงข้อมูลของข้าพเจ้าในงานวิจัยนี้ และทราบว่าในการเผยแพร่ข้อมูล รวมไปถึงการตีความจะไม่มีการระบุตัวตนของข้าพเจ้า

__________________________________ ____________________

ลายมือชื่อผู้เข้าร่วมการวิจัย วัน เดือน ปี

ส่วนที่ 2

กรุณารับรองว่าท่านได้ถูกปฏิบัติตามข้อความด้านล่างนี้ เมื่อเสร็จสิ้นการวิจัยและได้รับฟังจุดประสงค์หรือรายละเอียดของการวิจัยในครั้งนี้

ข้าพเจ้าได้รับทราบรายละเอียดการวิจัยอย่างเพียงพอและเหมาะสม ลายมือชื่อ_______________

ข้าพเจ้าไม่ได้ถูกบังคับให้ทำการวิจัยในครั้งนี้ ลายมือชื่อ_______________

คำถามของข้าพเจ้าทุกคำถามได้ถูกตอบ ลายมือชื่อ_______________

Appendix M: Initial questionnaire for the study of the effect of text presentations on reading text on tablet computers

a) Initial questionnaire in English

Initial Questionnaire

This study is being conducted by Maneerut Chatrangsan, a PhD student in Human Computer Interaction (HCI) Research Group, Department of Computer Science, University of York. The aim of the study is to investigate how best to present text for people on tablet computers.

This initial questionnaire consists of 3 parts (4 pages):

Part 1: Questions on your use of the web

Part 2: Questions on your use of tablet computers

Part 3: Questions about you

It should take about 10 minutes to complete.

Part1 use of the web

1. Approximately how long have you been you been using the web?
   ________________ years
2. How did you learn to use the web (tick as many as are appropriate)?
   - ❑ taught myself
   - ❑ from family members
   - ❑ from friends
   - ❑ from colleagues at work
   - ❑ From reading a guide
   - ❑ I took a course (if so, where________________________________)
3. Approximately how often do you use the web in a typical week?
   ________________ hours

4. How do you access the web (tick as many as are appropriate)?

❑ Desktop computer ❑ Laptop computers ❑ Mobile phone

❑ Tablet computer ❑ Others___________________________

5. How device do you use the most for accessing to the web (tick as many as are appropriate)?

   ❑ Desktop computer ❑ Laptop computers ❑ Mobile phone

   ❑ Tablet computer ❑ Others___________________________

6. How would you rate your level of **experience** of using web (circle one of the crosses)?

   None at all Extensive

   + -------- + -------- + -------- + -------- + -------- + -------- +

7. How would you rate your level of **expertise** in using the web (circle one of the crosses)?

   None at all Extensive

   + -------- + -------- + -------- + -------- + -------- + -------- +

If you have used a tablet computer, please answer the questions in Part 2, otherwise go to Part3

Part 2 use of the tablet computers

1. Approximately how long have you been using the tablets?

   _________ months _________ years

2. How did you learn to use the tablet (tick more than one)?

   ❑ Taught myself ❑ From family members ❑ From friends

   ❑ From colleagues at work ❑ From reading a guide

   ❑ I took a course (if so, where______________________________)

3. Approximately how often do you use the tablet in a typical week?

   ________________ hours

4. What do you usually use a tablet computer for? (Reading, Watching, Sending an email and so on)

   ____

5. How would you rate your level of **experience** of using tablet (circle one of the crosses)?

   None at all Extensive

   + -------- + -------- + -------- + -------- + -------- + -------- +

6. How would you rate your level of **expertise** in using the tablet (circle one of the crosses)?

None at all Extensive

\+ -------- + -------- + -------- + -------- + -------- + -------- +

Part 3 About you

Please answer the following general questions about yourself (this information is only for statistical purposes, and is confidential and anonymous)

1. Age: ___________ years
2. Gender: ❑ Male ❑ Female
3. What is your current employment status?
   ❑ Working ❑ Not working or Retired

If you are working, what is your job: ____

4. Do you have problems to read on screens?
   ❑ Yes, because____
   ❑ No
5. Do you usually wear or use optical equipment for your reading? (For example: glasses)
   ❑ Yes, What the equipment? ____
   ❑ No
6. Do you wear or use optical equipment for your reading in this experiment?
   ❑ Yes, What the equipment? ____
   ❑ No

Thank you for taking the time to complete these questions

b) Initial questionnaire in Thai

แบบสอบถามก่อนการทดลอง

แบบสอบถามนี้เป็นส่วนหนึ่งของการศึกษาของ นางสาวมณีรัตน์ ชาติรังสรรค์ นักศึกษาปริญญาเอก กลุ่มวิจัยด้านปฏิสัมพันธ์ระหว่างมนุษย์และคอมพิวเตอร์ คณะวิทยาศาสตร์คอมพิวเตอร์ มหาวิทยาลัยยอร์ค สหราชอาณาจักร โดยมีวัตถุประสงค์เพื่อการศึกษาในการแสดงผลข้อความบนแท็บเล็ตคอมพิวเตอร์

แบบสอบถามนี้มีทั้งหมด 3 ส่วน (3 หน้า)

ส่วนที่ 1 คำถามเกี่ยวกับการใช้เว็บ

ส่วนที่ 2 คำถามเกี่ยวกับการใช้แท็บเล็ต

ส่วนที่ 3 คำถามเกี่ยวกับข้อมูลส่วนบุคคล

การทำแบบสอบถามนี้จะใช้เวลาโดยประมาณ 10 นาที

ส่วนที่ 1 การใช้งานเว็บไซต์ของท่าน

1. ท่านเข้าใช้งานเว็บไซต์มาโดยประมาณนานเท่าไร
   ________________ ปี
2. ท่านเรียนรู้การใช้งานเว็บไซต์ด้วยวิธีใด (เลือกได้มากกว่าหนึ่งข้อ)
   - ❑ ด้วยตัวท่านเอง
   - ❑ จากคนในครอบครัว
   - ❑ จากเพื่อน
   - ❑ จากเพื่อนร่วมงาน
   - ❑ จากการอ่านคู่มือหรือคำแนะนำ
   - ❑ ลงเรียนหรืออบรมคอร์สระยะสั้น (ถ้าลงเรียน ท่านลงเรียนที่ไหน ______________________)
3. ท่านเข้าใช้งานเว็บไซต์โดยประมาณเป็นระยะเวลาเท่าใดใน 1 สัปดาห์

   ________________ ชั่วโมง
4. ท่านเข้าใช้งานเว็บไซต์ด้วยอุปกรณ์ใด (เลือกได้มากกว่าหนึ่งข้อ)
   - ❑ คอมพิวเตอร์แบบตั้งโต๊ะ
   - ❑ คอมพิวเตอร์แบบพกพา
   - ❑ โทรศัพท์มือถือ
   - ❑ คอมพิวเตอร์แท็บเล็ต
   - ❑ อื่น ๆ______________________________

5. ท่านคิดว่าประสบการณ์การเข้าใช้งานเว็บไซต์ของท่านอยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)

ไม่มีประสบการณ์เลย มีประสบการณ์อย่างกว้างขวาง

+ ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

6. ท่านคิดว่าตัวท่านมีความเชี่ยวชาญในการใช้งานเว็บไซต์อยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)

ไม่มีความเชี่ยวชาญเลย มีความเชี่ยวชาญอย่างมาก

+ ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

ถ้าท่านเคยใช้คอมพิวเตอร์แท็บเล็ต กรุณาตอบคำถามในส่วนที่ 2 แต่สำหรับท่านที่ไม่เคยใช้คอมพิวเตอร์แท็บเล็ต กรุณาข้ามคำถามในส่วนที่ 2 ไป โดยไปตอบคำถามในส่วนที่ 3

ส่วนที่ 2 การใช้คอมพิวเตอร์แท็บเล็ตของท่าน

1. ท่านใช้งานคอมพิวเตอร์แท็บเล็ตมาโดยประมาณนานเท่าไร

_________ เดือน _________ ปี

2. ท่านเรียนรู้การใช้งานคอมพิวเตอร์แท็บเล็ตด้วยวิธีใด (เลือกได้มากกว่าหนึ่งข้อ)

❑ ด้วยตัวท่านเอง ❑ จากคนในครอบครัว ❑ จากเพื่อน

❑ จากเพื่อนร่วมงาน ❑ จากการอ่านคู่มือหรือคำแนะนำ

❑ ลงเรียนหรืออบรม (ถ้าลงเรียน ลงเรียนที่ไหน ________________________________)

3. ท่านใช้งานคอมพิวเตอร์แท็บเล็ตโดยประมาณเป็นระยะเวลาเท่าใดใน 1 สัปดาห์

________________ ชั่วโมง

4. ท่านคิดว่าประสบการณ์ในการใช้คอมพิวเตอร์แท็บเล็ตของท่านอยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)

ไม่มีประสบการณ์เลย มีประสบการณ์อย่างกว้างขวาง

+ ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

5. ท่านคิดว่าตัวท่านมีความเชี่ยวชาญในการใช้งานคอมพิวเตอร์แท็บเล็ตอยู่ในระดับใด (กรุณาวงกลมที่เครื่องหมาย +)

ไม่มีความเชี่ยวชาญเลย มีความเชี่ยวชาญอย่างมาก

+ ---------- + ---------- + ---------- + ---------- + ---------- + --------- +

ส่วนที่ 3 เกี่ยวกับตัวท่าน

กรุณาตอบคำถามเกี่ยวกับข้อมูลส่วนตัวของท่าน (ข้อมูลนี้ใช้ในการวิเคราะห์ทางสถิติเท่านั้น และข้อมูลนี้จะถูกเก็บเป็นความลับและไม่มีการเปิดเผยตัวตนของท่าน)

1. อายุ: ________ ปี

2. เพศ: ❑ ชาย ❑ หญิง

3. ปัจจุบันท่าน

   ❑ ทำงาน ❑ ไม่ทำงาน หรือเกษียณอายุ

ถ้าท่านทำงาน ท่านทำอาชีพอะไร ____

4. ท่านมีปัญหาในการอ่านบนจอคอมพิวเตอร์หรือแท็บเล็ตหรือไม่

   ❑ มี เพราะ____

   ❑ ไม่มี

5. ท่านมีปัญหาในการมองเห็นสีเมื่ออ่านหนังสือหรือไม่ (ตาบอดสี)

   ❑ มี เพราะ____

   ❑ ไม่มี

6. โดยปกติท่านใส่อุปกรณ์ช่วยในการมองเห็นหรือไม่ (เช่น แว่นตา, แว่นขยาย ฯลฯ)

   ❑ ใส่อุปกรณ์ช่วยในการมองเห็น อุปกรณ์ที่ท่านใส่คืออะไร____________________

   ❑ ไม่ใส่อุปกรณ์ช่วยในการมองเห็น

7. ท่านมีการใส่หรือใช้อุปกรณ์ช่วยในการมองเห็นหรือการอ่านในการวิจัยครั้งนี้หรือไม่

   ❑ ใส่อุปกรณ์ช่วยในการมองเห็น อุปกรณ์ที่ท่านใส่คืออะไร_____________________

   ❑ ไม่ใส่อุปกรณ์ช่วยในการมองเห็น

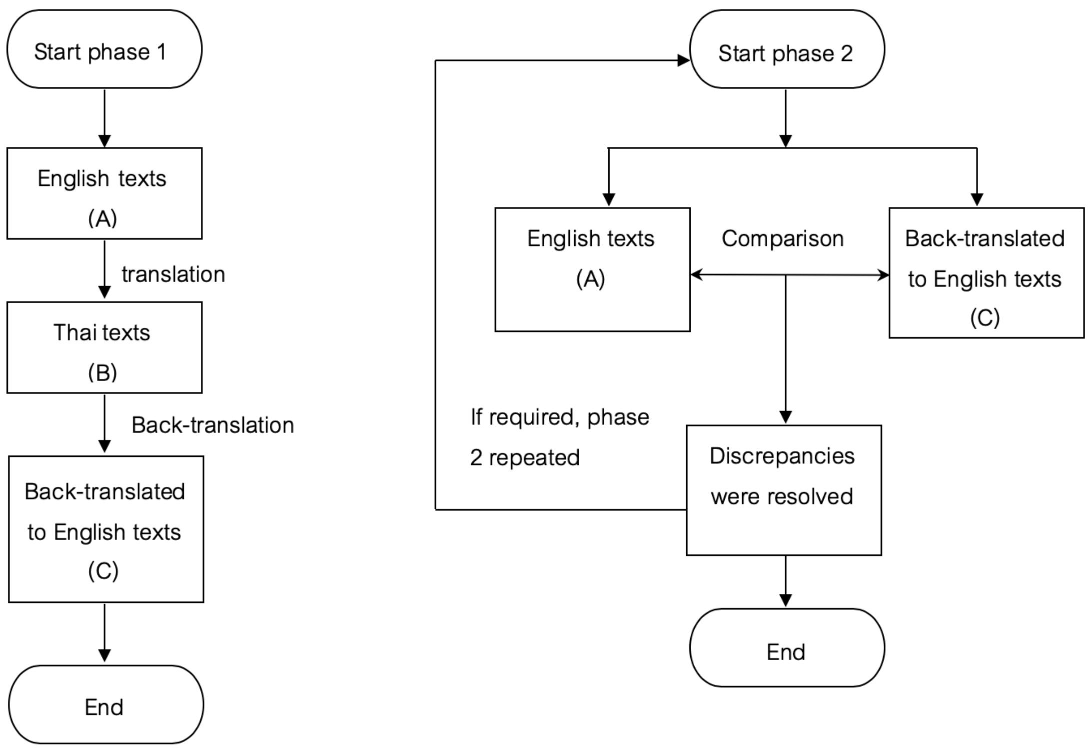
ขอขอบคุณท่านที่สละเวลาในการตอบคำถาม

Appendix N : Procedure of translation for Thai texts

There were two phase of procedure translation for Thai texts. Each phase shows as below:

Phase 1: The researcher translated English texts (A) to Thai text (B) and another native Thai speaker (who studied in English language and linguistic department in the UK) translated the Thai texts back into English texts (C).

Phase 2: My supervisor will do the comparison the original English texts (A) with the back-translated texts (English texts: C), then the problems were resolved. If the problems are major, phase 2 was required to repeat.



Appendix O: The example of texts and multiple-choice questions for study 2 to 4

a) The seven texts and multiple-choice questions in English for study 2

1) Text 1: Durian (practice text was used for study 2 to 4)

The durian is the fruit of several different tree species. The name durian is derived from the Malay word for "spike", a reference to the numerous spikes or thorns on the fruit. There are 30 recognised species of durian, at least nine of which produce edible fruit. The durian is native to Southeast Asia. It has been known to the Western world for about 600 years. The nineteenth century British naturalist Alfred Wallace described its flesh as a rich custard highly flavoured with almonds.

The durian is regarded by many people in Southeast Asia as the "king of fruits". The fruit is distinctive for its large size, very strong odour, and formidable thorn covered skin. The fruit can grow as large as 12 inches long and 6 inches in diameter and typically weighs two to seven pounds. The shape ranges from oblong to round and the colour of its husk from green to brown. The flesh pale yellow to red, depending on the species.

Some people regard the durian as having a pleasantly sweet fragrance. Others find the aroma overpowering with an unpleasant odour. The smell evokes reactions from deep appreciation to intense disgust. It has been described variously as rotten onions, turpentine, and raw sewage. The persistence of the odour, which may linger for several days, has led to the fruit's banishment from certain hotels and public transportation in Southeast Asia.

Questions

1. What is durian known as?

- ○ the thorny fruit
- ○ King of fruits
- ○ Queen of fruits
- ○ the custard fruits

2. Which statement about durian is correct?

- ○ Every species of durian can produce edible fruit
- ○ Durian has been known to the Western world for about 100 years
- ○ British naturalist Alfred Wallace described its flesh as a rich custard
- ○ Durian typically weigh seven to nine pounds

3. Due to its persistent odour, durian are banned:

- ○ at certain hotels and on public transportation in Southeast Asia
- ○ on all public transportation in Southeast Asia
- ○ at hospitals and on public transportation in Southeast Asia
- ○ from being eaten in public in Southeast Asia

2) Text 2: Emperor penguin

The emperor penguin is the tallest and heaviest of all surviving penguin species. It is native to Antarctica. The male and female are similar in plumage and size. They reach 48 inches in height and weighing from 49 to 99 pounds. The back and head are black and sharply delineated from the white belly, pale-yellow breast and bright-yellow ear patches. Like all penguins it is flightless. It has a streamlined body, and wings stiffened and flattened into flippers for a marine habitat.

The emperor penguin's diet consists primarily of fish, but can also include crustacea and squid. In hunting, the penguin can remain submerged up to 18 minutes, diving to a depth of over 1,500 feet. The penguin has several adaptations to facilitate this amazing diving ability. These include unusually structured blood to allow it to function at low oxygen levels, solid bones to resist the pressure. It also has the ability to reduce its metabolism and shut down non-essential organ functions.

The emperor is the only penguin species that breeds during the Antarctic winter, the penguins trek 30 to 75 miles over the ice to breeding colonies which may include thousands of individuals. The female penguin lays a single egg. This is cared for by the male penguin while the female returns to the sea to feed. Parents subsequently take turns foraging at sea and caring for their chick in the colony.

Question

1. The emperor penguin is...

- ○ the shortest and heaviest of all surviving penguin species
- ○ the tallest and heaviest of all surviving penguin species
- ○ the shortest and lightest of all surviving penguin species
- ○ the tallest and lightest of all surviving penguin species

2. How long can the emperor penguin dive when hunting?

- ○ up to 16 minutes
- ○ up to 18 minutes
- ○ up to 20 minutes
- ○ up to 22 minutes

3. Which statement is NOT a reason why the emperor penguin can dive to deep levels: ...?

- ○ they have unusually structured blood to allow them to function at low oxygen levels
- ○ their organs are resistant to high pressure
- ○ they have solid bones to resist the water pressure
- ○ they have the ability to reduce their metabolism

3) Text 3: Dates

Dates have been a staple food in the Middle East for thousands of years. There is archaeological evidence of their cultivation in eastern Arabia as early as 5530 BC. The ancient Egyptians used them to make date wine and ate them at harvest. In later times, traders spread dates around South West Asia, northern Africa, and Spain and the Spaniards introduced dates to Mexico and California in 1765. Dates are an important traditional crop in Iraq, Arabia, and North Africa. Dates are also mentioned more than fifty times in the Bible and twenty times in the Koran.

Date palms can take up to eight years after planting before they bear fruit. Dates are naturally wind pollinated, but in both tradition oasis horticulture and in modern commercial orchards they are pollinated entirely manually. They produce enough fruit for commercial harvest when they are seven to ten years old. Mature date palms can produce 150 to 300 pounds of dates per harvest. To produce fruit of marketable quality, the bunches of dates must be thinned and covered with mesh before ripening.

Dry dates are eaten in their natural state, or can be pitted and stuffed. Pitted dates are also called stoned dates. Partially dried pitted dates glazed with glucose syrup are delicious as a snack food. When Muslims break their fast in the evening meal during Ramadan, it is traditional to eat a date first.

Question

1. In which country did people first use dates for making wine?

- ○ Iraq
- ○ Spain
- ○ Egypt
- ○ Mexico

2. How many pounds of dates can a mature date palm produce?

- ○ 100 to 150 minutes
- ○ 150 to 300 minutes
- ○ 300 to 350 minutes
- ○ 350 to 450 minutes

3. How many times are dates mentioned in the Bible?

○ More than twenty times
○ More than thirty times
○ More than forty times
○ More than fifty times

4) Text 4: Tower of Pisa

The Leaning Tower of Pisa is the bell tower of the cathedral of the Italian city of Pisa. It is famous worldwide for its obvious tilt. The tower is situated behind Pisa Cathedral. It is the third oldest structure in the city's Cathedral Square, after the cathedral and baptistry.

The tower began to tilt during its construction in the 12th century. There were inadequate foundations to support the tower's weight. In addition, the ground was too soft on one side to properly support the structure's weight. The tilt increased before the structure was completed in the 14th century. It gradually increased until the structure was stabilized, by restoration in the late 20th and early 21st centuries. For many years, the tower leaned at an angle of 5.5 degrees. But since restoration work performed between 1990 and 2001, it now leans at about four degrees. This means the top of the tower is nearly four metres askew from the centre of the base.

Galileo is said to have dropped two cannonballs from the tower to show that their speed of descent. However, this is probably a myth. During World War II, the Allies suspected that the Germans were using the tower as an observation post. An American sergeant sent to confirm this was so impressed by the beauty the tower, that he failed to report any Germans in order to spare its destruction.

Questions

1. Where is Tower of Pisa located?

○ Beside the Pisa Baptistery
○ Beside the Pisa Cathedral
○ Behind the Pisa Baptistery
○ Behind the Pisa Cathedral

2. What saved the Tower during World War?

○ Because an American sergeant was so impressed by its beauty
○ Because there were no Germans in the observation post
○ Because the bomber missed the target
○ Because two cannonballs protected the structure

3. The tower now leans at an angle of...

- ○ about three degrees
- ○ about 3.5 degrees
- ○ about four degrees
- ○ about 5.5 degrees

5) Text 5: Meerkat

The meerkat is a small carnivorous animal of the mongoose family. Meerkats are native to Africa. They are found in the Kalahari Desert in Botswana, in much of the desert in Namibia and southwestern Angola, and in South Africa. A group of meerkats has many names, including a mob, gang or clan. A meerkat clan usually contains approximately twenty meerkats, but some clans have fifty or more members. In captivity, meerkats have an average life span of twelve to fourteen years, and only about half this in the wild.

The name probably has a Dutch origin, but is the result of several poor translations. The word meerkat is Dutch for lake cat, but the meerkat is not part of the cat family. The word possibly started as a Dutch adaptation of the Sanskrit word markata meaning ape perhaps via an Indian sailor on board a Dutch trading ship.

At the end of each of a meerkat's fingers is a claw used for digging burrows. Meerkats have four toes on each foot and long slender limbs. Their coat is usually peppered grey, tan, or brown with silver. They have short parallel stripes across their backs, extending from the base of the tail to the shoulders. The patterns of stripes are unique to each meerkat. But their belly usually has a patch which is only sparsely covered with hair and shows the black skin underneath.

Questions

1. Which word does not refer to a group of Meerkats?

- ○ Mob
- ○ Gang
- ○ Crowd
- ○ Clan

2. What is the origin of the word meerkat?

- ○ Poor translation of the Sanskrit word for ape
- ○ Meerkats typically live be lakes
- ○ Dutch sailors thought they were cats
- ○ Indians thought they were merely small cats

3. In captivity, meerkats have an average lifespan of...

- ○ five to eight years

○ eight to twelve years
○ twelve to twenty years
○ twelve to fourteen years

6) Text 6: Niagara Falls

Niagara Falls is the overall name for three waterfalls that straddle the border between Canada and the United States. More specifically, they are located between the province of Ontario and the state of New York. They form the southern end of the Niagara Gorge. The falls are located on the Niagara River, which drains Lake Erie into Lake Ontario. They have the highest flow rate of any waterfall in the world that has a vertical drop greater than 50 metres.

The largest falls is the Horseshoe Falls. The second largest is the American Falls. The smallest is the Bridal Veil Falls. The Horseshoe Falls lies on the border of the United States and Canada. The American Falls lies entirely on the American side. The Bridal Veil Falls are also on the American side, separated from the other falls by Luna Island. The international boundary line was originally drawn through Horseshoe Falls in 1819, but the boundary has long been disputed between the two countries due to natural erosion and construction.

Niagara Falls was formed when glaciers receded at the end of the last ice age. Then water from the newly formed Great Lakes carved a path through the Niagara escarpment on its way to the Atlantic Ocean. While not very high, Niagara Falls is very wide. Niagara Falls is famed both for its beauty and as a valuable source of hydroelectric power.

Questions

1. Which waterfall is NOT part of Niagara falls?

○ The Bridal Veil Falls
○ The Canada Falls
○ The American Falls
○ The Horseshoe Falls

2. The Niagara falls were formed in the last ice age when...

○ water from the newly formed Great Lakes carved a path through Lake Erie
○ water from the newly formed lake Ontario carved a path through the Niagara escarpment
○ water from the newly formed Great Lakes carved a path through the Niagara escarpment
○ water from the newly formed Niagara River carved a path through the Ontario escarpment

3. Niagara Falls has the highest flow...

○ of any waterfall in the world that has a horizontal width less than 50 metres
○ of any waterfall in the world that has a vertical drop less than 50 metres

- ○ of any waterfall in the world that has a horizontal width greater than 50 metres
- ○ of any waterfall in the world that has a vertical drop greater than 50 metres

7) Text 7: Flamingos

Flamingos are a particular type of wading bird. There are four flamingo species in the Americas. There are a further two species in other parts of the world, particularly Africa and India. Flamingos usually stand on one leg while the other leg is tucked beneath their body. The reason for this behaviour is not fully understood.

One theory is that standing on one leg allows the birds to conserve more body heat. This may be because they spend a significant amount of time wading in cold water. However, the behaviour also takes place in warm water and is also observed in birds that do not typically stand in water. An alternative theory is that standing on one leg reduces the energy expenditure for producing muscular effort to stand and balance on one leg. As well as standing in the water, flamingos may stamp their webbed feet in the mud to stir up food from the bottom.

Young flamingos hatch with greyish to reddish plumage. However adult birds range in colour from light pink to bright red depending on their food supply. A well-fed, healthy flamingo is more vibrantly coloured and thus a more desirable mate. Whereas a white or pale flamingo is usually unhealthy or malnourished. Captive flamingos are a notable exception. They may turn a pale pink if they are not fed carotene at levels comparable to the wild.

Questions

1. Where are flamingos found?

- ○ Only in the Americas
- ○ Only in Africa and India
- ○ In the Americas, and other parts of the world, particularly Africa and India
- ○ In the Americas and other parts of the world, particularly India

2. It is not fully understood why flamingos usually stand on only one leg, but which is definitely NOT a reason?

- ○ Standing on one leg reduces energy expenditure
- ○ It allows flamingos to conserve more heat in their bodies
- ○ It allows flamingos to spend time standing in cold water
- ○ Their webbed feet allow them to stand easily on one leg

3. Young flamingos are what range of colour when they hatch?

- ○ White or pale but become pink as they age
- ○ Greyish to reddish
- ○ Light pink to bright red

○ Vibrantly coloured which fades as they age

b) The seven texts and multiple-choice questions in Thai for study 2

1) Text 1: **ทุเรียน** (Durian)

ทุเรียนเป็นผลไม้ที่มีหลายสายพันธุ์ คำว่าทุเรียน มาจากคำว่า “หนาม” ของภาษามลายู โดยดูจากทุเรียนมีหนามมากมายบนผล ทุเรียนมี 30 สายพันธุ์ มีอย่างน้อยเก้าสายพันธุ์ที่รับประทานได้ ทุเรียนมีถิ่นกำเนิดในเอเชียตะวันออกเฉียงใต้ เป็นที่รู้จักดีในโลกตะวันตกประมาณ 600 ปี ในคริสต์ศตวรรษที่สิบเก้า นักธรรมชาติวิทยาชาวอังกฤษ อัลเฟรด รัสเซล วอลเลซ ได้พรรณนาถึงทุเรียนว่า "เนื้อเหมือนคัสตาร์ด รสชาติคล้ายอัลมอนด์"

ทุเรียนถือได้ว่าหลายคนในเอเชียตะวันออกเฉียงใต้ยกให้เป็น "ราชาแห่งผลไม้" ผลไม้มีลักษณะเด่นคือมีขนาดใหญ่ กลิ่นแรง และมีหนามแข็งปกคลุมทั่วเปลือก ผลของมันยาวได้ถึง 12 นิ้วและมีเส้นผ่านศูนย์กลาง 6 นิ้ว โดยทั่วไปมีน้ำหนักสองถึงเจ็ดปอนด์ รูปร่างมีลักษณะเป็นวงรี และเปลือกมีสีเขียวถึงสีน้ำตาล เนื้อในมีสีเหลืองอ่อนถึงแดง แตกต่างกันไปตามสายพันธุ์

บางคนถือว่าทุเรียนมีกลิ่มหอมหวาน แต่บางส่วนบอกว่ามีกลิ่นเหม็นรุนแรงจนถึงขั้นสะอิดสะเอียน และยังได้รับการอธิบายถึงกลิ่นของทุเรียนไปต่าง ๆ ตั้งแต่ หัวหอมเน่า น้ำมันสน และน้ำเน่า หลังจากนั้นทำให้มีการห้ามนำทุเรียนเข้ามาในโรงแรมและการขนส่งสาธารณะในเอเชียตะวันออกเฉียงใต้

คำถาม

1. ทุเรียน รู้จักในนาม

○ ผลไม้ที่มีหนาม

○ ราชาแห่งผลไม้

○ ราชินีแห่งผลไม้

○ ผลไม้คัสตาด

2. ประโยคไหนถูกต้องที่สุดสำหรับทุเรียน

○ ทุเรียนทุกสายพันธุ์สามารถรับประทานได้หมด

○ โลกตะวันตกรู้จักทุเรียนประมาณ 100 ปี

○ อัลเฟรด วอลเลซ นักธรรมชาติวิทยาชาวอังกฤษ พรรณาว่าทุเรียนเป็นคัสตาร์ด

○ โดยปกติ ทุเรียนจะมีน้ำหนักอยู่ที่เจ็ดถึงเก้าปอนด์

3. เนื่องจากกลิ่นของทุเรียนเป็นกลิ่นเหม็นรุนแรง มันจะถูกห้าม...

○ นำเข้าที่โรงแรมและการขนส่งสาธารณะในเอเชียตะวันออกเฉียงใต้

○ นำเข้าการขนส่งสาธารณะทั้งหมดในเอเชียตะวันออกเฉียงใต้

○ นำเข้าที่โรงพยาบาลและการขนส่งสาธารณะในเอเชียตะวันออกเฉียงใต้

○ นำมากินในที่สาธารณะในเอเชียตะวันออกเฉียงใต้

2) Text 2: **เพนกวินจักรพรรดิ** (Emperor penguin)

เพนกวินจักรพรรดิ เป็นเพนกวินที่สูงและขนาดใหญ่ที่สุดในบรรดาชนิดอื่น มีถิ่นฐานอยู่ในทวีปแอนตาร์กติกา ตัวผู้และตัวเมียมีสีขนและขนาดใกล้เคียงกัน สูง 48 นิ้ว หนัก 49-99 ปอนด์ ส่วนหลังและหัวมีสีดำตัดกับขนด้านหน้าตรงบริเวณท้องที่มีสีขาว อกตอนบนสีเหลืองอ่อน บริเวณหูเป็นสีเหลืองเข้ม ไม่สามารถบินได้เหมือนกับเพนกวินชนิดอื่น มีรูปร่างเพรียวและปีกที่ลู่ตามตัว แข็งแบนเหมือนครีบเหมาะกับการเป็นสัตว์น้ำ

อาหารส่วนใหญ่เป็นปลา รวมทั้งสัตว์จำพวกกุ้ง และปลาหมึก ในการหาอาหาร เพนกวินสามารถอยู่ใต้น้ำได้นาน 18 นาที ดำน้ำได้ลึก 1,500 ฟุต เนื่องจากมีลักษณะหลายอย่างช่วยในการอยู่ใต้น้ำได้นาน รวมทั้งโครงสร้างของฮีโมโกลบินที่ทำให้อยู่ได้ในบรรยากาศที่มีระดับออกซิเจนต่ำ โครงสร้างกระดูกที่แน่นที่ช่วยต้านทานความดันในน้ำ และความสามารถในการลดการเผาผลาญของร่างกายและหยุดการทำงานของอวัยวะที่ไม่จำเป็นได้

เพนกวินจักรพรรดิเป็นชนิดเดียวที่ผสมพันธุ์ในฤดูหนาวของแอนตาร์กติก มันสามารถเดินทางราว 30 ถึง 75 ไมล์ จากชายฝั่งไปยังบริเวณที่ทำการผสมพันธุ์ ซึ่งมีเพนกวินอาศัยอยู่ด้วยกันเป็นพันๆ ตัว ตัวเมียจะออกไข่ฟองเดียว ทิ้งไว้ให้ตัวผู้ดูแล ขณะตัวเมียกลับไปหาอาหารในทะเล เมื่อกลับมาพวกมันก็จะสลับกันเลี้ยงลูกและออกไปหาอาหาร

คำถาม

1. เพนกวินจักรพรรดิ…...

○ เตี้ยและหนักที่สุดในบรรดาเพนกวินชนิดอื่น ๆ
○ สูงและหนักที่สุดในบรรดาเพนกวินชนิดอื่น ๆ
○ เตี้ยและเบาที่สุดในบรรดาเพนกวินชนิดอื่น ๆ
○ สูงและเบาที่สุดในบรรดาเพนกวินชนิดอื่น ๆ

2. เพนกวินจักรพรรดิสามารถดำน้ำในการล่าอาหารได้นานเท่าไร

○ นานกว่า 16 นาที
○ นานกว่า18 นาที
○ นานกว่า 20 นาที
○ นานกว่า 22 นาที

3. ประโยคไหนไม่ใช่เหตุผลว่าทำไมเพนกวินจักรพรรดิสามารถดำน้ำได้ลึก...

○ พวกมันมีโครงสร้างของเลือดที่สามารถทำงานได้ที่ระดับออกซิเจนต่ำ
○ อวัยวะของมันทนต่อแรงดันสูงได้
○ พวกมันมีกระดูกที่แข็งแรงที่ทนต่อแรงดันน้ำได้
○ พวกมันมีความสามารถในการลดการเผาผลาญของพวกมันได้

3) Text 3: **อินทผลัม** (Dates)

อินทผลัม เป็นอาหารหลักในตะวันออกกลางเป็นเวลาหลายปี มีหลักฐานทางโบราณคดีเกี่ยวกับการเพาะปลูกอินทผลัมในแถบตะวันออกของอาระเบียประมาณ 5530 ปีก่อนคริสตกาล ชาวอียิปต์โบราณใช้มันทำไวน์อินทผลัม และใช้ทานช่วงฤดูเก็บเกี่ยว ต่อมาการค้าขายอินทผลัมได้แพร่ไปยังเอเชียตะวันออก

เชียงใต้ แอฟริกาเหนือ และสเปน ชาวสเปนได้นำเข้าอินทผลัมไปยังเม็กซิโก และแคลิฟอร์เนีย ในปี ค.ศ. 1765 อินทผลัมได้ถูกกล่าวถึงในคัมภีร์ไบเบิลมากกกว่าห้าสิบครั้ง และยี่สิบครั้งในคัมภีร์อัลกุรอาน

อินทผลัมต้องใช้เวลาถึงแปดปีถึงจะออกผลได้ การผสมเกสรของมันจะผสมโดยอาศัยลมตามธรรมชาติ แต่ในทางพืชสวน และสวนผลไม้ในเชิงพาณิชย์สมัยใหม่จะเป็นการผสมเกสรด้วยชาวสวนเอง ต้นอินทผลัมจะสามารถผลิตผลอินทผลัมได้มากเพียงพอเมื่อมีอายุเจ็ดถึงสิบปี โดยสามารถเก็บเกี่ยวผลผลิตได้ 150 ถึง 300 ปอนด์ต่อวัน การได้อินทผลัมที่มีคุณภาพ ช่อต้องบางและห่อด้วยตาข่ายก่อนมันจะสุก

อินทผลัมแห้งสามารถรับประทานได้ทั้งผล หรือจะคว้านเมล็ดออก และนำมายัดไส้ทานก็ได้ อินทผลัมที่ถูกคว้านเมล็ดออก สามารถเรียกอีกอย่างหนึ่งได้ว่า อินทผลัมแข็ง อินทผลัมที่ถูกคว้านเมล็ดออกจะถูกนำมาเคลือบด้วยน้ำเชื่อมและสามารถนำมาเป็นอาหารหวานที่อร่อยได้ และเป็นถูกนำมาเป็นอาหารมื้อแรกของวันของชาวมุสลิมในช่วงระหว่างการถือศีลอด ซึ่งถือเป็นธรรมเนียมดั้งเดิม

คำถาม

1. ประเทศไหนที่คนนำอินทผลัมมาใช้ในการทำไวน์ครั้งแรก

○ อิรัก

○ สเปน

○ อียิปต์

○ เม็กซิโก

2. ต้นอินทผลัมที่โตเต็มที่แล้วสามารถผลิตอินทผลัมได้ประมาณเท่าไร

○ 100 ถึง 150 ปอนด์

○ 150 ถึง 300 ปอนด์

○ 300 ถึง 350 ปอนด์

○ 350 ถึง 450 ปอนด์

3. ประโยคไหนไม่ใช่เหตุผลว่าทำไมเพนกวินจักรพรรดิสามารถดำน้ำได้ลึก...

○ พวกมันมีโครงสร้างของเลือดที่สามารถทำงานได้ที่ระดับออกซิเจนต่ำ

○ อวัยวะของมันทนต่อแรงดันสูงได้

○ พวกมันมีกระดูกที่แข็งแรงที่ทนต่อแรงดันน้ำได้

○ พวกมันมีความสามารถในการลดการเผาผลาญของพวกมันได้

4) Text 4: **หอเอนเมืองปิซา** (Tower of Pisa)

หอเอนเมืองปิซา เป็นหอระฆังของมหาวิหารแห่งเมืองปิซาของประเทศอิตาลี เป็นที่รู้จักทั่วโลกในเรื่องความเอียงที่ชัดเจน หอคอยตั้งอยู่ด้านหลังของมหาวิหารปิซา เป็นโครงสร้างที่เก่าแก่ที่สุดในอันดับสามรองจากมหาวิหารปิซาและหอล้างบาป

หอคอยเริ่มเอียงในระหว่างการก่อสร้างในศตวรรษที่ 12 เพราะฐานของหอคอยไม่เพียงพอที่จะรองรับน้ำหนักของตัวหอคอย นอกจากนี้ยังมีปัญหาของพื้นดินที่อ่อนเกินไปในด้านใดด้านหนึ่งเพื่อจะมารองรับน้ำหนักของโครงสร้างอย่างถูกต้อง การเอียงเพิ่มขึ้นก่อนหอคอยจะสร้างเสร็จในศตวรรษที่ 14 ตัวหอคอยค่อยๆ เริ่มเอียงเรื่อยๆ จนกระทั่งคงที่ในช่วงซ่อมแซมตอนปลายศตวรรษที่ 20 และต้นต้นศตวรรษที่ 21

หอคอยมีการเอนตัว 5.5 องศาเป็นเวลาหลายปี แต่เนื่องจากการบูรณะในระหว่างปี 1990 ถึง 2001 ทำให้หอคอยเอนตัวประมาณสี่องศา ซึ่งหมายความว่าด้านบนของหอคอยมีความสูงประมาณสี่เมตรจากฐานตรงกลาง

กาลิเลโอได้กล่าวไว้ว่าการทิ้งลูกกระสุนปืนใหญ่ 2 ลูก จากหอคอยจะแสดงความเร็วของการตกถึงพื้นของวัตถุ อย่างไรก็ตามเรื่องนี้เป็นตำนาน ในช่วงสงครามโลกครั้งที่ 2 ฝ่ายพัทธมิตรสงสัยว่าชาวเยอรมันกำลังใช้หอคอยเป็นที่สังเกตการณ์ ทางสหรัฐอเมริกาจึงส่งทหารมายืนยันเรื่องนี้ แต่เกิดความประทับใจในความสวยงามของหอคอย จึงรายงานว่าไม่พบชาวเยอรมันในหอคอย เพื่อที่ต้องการจะรักษาหอคอยนี้ไว้

คำถาม

1. หอคอยปิซาตั้งอยู่ที่ไหน

◯ ข้างหอล้างบาป

◯ ข้างมหาวิหารปิซา

◯ ข้างหลังหอล้างบาป

◯ ข้างหลังมหาวิหารปิซา

2. อะไรที่ทำให้หอคอยไม่ถูกทำลายในช่วงสงครามโลกครั้งที่ 2

◯ เพราะว่าทหารอเมริการู้สึกประทับใจในความสวยของหอคอย

◯ เพราะว่าไม่มีชาวเยอรมันเข้ามาสังเกตุการณ์

◯ เพราะว่าเครื่องบินทิ้งระเบิดพลาดเป้าหมาย

◯ เพราะว่าลูกกระสุนปืนขนาดใหญ่สามารถป้องกันหอคอยได้

3. ขณะนี้หอเอนเมืองปิซามีความเอียงอยู่...

◯ ประมาณสามองศา

◯ ประมาณ 3.5 องศา

◯ ประมาณสี่องศา

◯ ประมาณ 5.5 องศา

5) Text 5: **เมียร์แคท** (Meerkat)

เมียร์แคทเป็นสัตว์กินเนื้อขนาดเล็กในตระกูลพังพอน มีต้นกำเนิดมาจากแอฟริกา พวกมันถูกพบที่ทะเลทรายคาลาฮารีในบอตสวานา จะพบมากที่ทะเลทรายในนามีเบียและทางตะวันตกเฉียงใต้ของแองโกลา และแอฟริกาใต้ กลุ่มของเมียร์แคทมีชื่อเรียกมากมาย ได้แก่ ฝูง แก๊ง และชนเผ่า ปกติชนเผ่าของเมียร์แคทจะมีสมาชิกประมาณ 20 ตัว แต่เมียร์แคทบางฝูงจะมีสมาชิก 50 หรือมากกว่านั้น สำหรับเมียร์แคทที่ถูกกักขังจะมีอายุขัยเฉลี่ย 12-14 ปี และกลุ่มที่อาศัยอยู่ในป่าจะมีอายุขัยเพียงครึ่งหนึ่งของที่เลี้ยง

ชื่อของมันมาจากภาษาดัตช์ แต่เป็นผลมาจากการแปลที่ไม่ดี คำว่าเมียร์แคทในภาษาดัตช์แปลว่าแมวทะเลสาบ แต่ไม่ได้เป็นสัตว์ตระกูลแมว เป็นไปได้ว่าคำนี้ถูกดัดแปลงมาจากภาษาสันสกฤต ซึ่งมีความหมายว่าลิง โดยผ่านกะลาสีเรืออินเดียที่มาทำการค้าขายกับชาวดัตช์

ปลายนิ้วของเมียร์แคทจะมีกรงเล็บเพื่อใช้ขุดโพรง แต่ละเท้าของมันจะมีสี่นิ้ว และมีขาที่เรียวยาว เมียร์แคทมีขนสั้นสีน้ำตาลอมเทา สีแทน หรือน้ำตาลเหลือบเงิน มีขนเป็นแนวเส้นขนานพาดข้ามหลัง แผ่ออกจากหาง

ไปยังไหล่ รูปแบบของแนวเส้นขนมีลักษณะเฉพาะในแต่ละตัว แต่ช่วงท้องของพวกมันมีขนปกคลุมเล็กน้อยและมันมีผิวสีดำ

คำถาม

1. คำใดไม่ได้หมายถึงกลุ่มของเมียร์แคท

◯ ฝูง

◯ แก๊ง

◯ ฝูงชน

◯ ชนเผ่า

2. ต้นกำเนิดของคำว่า เมียร์แคท มาจากอะไร

◯ จากการแปลจากภาษาสันสกฤตแบบไม่ค่อยดีที่หมายถึงลิง

◯ จากการที่เมียร์แคทอาศัยในทะเลสาบ

◯ จากชาวประมงชาวดัตช์คิดว่าพวกมันเป็นแมว

◯ จากชาวอินเดียที่คิดว่าพวกมันเป็นแมวตัวเล็กๆ

3. เมียร์แคทที่ถูกกักขัง จะมีอายุขัยโดยเฉลี่ย...

◯ ห้าถึงแปดปี

◯ แปดถึงสิบสองปี

◯ สิบสองถึงยี่สิบปี

◯ สิบสองถึงสี่สิบปี

6) Text 6: **น้ำตกไนแอการา** (Niagara Fall)

น้ำตกไนแอการาเป็นชื่อของน้ำตกสามแห่งที่ตั้งอยู่บนพรหมแดนระหว่างแคนาดาและสหรัฐอเมริกา มากไปกว่านั้น น้ำตกเหล่านั้นอยู่ระหว่างเมืองออนแทรีโอและนิวยอร์ก ซึ่งก่อตัวจากทางตอนใต้สุด ของหุบเขาไนแอการา โดยตั้งอยู่บนแม่น้ำไนแองการา ซึ่งไหลมาจากทะเลสาบอีรีลงสู่ทะเลสาบออนแทรีโอ ไนแองการาเป็นน้ำตกที่มีอัตราการไหลของน้ำสูงที่สุดในโลก โดยมีความสูงมากกว่า 50 เมตร

น้ำตกใหญ่ที่สุดในสามน้ำตกคือ น้ำตกเกือกม้า น้ำตกใหญ่เป็นอับดับสองคือ น้ำตกอเมริกา และน้ำตกเล็กสุดคือ น้ำตกไบรดัลเวล โดยน้ำตกเกือกม้าตั้งอยู่บนพรหมแดนระหว่างสหรัฐอเมริกาและแคนาดา น้ำตกอเมริกาตั้งอยู่ฝั่งอเมริกา และน้ำตกไบรดัลเวลตั้งอยู่ฝั่งอเมริกาด้วยเช่นกันซึ่งถูกแยกออกจากน้ำตกอื่นๆ โดยเกาะลูนา เส้นแบ่งเขตแดนระหว่างประเทศถูกลากผ่านน้ำตกเกือกม้าในปี ค.ศ.1819 อย่างไรก็ตามเขตแดนนี้มีการโต้เถียงระหว่างสองประเทศนี้มานาน เนื่องจากการพังทลายของธรรมชาติ

น้ำตกไนแอการาถูกสร้างขึ้นเมื่อธารน้ำแข็งหายไปเมื่อสิ้นสุดยุคน้ำแข็ง จากนั้นมีทะลสาบเกรตเลกส์ที่ตั้งขึ้นใหม่ ตัดผ่านที่ลาดชันไนแอการาระหว่างทางไปมหาสมุทรแอตแลกติก แม้ว่าน้ำตกไนแอการาไม่สูงมากนักแต่ก็กว้างมาก และเป็นที่เลื่องลือทั้งความสวยงามและเป็นแหล่งพลังงานน้ำที่ทรงพลัง

คำถาม

1. น้ำตกใดไม่ได้เป็นส่วนหนึ่งของน้ำตกไนแอการา

◯ น้ำตกไบดัลเวล

◯ น้ำตกแคนาดา

◯ น้ำตกอเมริกา

◯ น้ำตกเกือกม้า

2. น้ำตกไนแอการาเกิดขึ้นในยุคน้ำแข็งเมื่อ...

◯ น้ำจากน้ำตกเกรตเลกส์ที่เพิ่งเกิดใหม่ ตัดผ่านทะเลสาบอีรี

◯ น้ำจากทะเลสาบออนแทรีโอที่เพิ่งเกิดขึ้นใหม่ ตัดผ่านที่ลาดชัดไนแอการา

◯ น้ำจากทะเลสาบเกรตเลกส์ที่เพิ่งเกิดขึ้นใหม่ ตัดผ่านที่ลาดชันไนแอการา

◯ น้ำจากแม่น้ำไนแอการาที่เพิ่งเกิดขึ้นใหม่ ตัดผ่านที่ลาดชันออนแทรีโอ

3. น้ำไนแอการามีการไหลของน้ำสูงสุด...

◯ ของน้ำตกใดๆ ในโลก ซึ่งมีความกว้างน้อยกว่า 50 เมตร

◯ ของน้ำตกใดๆ ในโลก ซึ่งมีการไหลสูงน้อยกว่า 50 เมตร

◯ ของน้ำตกใดๆ ในโลก ซึ่งมีความกว้างมากกว่า 50 เมตร

◯ ของน้ำตกใดๆ ในโลก ซึ่งมีการไหลสูงมากกว่า 50 เมตร

7) Text 7: **ฟลามิงโก** (Flamingo)

ฟลามิงโกเป็นนกน้ำชนิดหนึ่ง มีสี่ชนิดในทวีปอเมริกา อีกสองชนิดในแอฟริกาและอินเดียและที่อื่นๆ ฟลามิงโกมีพฤติกรรมยืนด้วยขาเดียว และอีกขาหนึ่งพับไว้ที่ใต้ตัวของมัน โดยยังไม่มีเหตุผลที่มารองรับได้อย่างชัดเจนสำหรับพฤติกรรมนี้

แต่มีทฤษฎีหนึ่งกล่าวว่า การยืนขาเดียวจะช่วยให้รักษาความอบอุ่นให้กับร่างกายได้มากขึ้น นั่นอาจทำให้ฟลามิงโกยืนขาเดียวในน้ำเย็นเป็นเวลานานๆ อย่างไรก็ตามพฤติกรรมนี้ยังพบได้ในฟลามิงโกที่ยืนในน้ำอุ่นด้วย หรือที่ไม่ได้ยืนในน้ำด้วยเช่นกัน อีกทฤษฎีหนึ่งกล่าวว่าการยืนขาเดียวของฟลามิงโกจะช่วยลดการใช้พลังงานในการสร้างกล้ามเนื้อ และปรับสมดุล และฟลามิงโกยังสามารถใช้เท้าของมันเขี่ยอาหารจากใต้น้ำ

ลูกฟลามิงโกที่เพิ่งเกิดจะมีขนสีเทาไปจนถึงสีแดงเรื่อๆ แต่เมื่อฟลามิงโกโตเต็มที่จะมีสีชมพูอ่อนจนถึงสีแดงเข้ม ทั้งนี้เป็นเพราะการกินอาหาร ฟลามิงโกที่มีสุขภาพดีและมีสีสันสดใส จะเป็นที่ต้องการมากขึ้น ฟลามิงโกที่ไม่แข็งแรงหรือขาดสารอาหารจะมีสีขาวหรือสีอ่อน แต่ไม่จริงเสมอไปกับฟลามิงโกที่ถูกเลี้ยง ซึ่งพวกมันอาจจะเปลี่ยนเป็นสีชมพูอ่อนถ้าพวกมันไม่ได้รับแคโรทีนในระดับที่พวกมันเคยได้รับในป่า

คำถาม

1. ฟลามิงโกถูกพบที่ไหน

◯ ในอเมริกาเท่านั้น

◯ ในแอฟริกาและอินเดียเท่านั้น

◯ ในอเมริกา และที่อื่นๆ ในโลก โดยเฉพาะแอฟริกาและอินเดีย

○ ในอเมริกา และที่อื่นๆ ในโลก โดยเฉพาะอินเดีย

2. ข้อใดไม่ใช่เหตุผลที่อธิบายว่าทำไมฟลามิงโกยืนเพียงขาข้างเดียว

○ การยืนขาข้างเดียวช่วยลดการใช้พลังงาน

○ การยืนขาข้างเดียวช่วยให้ฟลามิงโกเก็บรักษาความร้อนในร่างกายของพวกมันได้มากขึ้น

○ ช่วยให้ฟลามิงโกสามารถใช้เวลาได้นานในน้ำเย็น

○ เนื่องจากขาที่เป็นพังผืดของมัน ทำให้ง่ายสำหรับการยืนขาข้างเดียว

3. น้ำลูกฟลามิงโกที่เพิ่งออกไข่จะมีสีอะไร

○ ขาวหรือซีด แต่จะกลายเป็นสีชมพูเมื่อโตขึ้น

○ สีเทาไปจนถึงสีแดงหม่น

○ สีชมพูอ่อนไปจนถึงแดงสด

○ สีส้นสดใส และจะจางลงเมื่อโตขึ้น

c) The five texts and multiple-choice questions in English for study 3

1) Text 1: Maple syrup

Maple syrup is usually made from the sap of sugar maple, red maple, or black maple trees. In cold climates, these trees store starch in their trunks and roots before the winter. The starch is then converted to sugar that rises in the sap in late winter and early spring. Maple trees are tapped by drilling holes into their trunks and collecting the sap which seeps out. The sap is processed by heating it. This evaporates much of the water, leaving the concentrated syrup.

The native peoples of North America were the first to collect maple syrup. They taught the practice to the European settlers, who improved production methods. Further changes in the 1970s again improved the processing of syrup. The Canadian province of Quebec produces by far the most maple syrup. It is responsible for 70% of the world's output. The state of Vermont is the largest producer in the United States, making 6% of world output.

There are local and national grades for maple syrup. These scales are based on density and clarity. In Canada, syrups must contain only maple sap to qualify as maple syrup and must also contain at least 66 percent sugar. However, in the United States, a syrup can be only partly maple sap to be labelled as "maple", though some states such as Vermont and New York have more restrictive definitions.

Questions

1. When is the maple trees can be started to convert from the starch to sugar?

○ Early and late autumn

○ Late autumn and early winter

- ○ Late winter and early spring
- ○ Early and late spring

2. Which statement is NOT corrected about the processing of maple syrup?

- ○ Maple trees store starch in their trunks and roots
- ○ The starch is converted to sugar
- ○ The trees are tapped by drilling holes into their trunks
- ○ The sap is processed by the cooling

3. Grades for maple are based on...

- ○ density and clarity
- ○ density and sugar percent
- ○ sugar percent and water
- ○ sugar percent and clarity

2) Text 2: Taj Mahal

The Taj Mahal is a white marble mausoleum on the south bank of the Yamuna river in the Indian city of Agra. The name is usually translated as Crown of the Palace. The Mughal emperor, Shah Jahan built it in 1632 to house the tomb of his favourite wife, Mumtaz. Mumtaz was a Persian princess who died giving birth to their fourteenth child. The tomb is the centrepiece of a four acre complex. The complex also includes several other tombs, a mosque and a guest house. The buildings are surrounded by beautiful formal gardens with flowerbeds and ponds.

20,000 artisans worked on the construction of the Taj with materials that came from all over India and Asia. More than one thousand elephants transported these materials. Construction of the mausoleum was mainly complete by 1643, but work continued on some phases of the project for another ten years. It is estimated that the Taj Mahal cost approximately 32 million rupees, which today would be 827 million US dollars.

The UNESCO named the Taj Mahal a World Heritage Site in 1983. They noted that it is "the jewel of Muslim art in India and one of the universally admired masterpieces of the world's heritage". The Taj is regarded as the best example of Mughal architecture and a symbol of India's rich history. The Taj attracts seven to eight million visitors a year from all over the world.

Questions

1. What does Taj Mahal mean?

- ○ Crown of Princess
- ○ Crown of Prince
- ○ Crown of Palace
- ○ Crown of City

2. Which statement is corrected about the Taj Mahal?

- ○ 10,000 artisans worked on the construction of the building.
- ○ The Taj Mahal is a mausoleum for Shan Jahan's fourteenth child
- ○ The cost of Taj Mahal would be approximately 32 million US dollars today
- ○ The Taj is a symbol of India's rich history

3. When did the Taj Mahal become a UNESCO World Heritage Site?

- ○ In 1632
- ○ In 1643
- ○ In 1943
- ○ In 1983

3) Text 3: Peafowl

Peafowls include three species of birds in pheasant family. There are two Asiatic species. These are the blue or Indian peafowl and the green peafowl of Southeast Asia. There is also one African species, the Congo peafowl, native only to the Congo Basin. The term peacock is properly reserved for the male, the female is known as a peahen, and the immature offspring are sometimes called peachicks.

Male peafowl, or peacocks are known for their piercing call and their extravagant plumage. They have a large eye-spotted "tail" or "train" of feathers which they display in courtship. The functions of the elaborate train have been the subject of extensive scientific debate. Charles Darwin suggested they served to attract females, and the showy features of the males had evolved by selection. More recently biologists have proposed that these features indicate the males' fitness, since less fit males would be disadvantaged by trying to survive with such large trains.

Peafowl are omnivores and eat plants, flower petals, seeds, insects, and reptiles. Wild peafowl look for their food scratching around in leaf litter early in the morning and at dusk. They retreat to the shade of woods for the hottest portion of the day. These birds are not picky and will eat almost anything they can fit in their beak. Domesticated peafowl may also eat bread and grain, cheese, cooked rice and sometimes cat food.

Questions

1. Which statement is NOT corrected about peafowl?

- ○ The large eye-spotted tail of peacock is display in courtship
- ○ The green peafowl specie is a native of southeast Asia
- ○ There are only two species of peafowl in the world
- ○ Domesticated peafowl sometimes eat cat food

2. Wild peafowl look for their food..

- ◯ in the morning and afternoon
- ◯ in the morning and at dusk
- ◯ in the afternoon and evening
- ◯ in the afternoon and at dusk

3. Which of the following is NOT a food commonly eaten by wild peafowl?

- ◯ Flower petals
- ◯ Seeds
- ◯ Insects
- ◯ Fish

4) Text 4: Dead sea

The Dead Sea is a salt lake bordered by Israel and Palestine to the west and Jordan to the east. It is one of the world's saltiest bodies of water. At 304 metres deep, it is the deepest highly saline lake in the world. It is nearly 10 times as salty as the ocean which makes swimming similar to floating. This salinity also means plants and animals cannot flourish, hence its name. Its main tributary is the Jordan River.

The Dead Sea has attracted visitors from around the Mediterranean basin for thousands of years. It was one of the world's first health resorts, visited by Herod the Great. It has been the supplier of a variety of products since ancient times, including asphalt for Ancient Egyptian mummification. People still use the salt and the minerals from the Dead Sea to create cosmetics and herbal sachets.

The Dead Sea is now receding at an alarming rate. Multiple canals and pipelines have been proposed to reduce this process, which began causing many problems of their own. The Red Sea And Dead Sea Water Conveyance project, carried out by Jordan, will provide fresh water to neighbouring countries. The resulting very salty water will be carried to the Dead Sea to help stabilise its levels. The first phase of the project is scheduled to begin in 2018 and be completed in 2021.

Questions

1. How much saltier is the Dead Sea compared to the ocean?

- ◯ 10 times
- ◯ 20 times
- ◯ 30 times
- ◯ 40 times

2. Which one is NOT a product from the Dead sea?

- ◯ Cosmetics

○ Herbal sachet

○ Balm

○ Asphalt

3. Which is the name of the project to provide fresh water to neighboring countries?

○ The Red Sea and Dead Sea Water Conveyance project

○ The Red Sea and Dead Sea Water project

○ The Dead Sea and River Jordan Conveyance project

○ he Dead Sea and Red Sea Water project

5) Text 5: Brownies

Chocolate brownies, or just brownies for short, refers to square small cakes. Brownies come in a variety of forms. They may be either fudgy or cakey, depending on their density. They often include chocolate chips, nuts or raisins. Sometimes they include other sweet additions. Brownies are typically eaten on their own, often accompanied by a cup of coffee. But they may be served warm with ice cream, topped with whipped cream, or sprinkled with icing sugar. In North America they are popular lunchbox items, and also popular in restaurants and cafes.

One story about the original of brownies involves Bertha Palmer. Bertha was a prominent Chicago socialite whose husband owned the Palmer House Hotel in the city. In 1893 Bertha asked a chef at the hotel for a cake-like dessert smaller than a piece of cake that could be included in boxed lunches. The result was the Palmer House Brownie which included walnuts and an apricot glaze. The Palmer House Hotel still serves a dessert made from the same recipe.

The first known printed use of the word brownie to describe a dessert appeared in the 1896 version of the Boston Cooking School cookery book by Fannie Farmer. This recipe is for small cakes baked individually in tin moulds, but they are not very like Palmer House brownies. The earliest known published recipes for a modern style chocolate brownie appeared in a 1904 cookery book.

Questions

1. Which statement is NOT corrected about brownies?

○ They are popular lunchbox items in North America

○ One story about orgin of brownies involves Bertha Palmer who was a prominent Chicago sicialite

○ The recipe for brownies in the Boston Cooking School Cookery book

○ The palmer House Hotel first served brownies as a dessert with ice cream

2. Which statement correctly describes Palmer House brownies?

○ A small cake with raisins and chocolate chips

○ A small cake with walnuts and apricot glaze

○ A small cake with raisins and apricot glaze

○ A small cake with walnuts and chocolate chips

3. Who is the first person who used the word "brownie" in print?

○ Maria Willet Howard

○ Bangor Brownies

○ Fannie Farmer

○ Bertha Palmer

d) The five texts and multiple-choice questions in Thai for study 3

1) Text 1: **เมเปิล ไซรัป** (Maple syrup)

เมเปิล ไซรัปโดยปกติทำมาจากน้ำหล่อเลี้ยงของต้นเมเปิล ในภูมิอากาศที่หนาวเย็นต้นเมเปิลจะจัดเก็บแป้งในลำต้นและรากของมันไว้ก่อนฤดูหนาว แป้งจะถูกเปลี่ยนเป็นน้ำตาลเพิ่มขึ้นในช่วงปลายฤดูหนาวและต้นฤดูใบไม้ผลิ ต้นเมเปิลจะถูกใช้ท่อเสียบเข้าไปในลำต้นเพื่อเก็บน้ำหล่อเลี้ยง น้ำหล่อเลี้ยงนี้จะถูกนำไปให้ความร้อน รอจนน้ำระเหยออกจนเหลือแต่น้ำเชื่อมเข้มข้น

เมเปิล ไซรัปถูกผลิตครั้งแรกโดยชนพื้นเมืองของทวีปอเมริกาเหนือ พวกเขาสอนวิธีการผลิตให้กับชาวยุโรปที่เข้ามาเป็นอาศัยอยู่ จากนั้นชาวยุโรปเป็นคนปรับปรุงวิธีการผลิตเรื่อยมา และในปี ค.ศ.1970 ได้มีการปรับปรุงกระบวนการผลิตไซรัปอีกครั้ง ซึ่งเมืองควิเบกในแคนาดาผลิตเมเปิลไซรัปได้มากที่สุด โดยผลิตได้มากถึง 70% ของผลผลิตทั่วโลก รัฐเวอร์มอนต์เป็นผู้ผลิตใหญ่ที่สุดในสหรัฐอเมริกา โดยคิดเป็น 6%

เมเปิลไซรัปได้รับการจัดเกรดตามระดับท้องถิ่นและประเทศ การแบ่งเกรดขึ้นอยู่กับความเข้มข้นและความบริสุทธิ์ของไซรัป ในแคนาดาไซรัปต้องทำจากน้ำเลี้ยงของต้นเมเปิ้ล ถึงจะเรียกได้ว่าเป็นเมเปิ้ลไซรัป และต้องมีอย่างน้อยร้อยละ 66 ของน้ำตาล แต่ในสหรัฐอเมริกา เมเปิลไซรัปทำมาจากน้ำหล่อเลี้ยงของต้นเมเปิลเพียงนิดเดียว แต่บางรัฐ เช่น เวอร์มอนต์และนิวยอร์กมีความเข้มงวดในการผลิต

คำถาม

1. ช่วงใดที่ต้นเมเปิลจะเริ่มเปลี่ยนจากแป้งเป็นน้ำตาล

○ ต้นและปลายฤดูใบไม่ร่วง

○ ปลายฤดูใบไม้ร่วงและต้นฤดูหนาว

○ ปลายฤดูหนาวและต้นฤดูใบไม้ผลิ

○ ต้นและปลายฤดูใบไม้ผลิ

2. ประโยคใดกล่าว ไม่ถูกต้อง เกี่ยวกับการผลิตเมเปิลไซรัป

○ ต้นเมเปิลเก็บแป้งมาจากลำต้นและราก

○ แป้งของต้นเมเปิลจะถูกเปลี่ยนเป็นน้ำตาล

○ ต้นเมเปิลจะถูกเจาะเข้าไปในลำต้น

○ น้ำหล่อเลี้ยงของต้นเมเปิลจะถูกนำไปให้ความเย็น

3. การแบ่งเกรดของเมเปิลไซรัปขึ้นอยู่กับ...

○ ความเข้มข้นและความบริสุทธิ์ของไซรัป

○ ความเข้มข้นและเปอร์เซ็นต์ของน้ำตาลของไซรัป

○ เปอร์เซ็นต์ของน้ำตาลและน้ำของไซรัป

○ เปอร์เซ็นต์ของน้ำตาลและความบริสุทธิ์ของไซรัป

2) Text 2: **ทัชมาฮาล** (Taj Mahal)

ทัชมาฮาลเป็นสุสานหินอ่อนสีขาวไข่มุก ตั้งอยู่ริมฝั่งแม่น้ำยมุนา ในเมืองอัคราของประเทศอินเดีย ชื่อของมันมีความหมายว่า มุงกฎแห่งราชวัง สมเด็จพระจักรพรรดิซาห์ชะฮันแห่งจักรวรรดิโมกุลได้สร้างสุสานให้กับมุมตัซ ซึ่งเป็นภรรยาคนโปรด โดยสร้างขึ้นในปี ค.ศ.1632 มุมตัซคือเจ้าหญิงชาวเปอร์เซียที่เสียชีวิตจากการให้กำเนิดทายาทองค์ที่ 14 ของพระองค์ สุสานนี้เป็นจุดศูนย์กลางของเนื้อที่ประมาณ 4 เอเคอร์ สถานที่แห่งนี้ประกอบไปด้วยสุสาน มัสยิด และเกสท์เฮาส์ ตัวอาคารถูกล้อมรอบไปด้วยสวนดอกไม้ที่สวยงามและสระน้ำ

ทัชมาฮาลมีผู้ร่วมสร้างและออกแบบร่วม 20,000 คน วัสดุที่ใช้สร้างมาจากทั่วทั้งอินเดียและเอเชีย โดยใช้ช้างมากกว่า 1,000 ตัวในการขนส่งวัสดุต่าง ๆ การก่อสร้างสุสานนี้เสร็จสิ้นในปี ค.ศ. 1643 แต่ยังคงก่อสร้างสิ่งอื่น ๆ ต่อไปอีก 10 ปี ทัชมาฮาลถูกตีราคาประมาณ 32 ล้านรูปี ซึ่งในปัจจุบันมีมูลค่าถึง 827 ล้านดอลล่าสหรัฐ

องค์การยูเนสโก้ได้ตั้งทัชมาฮาลเป็นมรดกโลกเมื่อปี ค.ศ. 1983 และกล่าวว่าเป็นอัญมณีของศิลปะทางมุสลิมในอินเดีย และเป็นผลงานชิ้นเอกของมรดกโลก ทัชมาฮาลถือเป็นตัวอย่างของสถาปัตยกรรมแห่งจักรวรรดิโมกุลที่ดีที่สุด และเป็นสัญลักษณ์ของประวัติศาสตร์ความร่ำรวยของอินเดีย ทัชมาฮาลดึงดูดนักท่องเที่ยวจากทั่วโลกได้ 7 ถึง 8 ล้านคนต่อปี

คำถาม

1. คำว่า ทัชมาฮาล หมายความว่าอะไร

○ มงกุฎแห่งเจ้าหญิง

○ มงกุฎแห่งเจ้าชาย

○ มงกุฎแห่งราชวัง

○ มงกุฎแห่งเมือง

2. ประโยคไหน ถูกต้อง เกี่ยวกับทัชมาฮาล

○ มีผู้ร่วมสร้างและออกแบบทัชมาฮาล 10,000 คน

○ ทัชมาฮาลเป็นสุสานหินอ่อนสีขาวไข่มุกของทายาทองค์ที่ 14 ของจักรพรรดิโมกุล

○ มูลค่าของทัชมาฮาลจะอยู่ที่ประมาณ 32 ล้านดอลล่าสหรัฐ

○ ทัชมาฮาล ถูกกล่าวว่าเป็นอัญมณีของศิลปะทางมุสลิมและเป็นสัญลักษณ์แห่งความร่ำรวยของอินเดียในอดีต

3. ทัชมาฮาลถูกยกขึ้นเป็นมรดกโลกเมื่อไร

○ ในปี ค.ศ. 1632

○ ในปี ค.ศ. 1643

○ ในปี ค.ศ. 1943

○ ในปี ค.ศ. 1983

3) Text 3: **นกยูง** (Peafowl)

นกยูง มีอยู่สามสายพันธุ์ในตระกูลไก่ฟ้า สองสายพันธุ์ที่เป็นพันธุ์เอเชีย โดยจะมีสีฟ้าหรือเป็นนกยูงอินเดีย และมีสีเขียวเป็นนกยูงในเอเชียตะวันออกเฉียงใต้ และอีกหนึ่งสายพันธุ์ คือ นกยูงคองโก จะอาศัยอยู่ที่ลุ่มน้ำคองโกที่แอฟริกันเท่านั้น ในภาษาอังกฤษคำว่าพีค็อค ถูกสงวนไว้เรียกนกยูงเพศผู้ ส่วนเพศเมียจะเรียกว่า พีเฮน และลูกอ่อนจะเรียกว่า พีชิค

นกยูงเพศผู้เป็นที่รู้จักกันดีว่า มีขนหางยาว และเมื่อแผ่ขยายออกจะมีความสวยงามหรือเรียกว่า รำแพน โดยหางมีจุดกลมใหญ่มากมาย เพื่อเกี้ยวตัวเมีย มีการอภิปรายทางด้านวิทยาศาสตร์เกี่ยวกับการกระทำเช่นนี้ของมัน ชาร์ล ดาร์วิน กล่าวว่าพวกมันทำเช่นนั้นเพราะต้องการดึงดูดตัวเมีย และแสดงคุณสมบัติของเพศผู้ และยังมีนักชีววิทยากล่าวว่า คุณสมบัติเหล่านี้สามารถบ่งบอกถึงสมรรถนภาพของเพศผู้ได้

นกยูงเป็นสัตว์กินพืช จะกินพวกพืชผัก กลีบดอกไม้ เมล็ดพืช แมลง และสัตว์เลื้อยคลาน ส่วนนกยูงป่าจะคุ้ยเขี่ยหาอาหารตามกองใบไม้ในตอนช่วงเช้าและช่วงพลบค่ำ พวกมันจะหลบอยู่ใต้เงาไม้ในช่วงที่ร้อนสุดของวัน นกยูงป่าจะไม่เลือกอาหาร และจะกินเกือบทุกอย่างที่มันสามารถใส่ลงไปในปากของพวกมันได้ นกยูงเลี้ยงอาจจะกินขนมปัง และเมล็ดข้าว ชีส ข้าวสุก และบางครั้งกินอาหารแมวก็เป็นได้

คำถาม

1. คำข้อใดกล่าว ไม่ถูกต้อง เกี่ยวกับนกยูง

○ การรำแพนหางของนกยูงตัวผู้ใช้ในการเกี้ยวตัวเมีย

○ นกยูงสีเขียวเป็นพันธุ์ที่มาจากเอเชียตะวันออกเฉียงใต้

○ นกยูงมีเพียงแค่สองพันธุ์เท่านั้นในโลก

○ บางครั้งนกยูงที่ถูกเลี้ยงสามารถกินอาหารแมวได้

2. นกยูงป่าจะออกหาอาหารในตอน...

○ เช้าและกลางวัน

○ เช้าและพลบค่ำ

○ กลางวันและเย็น

○ กลางวันและพลบค่ำ

3. ข้อใด ไม่ใช่ อาหารโดยทั่วไปของนกยูงป่า

○ กลีบดอกไม้

○ เมล็ดพืช

○ แมลง

○ ปลา

4) Text 4: **ทะเลเดดซี** (Dead sea)

ทะเลเดดซีเป็นทะเลสาบน้ำเค็ม ที่มีพรมแดนติดกับประเทศอิสราเอล และปาเลสไตน์ทางตะวันตก และทางตะวันออกของประเทศจอร์แดน เป็นทะเลที่เค็มที่สุดแห่งหนึ่งของโลก โดยความลึกอยู่ที่ 304 เมตร และมีความเข้มข้นของเกลือสูงมากที่สุดในโลก ซึ่งมีความเค็มกว่าน้ำทะเลปกติเกือบ 10 เท่า จึงทำให้สามารถ

ลอยตัวในน้ำได้ และด้วยความเค็มนี้ทำให้ไม่มีสิ่งมีชีวิตอยู่ได้เลย ด้วยเหตุนี้จึงเป็นเรียกว่าทะเลเดดซี แหล่งน้ำหลักของทะเลนี้คือแม่น้ำจอร์แดน

ทะเลเดดซีเป็นแหล่งที่ชื่นชอบของนักท่องเที่ยวรอบทะเลเมดิเตอร์เรเนียนเป็นเวลาหลายพันปี และยังเป็นหนึ่งในรีสอร์ทเพื่อสุขภาพแห่งแรกของโลก ซึ่งถูกเยี่ยมชมโดยพระเจ้าเฮโรดมหาราช และยังถูกนำมาสร้างเป็นผลิตภัณฑ์หลากหลายตั้งแต่สมัยโบราณ รวมถึงยางมะตอยที่ใช้สำหรับการรักษาศพของชาวอียิปต์โบราณ ผู้คนยังคงใช้เกลือและแร่ธาตุจากทะเลเดดซีมาทำเครื่องสำอาง และถุงใส่เครื่องหอม

ขณะนี้น้ำทะเลเดดซีกำลังลดลงในอัตราที่น่าตกใจ หลายคลองและท่อลำเลียงน้ำได้ลดลง ซึ่งทำให้เกิดปัญหาขึ้น โครงการขนส่งน้ำเรดซีและเดดซี ซึ่งดำเนินการโดยจอร์แดน จะจัดหาน้ำจากประเทศเพื่อนบ้าน โดยน้ำเค็มที่เกิดขึ้นมาจะนำไปที่เดดซี เพื่อช่วยให้ระดับน้ำเสถียร โดยระยะแรกของโครงการจะเริ่มในปี ค.ศ. 2018 และจะเสร็จสิ้นในปี ค.ศ. 2021

คำถาม

1. ระดับความเค็มของน้ำทะเลเดดซีเค็มมากกว่าทะเลอื่นๆ เป็นกี่เท่า

○ 10 เท่า

○ 20 เท่า

○ 30 เท่า

○ 40 เท่า

2. ข้อใด ไม่ใช่ ผลผลิตของทะเลเดดซี

○ เครื่องสำอาง

○ ถุงใส่เครื่องหอม

○ ยาหม่อง

○ ยางมะตอย

3. โครงการที่จะช่วยให้ทะเลสาบเดดซีมีระดับน้ำที่เสถียร มีชื่อว่าอะไร

○ โครงการขนส่งน้ำเรดซีและเดดซี

○ โครงการน้ำเรดซีและเดดซี

○ โครงการขนส่งน้ำเดดซีและแม่น้ำจอร์แดน

○ โครงการน้ำเดดซีและเรดซี

5) Text 5: **บราวนี่** (Brownies)

บราวนี่ช็อกโกแลต หรือเรียกสั้นๆ ว่า บราวนี่ เป็นเค้กขนาดเล็กทรงสี่เหลี่ยม บราวนี่ถูกผลิตในรูปแบบต่าง ๆ บางครั้งมีความหนึบ หรือเป็นชิ้นเนื้อเค้ก และอาจมีส่วนผสมของถั่ว ลูกเกด ครีม ครีมชีส ช็อกโกแลตชิป และอื่น ๆ โดยส่วนมากบราวนี่มักจะทานร่วมกับกาแฟ บางครั้งก็เสิร์ฟกับไอศกรีม พร้อมด้วยวิปครีม หรือโรยด้วยน้ำตาลไอซิ่ง ในอเมริกาเหนือนิยมนำบราวนี่มาบรรจุในกล่องอาหารกลางวัน และยังเป็นที่นิยมในร้านอาหารทั่วไป

ต้นกำเนิดของบราวนี่มีอยู่ว่า เบอร์ธา พาล์มเมอร์ เธอเป็นสาวสังคมในชิคาโก ซึ่งสามีของเธอเป็นเจ้าของโรงแรมพาล์มเมอร์เฮาส์ ในปี ค.ศ. 1893 เธอได้ให้พ่อครัวของโรงแรมทำขนมที่มีขนาดเล็กกว่าเค้ก แต่ต้อง

มีลักษณะคล้ายเค้ก โดยต้องสามารถบรรจุในกล่องอาหารกลางวันได้ ซึ่งทำให้เกิด บราวนี่พาล์มเมอร์เฮาส์ ซึ่งมีส่วนผสมของวอลนัท และโรยหน้าด้วยแอพริคอต ปัจจุบันโรงแรมยังทำบราวนี่สูตรดั้งเดิมขายอยู่

คำว่า บราวนี่ ถูกใช้บรรยายถึงขนมหวาน ในการตีพิมพ์ครั้งแรกของตำราอาหารในโรงเรียนสอนทำอาหารบอสตัน ซึ่งเขียนโดยแฟนนี่ ฟาร์มเมอร์ ในปี ค.ศ.1896 ซึ่งสูตรนี้มีลักษณะเป็นเค้กชิ้นเล็ก ไม่เหมือนกับบราวนี่พาล์มเมอร์เฮาส์ ส่วนสูตรบราวนี่ช็อกโกแลตที่ทำกันในปัจจุบัน ได้ถูกตีพิมพ์ไว้ในหนังสือการทำอาหารในบ้าน ในปี ค.ศ.1904

คำถาม

1. ประโยคไหนกล่าว ไม่ถูกต้อง เกี่ยวกับ บราวนี่

◯ ในอเมริกาเหนือ บราวนี่จะนิยมนำมาบรรจุในกล่องอาหารกลางวัน
◯ ต้นกำเนิดของบราวนี่เกี่ยวข้องกับ เบอร์ธา พาล์มเมอร์ ผู้ซึ่งเป็นสาวสังคมในชิคาโก
◯ เค้กขนาดเล็กที่อบเป็นชิ้นเล็กๆ เป็นสูตรที่ตีพิมพ์ในตำราอาหารของโรงเรียนสอนการทำอาหารบอสตัน
◯ บราวนี่ช็อกโกแลตสูตรปัจจุบันได้ถูกตีพิมพ์ในตำราอาหารของโรงเรียนสอนการทำอาหารบอสตัน

2. ประโยคไหนอธิบายเกี่ยวกับบราวนี่พาล์มเมอร์เฮาส์ได้อย่างถูกต้อง

◯ เค้กชิ้นเล็กๆ ที่มีส่วนผสมของลูกเกด และโรยหน้าด้วยช็อกโกแลตชิป
◯ เค้กชิ้นเล็กๆ ที่มีส่วนผสมของวอลนัท และโรยหน้าด้วยแอพริคอต
◯ เค้กชิ้นเล็กๆ ที่มีส่วนผสมของลูกเกด และโรยหน้าด้วยแอพริคอต
◯ เค้กชิ้นเล็กๆ ที่มีส่วนผสมของวอลนัท และโรยหน้าด้วยช็อกโกแลตชิป

3. บุคคลใดที่นำคำว่า บราวนี่ ไปใช้เป็นครั้งแรกของโลก

◯ มาเรีย วิลเลท โฮเวิร์ด
◯ แบงกอร์ บราวนี่
◯ แฟนนี่ ฟาร์มเมอร์
◯ เบอร์ธา พาล์มเมอร์

e) The six texts and multiple-choice questions in English for study 4

1) Text 1: Fondue

Fondue is a Swiss dish of melted cheese served in a communal pot over a portable stove. The stove can be heated with a candle or spirit lamp. Fondue is eaten by dipping bread into the cheese using long-stemmed forks. The Swiss Cheese Union promoted fondue as a Swiss national dish in the 1930s. After World War II, the Union continued this promotion. It sent fondue sets to military regiments and event organizers across Switzerland. Fondue also became popular in North America in the 1960s.

The earliest known recipe for cheese fondue as we know it today comes from a 1699 book published in Zurich. The recipe was "to cook cheese with wine". It calls for grated or cut-up cheese to be melted with wine, and for bread to be dipped in it. However, until the late nineteenth century "cheese fondue" referred to a preparation including eggs and cheese. This dish was something between scrambled eggs with cheese and a cheese soufflé.

Since the 1950s, the term "fondue" has been generalized to other dishes in which a food is dipped into a communal pot of hot liquid. For example, chocolate fondue, involves pieces of fruit or pastry which are dipped into a melted chocolate mixture. Also fondue bourguignonne which involves pieces of meat that are cooked in hot oil or broth and dipped in a range of sauces.

Questions

1. When was fondue first promoted as a Swiss national dish?

○ 1630s
○ 1690s
○ 1930s
○ 1950s

2. Which ingredient is NOT found in cheese fondue?

○ Cheese
○ Eggs
○ Oil
○ Wine

3. Which statement is correct about fondue?

○ Fondue became popular in Zurich in the 1960s
○ Fondue was originally pieces of meat cooked in hot oil or broth
○ Fondue became popular in North America in the 1980s
○ A recipe for cheese fondue was published in 1699

2) Text 2: Banff

Banff is a town within the Banff National Park in the province of Alberta in Canada. It is located in the Rocky Mountains along the Trans-Canada Highway. It is approximately 126 kilometres west of the city of Calgary and 58 kilometres east of Lake Louise. At an elevation of 1,400 metres to 1,630 metres, Banff has the second highest elevation in Alberta after Lake Louise.

Banff is one of Canada's most popular tourist destinations. Known for its mountainous surroundings and hot springs, it features extensive hiking, biking and skiing destinations in the area. Sunshine Village, Ski Norquay and Lake Louise Mountain Resort are three nearby ski resorts located within the national park.

Banff was first settled in the 1880s, after the Canadian Pacific Railway was built through the Bow Valley. In 1883, three railway workers stumbled on a series of natural hot springs on the side of

Sulphur Mountain. In 1885, Canada established a federal reserve of 26 km^2 around the Cave and Basin hot springs. The area was first promoted as a holiday resort and spa as a way to support the new railway. In 1887, the reserve area was increased to 673 km^2 and named "Rocky Mountain Park". This was the beginning of Canada's National Park system. George Stephen, president of the Canadian Pacific Railway, named Banff in 1884 after his birthplace in Scotland.

Questions

1. When was Banff given its name?

○ In 1883
○ In 1884
○ In 1885
○ In 1887

2. Which statement about Banff is NOT correct?

○ Banff has the highest elevation in Alberta
○ Banff was settled after building the Canadian Pacific Railway
○ Banff is located in the Rocky Mountains
○ Banff was named by George Stephen

3. When was the Rocky Mountain Park named?

○ In 1883
○ In 1884
○ In 1885
○ In 1887

3) **Text 3: Flamingo** (see the Flamingo text and questions in Appendix O, section a)

4) **Text 4: Lamington**

The lamington is a small cake which is very popular in Australia for afternoon tea or a snack. It is made from dry squares of sponge cake which are coated in a thin chocolate sauce. These are then rolled in desiccated coconut. The dry outside of the sponge cake absorbs the thin sauce. The small pieces of coconut stick to the sauce, so they do not fall off. The coating sets overnight, giving the cake a distinctive texture. A rich variation has a layer of raspberry jam or cream in the middle of the cake.

Although mystery shrouds its origin, it is fairly certain that lamingtons were named after Lord Lamington. He served as Governor of Queensland, then one of the colonies in Australia, from 1896 to 1901. Another possibility is that they were named for his wife, Lady Lamington, Mary Hozier.

The earliest known reference to the naming of the lamington, from June 1927, links the cake to Lord Lamington.

There is also considerable debate about the identity of the recipe's inventor. Most stories attribute its creation to Lord Lamington's chef, the French-born Armand Galland, who fed a group of unexpected guests at short notice. Galland cut up some left-over sponge cake, dipped the slices in chocolate and rolled them in coconut. Apparently the guests were so impressed by Galland's creation they later asked for the recipe.

Questions

1. When was the first reference to the naming of the lamington?

○ 1801
○ 1896
○ 1901
○ 1927

2. Where was the first Lamington made?

○ France
○ Austria
○ New Zealand
○ Australia

3. Who is believed to have invented the lamington?

○ Mary Hozier
○ Lord Lamington
○ Armand Galland
○ Lady Lamington

5) Text 5: Florianopolis

Florianopolis is the capital and second largest city of the state of Santa Catarina, in the south of Brazil. The city includes Santa Catarina Island and many surrounding small islands, as well as part of the mainland. It has a population of nearly half a million people. The city is considered safe by Brazilian standards. In 2014, Florianopolis had the second lowest incidence of murders of Brazilian capitals.

The economy of Florianopolis is heavily based on information technology, tourism and services. The city has 60 beaches and is a centre of surfing activity. The New York Times reported that Florianopolis is the Party Destination of the Year in 2009. Newsweek magazine placed Florianopolis on its list of the ten most dynamic cities of the world in 2006. As a result of this exposure, Florianopolis is growing as a second home destination for many wealthy Brazilians, Argentines, North Americans, and Europeans.

Most of the population of Florianopolis lives on the mainland and on Santa Catarina Island. Many small commercial fishermen populate the island. The island has fishing boats, lacemakers, folklore, and colonial architecture. Lagoa da Conceição (Conception Lagoon) is the largest lagoon on the island and one of the most visited area of the island. Many visitors and locals choose to live by the lagoon because of its stunning views, safety, nature and quality of life.

Questions

1. Which statement is NOT correct about Florianopolis?

○ Florianopolis was the Brazilian party city of the year 2006
○ Florianopolis is a second home destination for many wealthy Europeans
○ Florianopolis is the capital city of the state of Santa Catarina
○ Florianopolis has the second lowest incidence of murders of Brazilian capitals

2. Florianopolis is a centre of which leisure activities?

○ Hiking
○ Surfing
○ Spa
○ Yoga

3. Most visitors and local people choose to live by the lagoon on Santa Catarina Island because of...

○ safety and nice views
○ safety and good seafood
○ good seafood and nature
○ privacy and nature

6) Text 6: Echidnas

Echidnas, also known as spiny anteaters, live in Australia and New Guinea. Although they eat ants and termites, they are not closely related to the true anteaters of the Americas. The four surviving species, together with the platypus, are the only living mammals that lay eggs. Echidnas evolved between 20 and 50 million years ago, descending from a platypus-like animal. This ancestor lived in water, but echidnas adapted to life on land.

Echidnas are named after a creature from Greek mythology, who was half-woman, half-snake, as they seem to have qualities of both mammals and reptiles. They resemble other spiny mammals such as hedgehogs and porcupines. They are usually black or brown in colour. There have been reports of albino echidnas, with pink eyes and white spines. They have elongated and slender snouts that function as both mouth and nose.

Echidnas do not tolerate extreme temperatures well. They use caves and rock crevices to shelter from harsh weather conditions. Echidnas are found in forests and woodlands, hiding under vegetation, roots or piles of debris. They sometimes use the burrows of animals such as rabbits and wombats. Individual echidnas have large, mutually overlapping territories. Despite their appearance, echidnas are capable swimmers. When swimming, they expose their snout and some of their spines, and are known to journey to water in order to groom and bathe themselves.

Questions

1. Where do echidnas live?

○ In Australia and New Zealand
○ In Australia and Africa
○ In Australia and New Guinea
○ In Australia and Indonesia

2. What do echidnas eat?

○ Ants and wombats
○ Rabbits and wombats
○ Ants and termites
○ Ants and crickets

3. Which statement is NOT true about echidnas?

○ Echidnas are descended from an aquatic ancestor
○ Echidnas are named for a creature from Greek mythology
○ Echidnas are mammals
○ Echidnas tolerate extreme temperatures very well

f) The six texts and multiple-choice questions in Thai for study 4

1) Text 1: **ฟงดูว์** (Fondue)

ฟงดูว์เป็นอาหารของสวิส ซึ่งเป็นชีสเหลวเสิร์ฟในหม้อวางบนเตาแบบพกพา โดยเตาสามารถอุ่นได้ด้วยเทียนหรือถาดใส่ไฟ สามารถรับประทานด้วยการจุ่มขนมปังลงไปในชีสเหลวโดยใช้ส้อมด้ามยาว ฟงดูว์ได้รับการส่งเสริมให้เป็นอาหารประจำชาติของสวิสเซอร์แลนด์ในคริสต์ทศวรรษที่ 1930 หลังจากสงครามโลกที่ 2 ได้มีการส่งเสริมฟงดูว์อย่างต่อเนื่อง โดยส่งชุดฟงดูว์ให้กับกองทหารและผู้จัดงานทั่วสวิสเซอร์แลนด์ และในคริสต์ทศวรรษที่ 1960 มันยังได้รับความนิยมในอเมริกาเหนืออีกด้วย

สูตรฟงดูว์ชีสที่เรารู้จักกันทุกวันนี้ เป็นสูตรที่มาจากหนังสือในปี ค.ศ. 1699 โดยตีพิมพ์ที่เมืองซูริค ซึ่งเป็นการปรุงชีสด้วยไวน์ คือเป็นการขูดหรือหั่นชีส จากนั้นละลายชีสด้วยไวน์ และนำขนมปังจุ่มลงไป แต่ช่วงปลายคริสต์ศตวรรษที่ 19 ฟงดูว์ชีส หมายถึงการใช้ไข่และชีสเป็นส่วนผสม ซึ่งอาจจะเป็นอะไรบางอย่างระหว่างไข่กวนกับชีส และฟองชีสก็ได้

ตั้งแต่คริสต์ทศวรรษที่ 1950 เป็นต้นมา มีการนำชื่อ "ฟงดูว์" ไปใช้เป็นคำทั่วไปเพื่อใช้เรียกอาหารที่มีการจุ่มอาหารลงในของเหลวร้อนๆ ในหม้อไฟ ยกตัวอย่างเช่น ฟงดูว์ช็อกโกแลต ซึ่งใช้ผลไม้ที่หั่นเป็นชิ้นๆ จุ่มลงไปในช็อกโกแลตเหลว และยังมี ฟงดูว์บูร์กอญ ซึ่งจะใช้เนื้อสัตว์หั่นเป็นชิ้นพอคำ จุ่มลงทอดในน้ำมันร้อน และนำมาจิ้มด้วยซอส

คำถาม

1. ฟงดูว์ถูกยกให้เป็นอาหารประจำชาติของประเทศสวิสเซอร์แลนด์เมื่อไร

◯ ในคริสต์ทศววรษที่ 1630

◯ ในคริสต์ทศววรษที่ 1690

◯ ในคริสต์ทศววรษที่ 1930

◯ ในคริสต์ทศววรษที่ 1950

2. ส่วนผสมในข้อใดต่อไปนี้ ไม่ใช่ ส่วนผสมของฟงดูว์ชีส

◯ ชีส

◯ ไข่

◯ ไวน์

◯ น้ำมัน

3. ประโยคใดต่อไปนี้ ถูกต้อง สำหรับฟงดูว์

◯ ฟงดูว์เป็นที่นิยมในซูริคในคริสต์ทศวรรษ 1960

◯ สีต้นตำรับของฟงดูว์จะเสิร์ฟเป็นเนื้อสัตว์หั่นเป็นชิ้น แล้วจุ่มลงไปในน้ำมันหรือน้ำซุปร้อนๆเพื่อให้สุก

◯ ฟงดูว์เป็นที่นิยมในอเมริกาเหนือในคริสต์ทศวรรษ 1980

◯ สูตรสำหรับฟงดูว์ชีสถูกตีพิมพ์ในปี ค.ศ. 1699

2) **แบมฟ์** (Banff)

แบมฟ์ คือเมืองในอุทยานแห่งชาติแบมฟ์ รัฐอัลเบอร์ตาในแคนาดา ตั้งอยู่ในเทือกเขาร็อกกี้เลียบถนนทางหลวง ห่างจากเมืองแคลกะรีทางทิศตะวันตก 126 กิโลเมตร และห่างจากทะเลสาบหลุยส์ทางทิศตะวันออก 58 กิโลเมตร แบมฟ์มีระดับความสูง 1,400 เมตร ถึง 1,630 เมตร ซึ่งสูงเป็นอันดับสองในรัฐอัลเบอร์ตา รองจากทะเลสาบหลุยส์

แบมฟ์เป็นหนึ่งสถานที่ยอดนิยมสำหรับนักท่องเที่ยว เป็นที่รู้จักดีว่ามีภูเขาล้อมรอบและมีน้ำพุร้อน และยังมีเส้นทางเดินเขา ขี่จักรยาน และพื้นที่สำหรับเล่นสกี ซันไชน์วินเลจ นอร์เกย์สกี เลกหลุยส์สกีรีสอร์ท เป็นสามสกีรีสอร์ทที่ตั้งอยู่ในอุทยานแห่งชาตินี้

แบมฟ์ถูกตั้งขึ้นในคริสต์ทศวรรษที่ 1880 หลังจากการสร้างทางรถไฟแคนาเดียนแปซิฟิกผ่านหุบเขาโบว์ โดยในปี ค.ศ. 1883 พนักงานรถไฟสามคนได้พบกับน้ำพุร้อนที่อยู่ข้างๆ กับภูเขาซัลเฟอร์โดยบังเอิญ ต่อมาในปี ค.ศ. 1885 แคนาดาได้ประกาศพื้นที่สงวนขึ้นโดยมีขนาด 26 ตารางกิโลเมตร รอบบริเวณถ้ำและน้ำพุร้อน พื้นที่นี้ถูกส่งเสริมให้เป็นรีสอร์ทและสปาครั้งแรกเพื่อสนับสนุนทางรถไฟแห่งใหม่ และในปี ค.ศ. 1887 พื้นที่นี้ได้ขยายเพิ่มขึ้นเป็น 673 ตารางกิโลเมตร และถูกตั้งชื่อว่า "อุทยานเทือกเขาร็อกกี้" นี่คือจุดเริ่มต้นของ

ระบบอุทยานแห่งชาติของแคนาดา จอร์จ สตีเฟน ประธานาธิบดีของกรมรถไฟแคนนาเดียนแปซิฟิก ได้ตั้งชื่อเมืองแบมฟ์ในปี ค.ศ. 1884 ตามเมืองเกิดของเขาในสก็อตแลนด์

คำถาม

1. เมืองแบมฟ์ถูกตั้งขึ้นเมื่อไร

◯ ในปี ค.ศ. 1883

◯ ในปี ค.ศ.1884

◯ ในปี ค.ศ.1885

◯ ในปี ค.ศ.1887

2. ประโยคในข้อใด ไม่ถูกต้อง เกี่ยวกับเมืองแบมฟ์

◯ เมืองแบมฟ์ มีระดับความสูงที่สุดในรัฐอัลเบอร์ตา

◯ เมืองแบมฟ์ถูกตั้งขึ้นหลังจากการสร้างทางรถไฟแคนาเดียนแปซิฟิก

◯ เมืองแบมฟ์ตั้งอยู่ในเทือกเขาร็อกกี้

◯ เมืองแบมฟ์ถูกตั้งชื่อโดย จอร์จ สตีเฟน

3. อุทยานเทือกเขาร็อกกี้ถูกตั้งขึ้นเมื่อไร

◯ ในปี ค.ศ.1883

◯ ในปี ค.ศ.1884

◯ ในปี ค.ศ 1885

◯ ในปี ค.ศ 1887

3) Text 3: **ฟลามิงโก** (See Flamingo text and questions in Appendix O, section a)

4) **ลามิงตัน** (Lamington)

ลามิงตันเป็นเค้กชิ้นเล็ก ๆ ซึ่งเป็นของทานเล่น หรือนิยมเสิร์ฟในการจิบชายามบ่ายของออสเตรเลีย มีลักษณะเนื้อนุ่มคล้ายฟองน้ำ เป็นทรงสี่เหลี่ยมจตุรัสเคลือบด้วยช็อกโกแลต และโรยด้วยเกล็ดมะพร้าวแห้ง ตัวเค้กมีลักษณะแห้ง ทำให้สามารถดูดซึมซอสช็อกโกแลต และเกล็ดมะพร้าวจะติดอยู่บนซอสได้โดยไม่หลุดออกมา โดยจะถูกทิ้งไว้ค้างคืน เพื่อให้มีการเซ็ทตัว และมีชั้นแยมราสเบอรี่หรือครีมอยู่กลางเค้ก

แม้ต้นกำเนิดของมันยังคลุมเครือ แต่มีความเชื่อว่าชื่อเค้ก มีการตั้งชื่อตามท่านลอร์ดลามิงตัน ผู้ว่าการรัฐควีนส์แลนด์ ซึ่งเคยตกเป็นอาณานิคมของออสเตรเลียระหว่าง ค.ศ.1896 ถึง 1901 แต่ก็เป็นไปได้ว่าชื่อนั้นอาจถูกตั้งจากชื่อท่านผู้หญิงลามิงตัน ภรรยาท่านลอร์ด ที่มีพระนามว่า แมรี่ โอซีเยอร์ แต่เริ่มมีเชื่อมโยงชื่อของเค้กลามิงตันไปยังท่านลอร์ด ตั้งแต่มิถุนายน ค.ศ.1927

แต่ยังมีการถกเถียงเกี่ยวกับเจ้าของสูตร ส่วนใหญ่กล่าวว่า ผู้คิดค้นสูตรคือพ่อครัวชาวฝรั่งเศสประจำตัวท่านลอร์ด นามว่า อาร์เมน กัลแลนด์ ผู้ดูแลกลุ่มแขกที่แวะมาโดยไม่ได้แจ้งล่วงหน้า ซึ่งเขาได้ตัดเค้กเนื้อนุ่มที่เหลืออยู่บางส่วนเป็นชิ้น แล้วจุ่มลงไปในช็อกโกแลตร้อน และนำมากลิ้งในเกล็ดมะพร้าว เห็นได้ชัดว่าเหล่าแขกประทับใจกับการสร้างสรรค์ของเขา จากนั้นเหล่าแขกก็ได้ถามหาสูตรของเค้ก

คำถาม

1. เค้กลามิงตันถูกคิดค้นขึ้นเมื่อใด

○ ในปี ค.ศ. 1801

○ ในปี ค.ศ.1896

○ ในปี ค.ศ.1901

○ ในปี ค.ศ.1927

2. เค้กลามิงตันถูกทำขึ้นครั้งแรกที่ประเทศใด

○ ฝรั่งเศส

○ ออสเตรีย

○ นิวซีแลนด์

○ ออสเตรเลีย

3. ใครเป็นผู้คิดค้นสูตรเค้กลามิงตัน

○ แมรี่ โอซีเยอร์

○ ท่านลอร์ดลามิงตัน

○ อาร์เมน กัลแลนด์

○ ท่านผู้หญิงลามิงตัน

5) Text 5: **โฟลเรียนอโปลิส** (Florianopolis)

โฟลเรียนอโปลิสเป็นเมืองหลวงและเป็นเมืองใหญ่ที่สุดอันดับสองของรัฐซันตากาตารีนา ทางตอนใต้ของบราซิล เมืองนี้ประกอบไปด้วย เกาะซันตากาตารีนา รวมถึงเกาะเล็กรอบ ๆ และบางส่วนเป็นแผ่นดินใหญ่ มีประชากรเกือบครึ่งล้านคน เป็นเมืองที่มีความปลอดภัยตามมาตรฐานของบราซิล และเป็นเมืองที่มีอัตราอาชญากรรมต่ำสุดเป็นอันดับสองของบราซิลในปี ค.ศ. 2014

เศรษฐกิจสำคัญคือ เทคโนโลยีสารสนเทศ การท่องเที่ยว และการบริการ เมืองนี้มีชายหาด 60 แห่งและเป็นศูนย์กลางของการโต้คลื่น นิวยอร์กไทม์รายงานว่า ในปี ค.ศ. 2009 โฟลเรียนอโปลิสถูกจัดให้เป็นเมืองปาร์ตี้ นิตยสารนิวส์วีคได้จัดให้เป็นเมืองที่ติดหนึ่งในสิบของเมืองที่มีการเปลี่ยนแปลงมากที่สุดแห่งหนึ่งของโลกในปี ค.ศ. 2006 เนื่องจากโฟลเรียนอโปลิส เติบโตขึ้นเป็นบ้านหลังที่สอง สำหรับเศรษฐีชาวบราซิล อาร์เจนตินา อเมริกาเหนือ และชาวยุโรป

ประชากรส่วนใหญ่อาศัยอยู่บนแผ่นดินใหญ่ และบนเกาะซันตากาตารีนา และมีชาวประมงจำนวนมากที่อาศัยอยู่บนเกาะ บนเกาะจะมีเรือประมง เครื่องถักลูกไม้ นิทานพื้นเมือง และสถาปัตยกรรมยุคอาณานิคม และยังมี ลาโกว์ ดาคอนไซเกาเป็นทะเลสาบที่ใหญ่ที่สุดบนเกาะ และเป็นที่ที่มีคนมาเที่ยวมากที่สุด โดยส่วนมากนักท่องเที่ยว และคนท้องถิ่นเลือกอาศัยอยู่รอบทะเลสาบ เพราะว่ามีทิวทัศน์ที่สวยงาม ปลอดภัย มีความเป็นธรรมชาติ และมีคุณภาพชีวิตที่ดี

คำถาม

1. ประโยคไหน ไม่ถูกต้อง เกี่ยวกับเมืองโฟลเรียนอโปลิส

○ โฟลเรียนอโปลิสถูกยกให้เป็นเมืองปาร์ตี้ในปี 2006

○ โฟลเรียนอโปลิสเปรียบเสมือนบ้านหลังที่สองสำหรับเศรษฐีชาวยุโรป

○ โฟลเรียนอโปลิสเป็นเมืองหลวงของรัฐซันตากาตารีนา

○ โฟลเรียนอโปลิสเคยเป็นเมืองที่มีอัตราการอาชญากรรมต่ำสุดเป็นอันดับสองของบราซิล

2. โฟลเรียนอโปลิสเป็นศูนย์กลางของกิจกรรม…

○ การเดินทางชันหรือขึ้นเขา

○ การโต้คลื่น

○ สปา

○ โยคะ

3. โดยส่วนใหญ่นักท่องเที่ยวและคนท้องถิ่นมักจะเลือกอยู่อาศัยรอบทะเลสาบบนเกาะซันตากาตารีนา เพราะ….

○ ปลอดภัยและมีทิวทัศน์ที่ดี

○ ปลอดภัยและมีอาหารทะเลที่ดี

○ มีอาหารทะเลที่ดีและมีความเป็นธรรมชาติ

○ มีความเป็นส่วนตัวและเป็นธรรมชาติ

6) **อิคิดนา** (Echidnas)

อิคิดนา หรือรู้จักกันในชื่อของ ตัวกินมดหนาม อาศัยอยู่ในออสเตรเลียและนิวกินี พวกมันกินมดและปลวกเป็นอาหาร แต่มันไม่เหมือนกับตัวกินมดของอเมริกา นอกจากตุ่นปากเป็ดแล้ว ก็มีอิคิดนาเพียง 4 สายพันธุ์ที่เป็นสัตว์เลี้ยงลูกด้วยนม และออกลูกเป็นไข่ มันมีวิวัฒนาการเมื่อ 20-50 ล้านปีที่แล้ว สืบเชื้อสายมาจากตุ่นปากเป็ด ซึ่งมีบรรพบุรุษเป็นสัตว์น้ำ แต่มันได้ปรับตัวมาอาศัยอยู่บนดิน

อิคิดนาถูกตั้งชื่อจากเทพนิยายกรีก ที่ร่างกายท่อนบนเป็นหญิง และท่อนล่างเป็นงู ซึ่งเหมือนกับอินาคิดที่เป็นครึ่งสัตว์เลี้ยงลูกด้วยนม และครึ่งสัตว์เลื้อยคลาน ลักษณะเหมือนเม่นตัวเล็ก ๆ มีสีดำและน้ำตาล ส่วนอิคิดนาเผือกจะมีดวงตาสีชมพูและขนสีขาว อิคิดนาจะมีจมูกที่เรียวยาว เพื่อใช้เป็นทั้งปากและจมูก

อิคิดนาไม่สามารถทนกับอุณหภูมิสูงได้ โดยจะหลบซ่อนตัวอยู่ในโพรงขอนไม้ ซอกหิน เพื่อกำบังจากอากาศที่ร้อนจัด จะพบได้ตามป่า ใต้พุ่มไม้ หรือรากของต้นไม้ บางครั้งมันจะหลบในโพรงของสัตว์อื่น เช่น กระต่าย หรือวอมแบต ด้วยมันมีขนาดใหญ่ จึงทำให้อาณาเขตทับซ้อนกัน แม้ว่าลักษณะภายนอกเป็นแบบนั้น แต่มันว่ายน้ำเก่ง เมื่อว่ายน้ำมันจะเปิดจมูกออกกว้าง และแผ่ขนบนตัวเพื่อให้ทำความสะอาดตัวเอง

คำถาม

1. อิคิดนาเป็นสัตว์ที่อาศัยอยู่ที่ไหน

○ ในออสเตรเลียและอเมริกา

○ ในออสเตรียและอเมริกา

○ ในออสเตรเลียและนิวกีนี

○ ในออสเตรียและนิวกีนี

2. ข้อใดเป็นอาหารของอิคิดนา

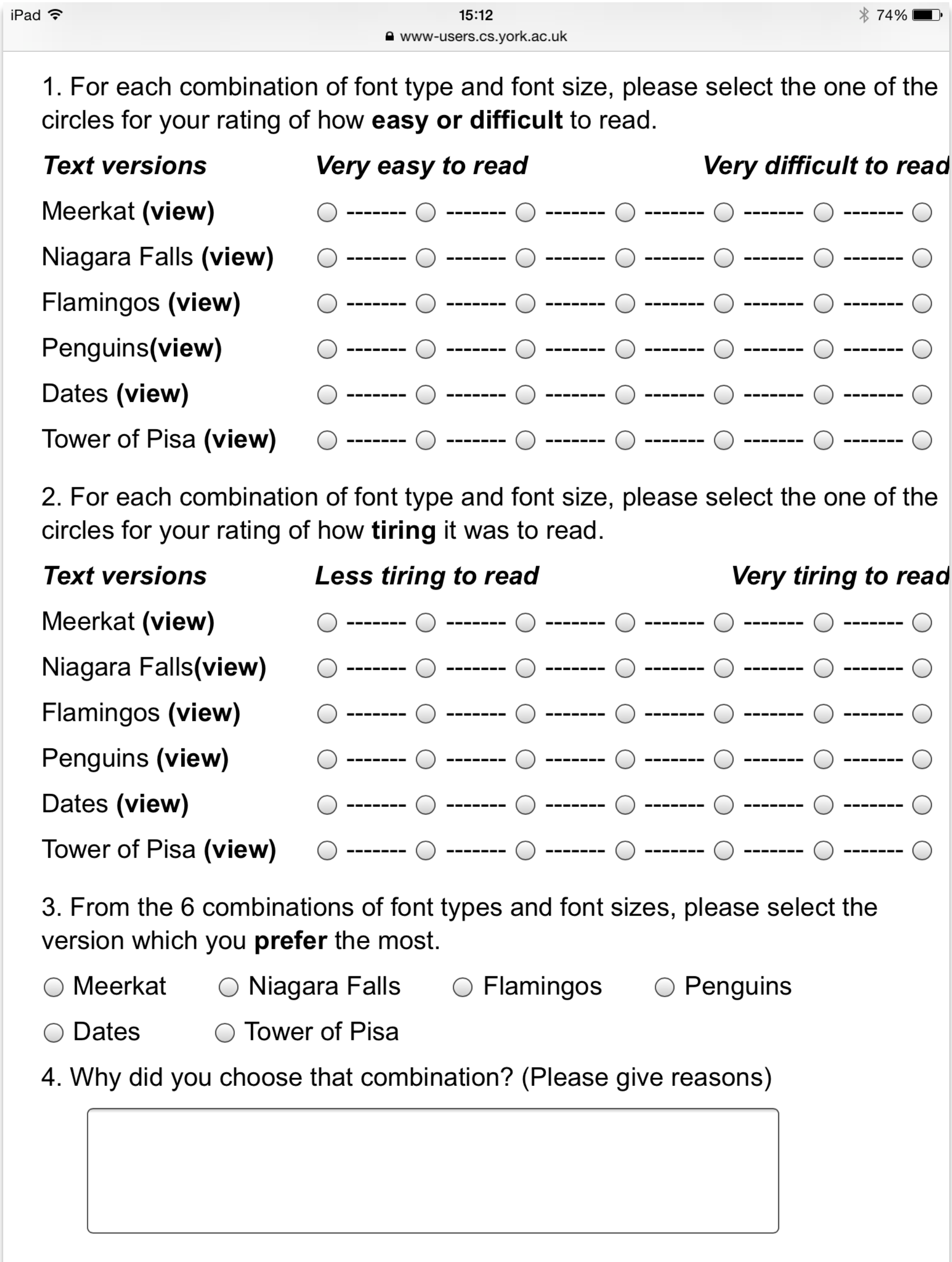
- ◯ มดและวอมแบตเขา
- ◯ กระต่ายและปลวก
- ◯ กระต่ายและวอมแบต
- ◯ มดและปลวก

3. ประโยคใดกล่าว ไม่ถูกต้อง เกี่ยวกับอิคิดนา

- ◯ บรรพบุรุษของอิคิดนาเป็นสัตว์น้ำ
- ◯ อิคิดนาเป็นชื่อที่ถูกตั้งมาจากสัตว์ในเทพนิยายกรีก
- ◯ อิคิดนาเป็นสัตว์เลี้ยงลูกด้วยนม
- ◯ อิคิดนาสามารถอดทนต่ออากาศที่มีความร้อนได้สูง

Appendix P : The example of online closing questionnaire for the study of the effect of text presentations on reading text on tablet computers (for study 2 to 4)

a) Example of online closing questionnaire in English


iPad 15:12 74%
www-users.cs.york.ac.uk

1. For each combination of font type and font size, please select the one of the circles for your rating of how **easy or difficult** to read.

Text versions	***Very easy to read***						***Very difficult to read***
Meerkat **(view)**	○	○	○	○	○	○	○
Niagara Falls **(view)**	○	○	○	○	○	○	○
Flamingos **(view)**	○	○	○	○	○	○	○
Penguins**(view)**	○	○	○	○	○	○	○
Dates **(view)**	○	○	○	○	○	○	○
Tower of Pisa **(view)**	○	○	○	○	○	○	○

2. For each combination of font type and font size, please select the one of the circles for your rating of how **tiring** it was to read.

Text versions	***Less tiring to read***						***Very tiring to read***
Meerkat **(view)**	○	○	○	○	○	○	○
Niagara Falls**(view)**	○	○	○	○	○	○	○
Flamingos **(view)**	○	○	○	○	○	○	○
Penguins **(view)**	○	○	○	○	○	○	○
Dates **(view)**	○	○	○	○	○	○	○
Tower of Pisa **(view)**	○	○	○	○	○	○	○

3. From the 6 combinations of font types and font sizes, please select the version which you **prefer** the most.

○ Meerkat ○ Niagara Falls ○ Flamingos ○ Penguins
○ Dates ○ Tower of Pisa

4. Why did you choose that combination? (Please give reasons)

b) Example of online closing questionnaire in Thai

iPad 15:13 73%

www-users.cs.york.ac.uk

1. กรุณาเลือกระดับ **ความง่ายหรือความยาก** ในการอ่านของท่าน สำหรับแต่ละข้อความที่ีมีการใช้แบบอักษรและขนาดอักษรแตกต่างกัน

ข้อความ	*ง่ายต่อการอ่านมาก*						*ยากต่อการอ่านมาก*
เมียร์แคท **(ข้อความ)**	○	○	○	○	○	○	○
น้ำตกไนแอการา **(ข้อความ)**	○	○	○	○	○	○	○
ฟลามิงโก **(ข้อความ)**	○	○	○	○	○	○	○
เพนกวิน **(ข้อความ)**	○	○	○	○	○	○	○
อินทผลัม **(ข้อความ)**	○	○	○	○	○	○	○
หอเอนเมืองปิซา **(ข้อความ)**	○	○	○	○	○	○	○

2. กรุณาเลือกระดับ **ความเหนื่อยล้า**ในการอ่านของท่าน สำหรับแต่ละข้อความที่ีมีการใช้แบบอักษรและขนาดอักษรแตกต่างกัน

ข้อความ	*เหนื่อยล้าต่อการอ่านน้อย*						*เหนื่อยล้าต่อการอ่านมาก*
เมียร์แคท **(ข้อความ)**	○	○	○	○	○	○	○
น้ำตกไนแอการา **(ข้อความ)**	○	○	○	○	○	○	○
ฟลามิงโก **(ข้อความ)**	○	○	○	○	○	○	○
เพนกวิน **(ข้อความ)**	○	○	○	○	○	○	○
อินทผลัม **(ข้อความ)**	○	○	○	○	○	○	○
หอเอนเมืองปิซา **(ข้อความ)**	○	○	○	○	○	○	○

3. จากข้อความทั้ง 6 รูปแบบที่มีแบบอักษรและขนาดอักษรที่แตกต่างกัน ท่าน**ชื่นชอบ**รูปแบบไหนมากที่สุด

○ เมียร์แคท ○ น้ำตกไนแอการา ○ ฟลามิงโก ○ เพนกวิน
○ อินทผลัม ○ หอเอนเมืองปิซา

4. ทำไมท่านถึงเลือกข้อความชุดนั้น (กุณาบอกเหตุผลด้วยค่ะ)

Appendix Q: Post-study debriefs for the study of the effect of text presentation on reading text on tablet computers

a) Debrief in English

In this study, I was interested in how should we use (font type and font size/ combination between text and background colours/ column formats and text justification) on tablet computers that will suit for older users' reading.

Moreover, we would be publicizing to developers of programs for tablets for older users. Would you like a short report about the results of this study – we can send that to you in a couple of months.

Do you have any questions?

Could you please complete Part B of the informed consent form for me?

Thank you very much for your participation.

b) Debrief in Thai

ในการศึกษานี้ ผู้วิจัยสนใจว่าควรจะใช้ (แบบอักษรและขนาดแบบอักษร / การผสมระหว่างสีข้อความและสีพื้นหลัง / รูปแบบคอลัมน์และการจัดข้อความ) บนคอมพิวเตอร์แท็บเล็ตอย่างไร เพื่อให้เหมาะสำหรับการอ่านของผู้สูงอายุ

นอกจากนี้ผู้วิจัยจะเผยแพร่ผลสรุปของการศึกษานี้ เพื่อเป็นการเป็นทางในการออกแบบและพัฒนาสำหรับให้ผู้พัฒนาโปรแกรมหรือเว็บไซต์สำหรับผู้สูงอายุ หากท่านต้องทราบการสรุปการทดลองนี้ - ผู้วิจัยสามารถส่งไปให้ท่านได้ ภายหลังจากการเสร็จสิ้นการทดลองนี้ประมาณสองถึงสามเดือนค่ะ

ท่านมีคำถามหรือข้อสงสัยจะถามหรือไม่?

ขอความกรุณาท่านช่วยเซ็นลายมือชื่อในหนังสือเจตนายินยอมเข้าร่วมการวิจัย ในส่วนที่ 2 ด้วยค่ะ

ขอขอบคุณอย่างมากสำหรับการเข้าร่วมการวิจัยในครั้งนี้

Appendix R : Counterbalancing of text and background colours

Latin Square with two treatment variables and balancing for carry-over (sequence effects):

Text	Colour Combination
T1 = Maple Syrup	CC1 = Black text on white background
T2 = Taj Mahal	CC2 = White text on Black background
T3 = Peafowl	CC3 = Black text on buff background
T4 = Dead Sea	CC4 = Sepia text on buff background
T5 = Brownies	CC5 = Black text on light blue background

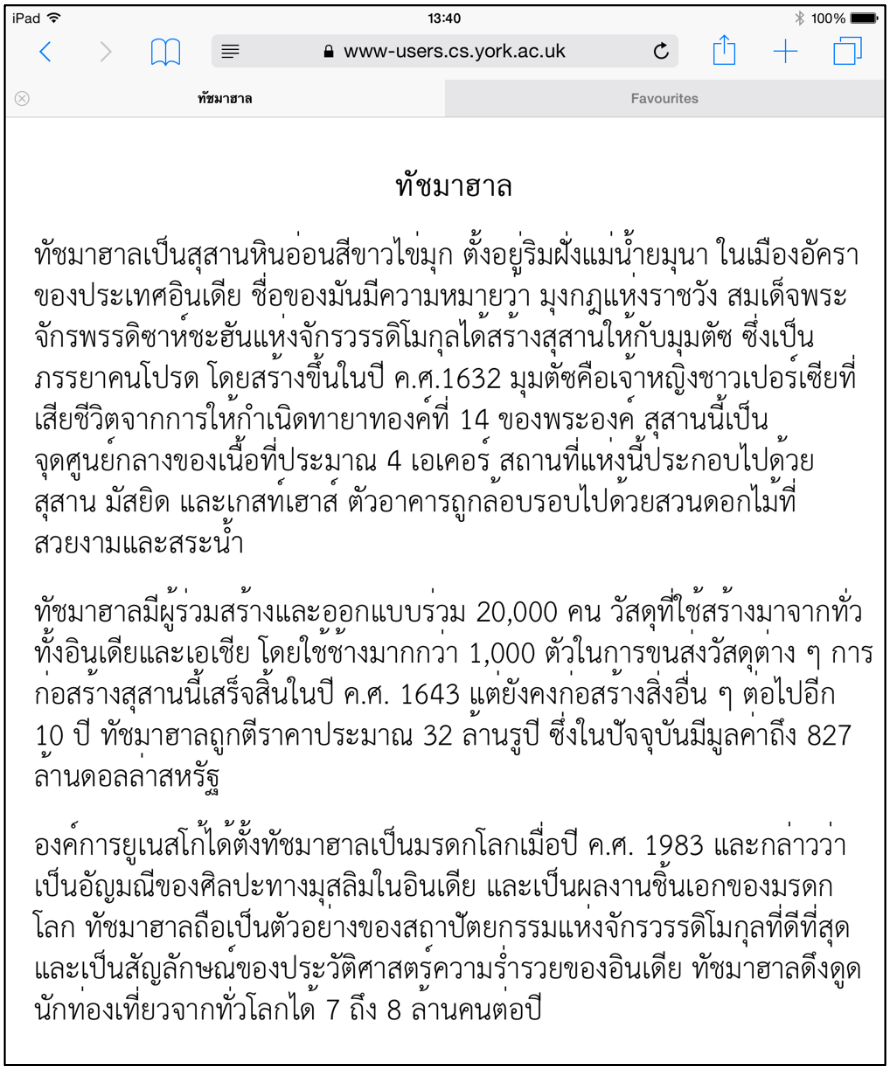
Order/ Participant No.	1	2	3	4	5
Participant 1	Maple Syrup T1-CC3	Brownies T5 – CC4	Taj Mahal T2 – CC2	Dead Sea T4 – CC5	Peafowl T3 – CC1
Participant 2	Taj Mahal T2 – CC4	Maple Syrup T1 – CC5	Peafowl T3 – CC3	Brownies T5 – CC1	Dead Sea T4 – CC2
Participant 3	Peafowl T3 - CC5	Taj Mahal T2 – CC1	Dead sea T4 – CC4	Maple Syrup T1 – CC2	Brownies T5 – CC3
Participant 4	Dead Sea T4 – CC1	Peafowl T3 - CC2	Brownies T5 - CC5	Taj Mahal T2 – CC3	Maple Syrup T1 – CC4

Order/ Participant No.	1	2	3	4	5
Participant 5	Brownies T5 - CC2	Dead Sea T4 – CC3	Maple Syrup T1 – CC1	Peafowl T3 – CC4	Taj Mahal T2 – CC5
Participant 6	Peafowl T3 – CC1	Dead Sea T4 – CC5	Taj Mahal T2 – CC2	Brownies T5 – CC4	Maple Syrup T1 – CC3
Participant 7	Dead Sea T4 – CC2	Brownies T5 – CC1	Peafowl T3 – CC3	Maple Syrup T1 – CC5	Taj Mahal T2 – CC4
Participant 8	Brownies T5 – CC3	Maple Syrup T1 – CC2	Dead Sea T4 – CC4	Taj Mahal T2 – CC1	Peafowl T3 - CC5
Participant 9	Maple Syrup T1 - CC4	Taj Mahal T2 – CC3	Brownies T5 – CC5	Peafowl T3 – CC2	Dead Sea T4 – CC1
Participant 10	Taj Mahal T2 – CC5	Peafowl T3 – CC4	Maple Syrup T1 – CC1	Dead Sea T4 – CC3	Brownies T5 – CC2

Appendix S : The examples of combination of text and background colour and the colour difference and brightness contrast for colour combinations

a) The combination of text colour and background colour in study 3

- Black text on White background (Thai text)



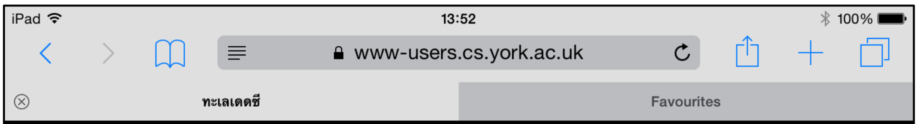
ทัชมาฮาล

ทัชมาฮาลเป็นสุสานหินอ่อนสีขาวไข่มุก ตั้งอยู่ริมฝั่งแม่น้ำยมุนา ในเมืองอัครา ของประเทศอินเดีย ชื่อของมันมีความหมายว่า มงกุฎแห่งราชวัง สมเด็จพระจักรพรรดิชาห์ชะฮันแห่งจักรวรรดิโมกุลได้สร้างสุสานให้กับมุมตัซ ซึ่งเป็นภรรยาคนโปรด โดยสร้างขึ้นในปี ค.ศ.1632 มุมตัซคือเจ้าหญิงชาวเปอร์เซียที่เสียชีวิตจากการให้กำเนิดทายาทองค์ที่ 14 ของพระองค์ สุสานนี้เป็นจุดศูนย์กลางของเนื้อที่ประมาณ 4 เอเคอร์ สถานที่แห่งนี้ประกอบไปด้วยสุสาน มัสยิด และเกสท์เฮาส์ ตัวอาคารถูกล้อมรอบไปด้วยสวนดอกไม้ที่สวยงามและสระน้ำ

ทัชมาฮาลมีผู้ร่วมสร้างและออกแบบร่วม 20,000 คน วัสดุที่ใช้สร้างมาจากทั่วทั้งอินเดียและเอเชีย โดยใช้ช้างมากกว่า 1,000 ตัวในการขนส่งวัสดุต่าง ๆ การก่อสร้างสุสานนี้เสร็จสิ้นในปี ค.ศ. 1643 แต่ยังคงก่อสร้างสิ่งอื่น ๆ ต่อไปอีก 10 ปี ทัชมาฮาลถูกตีราคาประมาณ 32 ล้านรูปี ซึ่งในปัจจุบันมีมูลค่าถึง 827 ล้านดอลล่าสหรัฐ

องค์การยูเนสโก้ได้ตั้งทัชมาฮาลเป็นมรดกโลกเมื่อปี ค.ศ. 1983 และกล่าวว่าเป็นอัญมณีของศิลปะทางมุสลิมในอินเดีย และเป็นผลงานชิ้นเอกของมรดกโลก ทัชมาฮาลถือเป็นตัวอย่างของสถาปัตยกรรมแห่งจักรวรรดิโมกุลที่ดีที่สุด และเป็นสัญลักษณ์ของประวัติศาสตร์ความร่ำรวยของอินเดีย ทัชมาฮาลดึงดูดนักท่องเที่ยวจากทั่วโลกได้ 7 ถึง 8 ล้านคนต่อปี

- White text on Black background colour (Thai text)



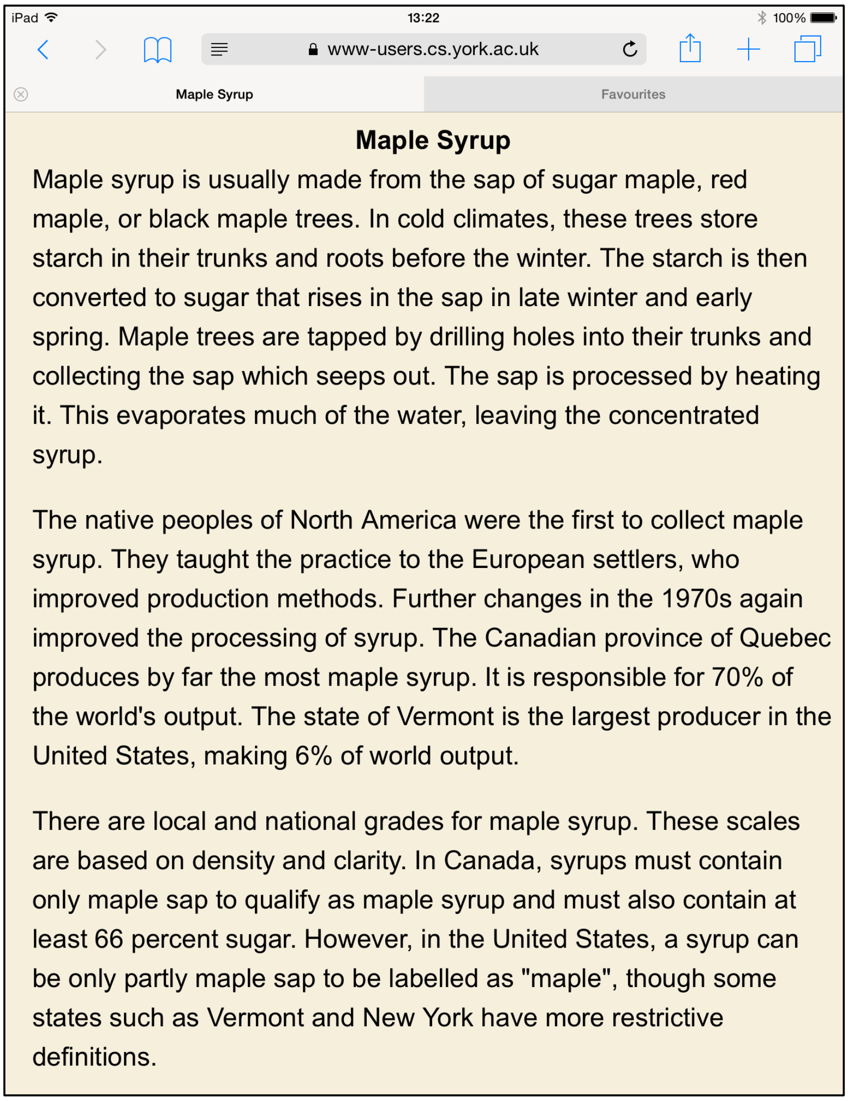
ทะเลเดดซี

ทะเลเดดซีเป็นทะเลสาบน้ำเค็ม ที่มีพรมแดนติดกับประเทศอิสราเอล และปาเลสไตน์ทางตะวันตก และทางตะวันออกของประเทศจอร์แดน เป็นทะเลที่เค็มที่สุดแห่งหนึ่งของโลก โดยความลึกอยู่ที่ 304 เมตร และมีความเข้มข้นของเกลือสูงมากที่สุดในโลก ซึ่งมีความเค็มกว่าน้ำทะเลปกติเกือบ 10 เท่า จึงทำให้สามารถลอยตัวในน้ำได้ และด้วยความเค็มนี้ทำให้ไม่มีสิ่งมีชีวิตอยู่ได้เลย ด้วยเหตุนี้จึงเป็นเรียกว่าทะเลเดดซี แหล่งน้ำหลักของทะเลนี้คือแม่น้ำจอร์แดน

ทะเลเดดซีเป็นแหล่งที่ชื่นชอบของนักท่องเที่ยวรอบทะเลเมดิเตอร์เรเนียนเป็นเวลาหลายพันปี และยังเป็นหนึ่งในรีสอร์ทเพื่อสุขภาพแห่งแรกของโลก ซึ่งถูกเยี่ยมชมโดยพระเจ้าเฮโรดมหาราช และยังถูกนำมาสร้างเป็นผลิตภัณฑ์หลากหลายตั้งแต่สมัยโบราณ รวมถึงยางมะตอยที่ใช้สำหรับการรักษาศพของชาวอียิปต์โบราณ ผู้คนยังคงใช้เกลือและแร่ธาตุจากทะเลเดดซีมาทำเครื่องสำอางและถุงใส่เครื่องหอม

ขณะนี้น้ำทะเลเดดซีกำลังลดลงในอัตราที่น่าตกใจ หลายคลองและท่อลำเลียงน้ำได้ลดลง ซึ่งทำให้เกิดปัญหาขึ้น โครงการขนส่งน้ำเรดซีและเดดซี ซึ่งดำเนินการโดยจอร์แดน จะจัดหาน้ำจากประเทศเพื่อนบ้าน โดยน้ำเค็มที่เกิดขึ้นมาจะนำไปที่เดดซี เพื่อช่วยให้ระดับน้ำเสถียร โดยระยะแรกของโครงการจะเริ่มในปี ค.ศ. 2018 และจะเสร็จสิ้นในปี ค.ศ. 2021

- Black text on Buff background colour (English text)



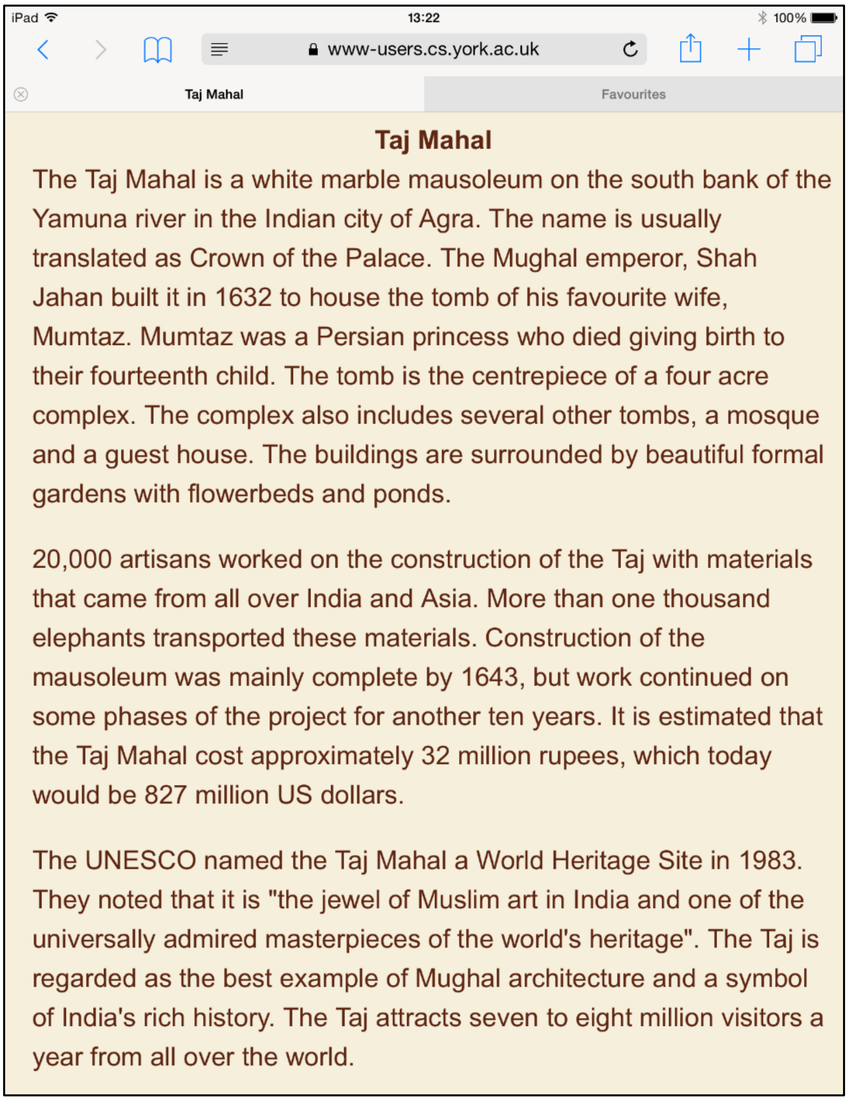
Maple Syrup

Maple syrup is usually made from the sap of sugar maple, red maple, or black maple trees. In cold climates, these trees store starch in their trunks and roots before the winter. The starch is then converted to sugar that rises in the sap in late winter and early spring. Maple trees are tapped by drilling holes into their trunks and collecting the sap which seeps out. The sap is processed by heating it. This evaporates much of the water, leaving the concentrated syrup.

The native peoples of North America were the first to collect maple syrup. They taught the practice to the European settlers, who improved production methods. Further changes in the 1970s again improved the processing of syrup. The Canadian province of Quebec produces by far the most maple syrup. It is responsible for 70% of the world's output. The state of Vermont is the largest producer in the United States, making 6% of world output.

There are local and national grades for maple syrup. These scales are based on density and clarity. In Canada, syrups must contain only maple sap to qualify as maple syrup and must also contain at least 66 percent sugar. However, in the United States, a syrup can be only partly maple sap to be labelled as "maple", though some states such as Vermont and New York have more restrictive definitions.

- Sepia text on Buff background colour (English text)



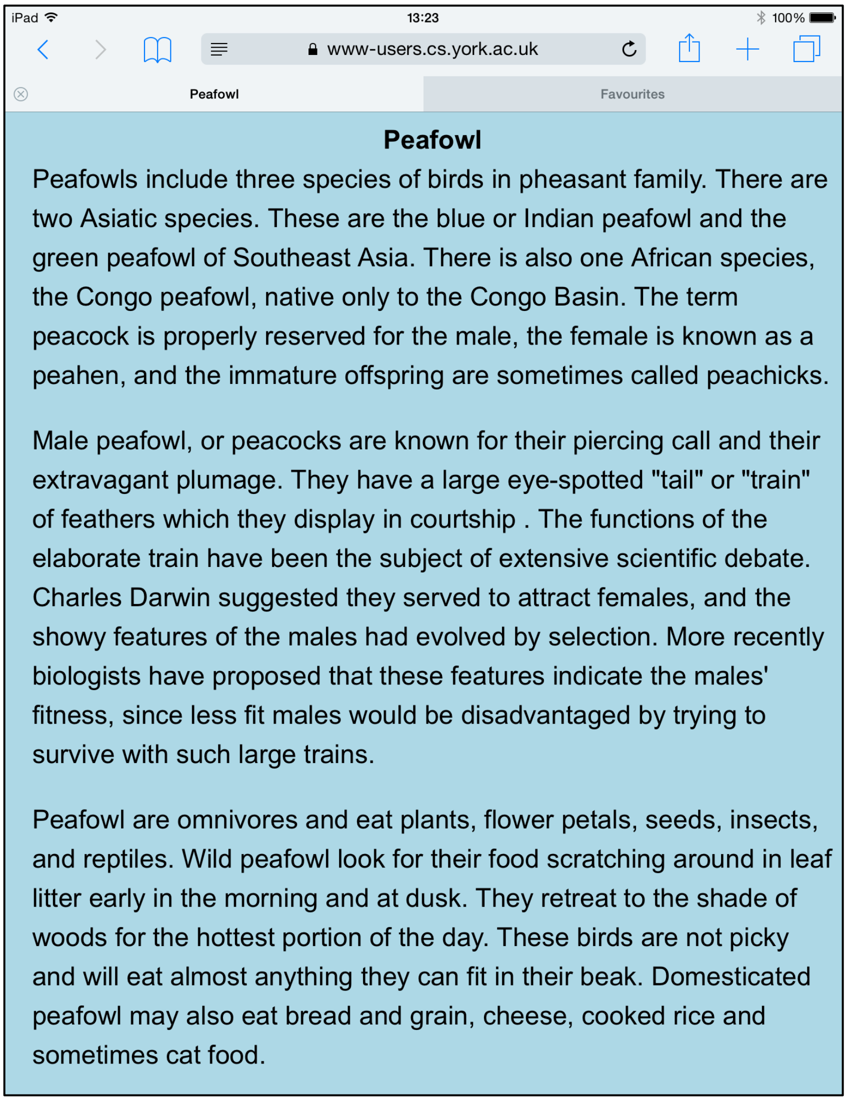
Taj Mahal

The Taj Mahal is a white marble mausoleum on the south bank of the Yamuna river in the Indian city of Agra. The name is usually translated as Crown of the Palace. The Mughal emperor, Shah Jahan built it in 1632 to house the tomb of his favourite wife, Mumtaz. Mumtaz was a Persian princess who died giving birth to their fourteenth child. The tomb is the centrepiece of a four acre complex. The complex also includes several other tombs, a mosque and a guest house. The buildings are surrounded by beautiful formal gardens with flowerbeds and ponds.

20,000 artisans worked on the construction of the Taj with materials that came from all over India and Asia. More than one thousand elephants transported these materials. Construction of the mausoleum was mainly complete by 1643, but work continued on some phases of the project for another ten years. It is estimated that the Taj Mahal cost approximately 32 million rupees, which today would be 827 million US dollars.

The UNESCO named the Taj Mahal a World Heritage Site in 1983. They noted that it is "the jewel of Muslim art in India and one of the universally admired masterpieces of the world's heritage". The Taj is regarded as the best example of Mughal architecture and a symbol of India's rich history. The Taj attracts seven to eight million visitors a year from all over the world.

- Black text on Light Blue background colour (English text)



Peafowl

Peafowls include three species of birds in pheasant family. There are two Asiatic species. These are the blue or Indian peafowl and the green peafowl of Southeast Asia. There is also one African species, the Congo peafowl, native only to the Congo Basin. The term peacock is properly reserved for the male, the female is known as a peahen, and the immature offspring are sometimes called peachicks.

Male peafowl, or peacocks are known for their piercing call and their extravagant plumage. They have a large eye-spotted "tail" or "train" of feathers which they display in courtship . The functions of the elaborate train have been the subject of extensive scientific debate. Charles Darwin suggested they served to attract females, and the showy features of the males had evolved by selection. More recently biologists have proposed that these features indicate the males' fitness, since less fit males would be disadvantaged by trying to survive with such large trains.

Peafowl are omnivores and eat plants, flower petals, seeds, insects, and reptiles. Wild peafowl look for their food scratching around in leaf litter early in the morning and at dusk. They retreat to the shade of woods for the hottest portion of the day. These birds are not picky and will eat almost anything they can fit in their beak. Domesticated peafowl may also eat bread and grain, cheese, cooked rice and sometimes cat food.

b) The colour difference and brightness contrast for combinations of colour

Text colour on background colour	Colour Difference	Colour Brightness Contrast	Ratio of contrast[1]
Black on White	765	255	21:1
White on Black	765	255	21:1
Black on Buff	704	239	18:1
Sepia on Buff	554	187	10:1
Black on light blue	619	205	14:1

Note: Black colour = #000000
White colour = #FFFFFF
Buff colour = #F5EFDC
Sepia colour = #5E2612
Light Blue colour = #ADD8E6

[1] level AA requires a contrast ratio of at least 4.5:1 for normal text (14 point) and 3:1 for large text (18 point) and level AAA requires a contrast ratio of at least 7:1 for normal text and 4.5:1 for large text (source: Web Content Accessibility Guidelines (WCAG) 2.0 https://www.w3.org/TR/WCAG20/).

Appendix T : Counterbalancing of column format and text justification

Texts	Column formats	Text justifications
T1 = Fondue T2 = Banff T3 = Flamingos T4 = Lamington T5 = Florianopolis T6 = Echidnas	1C = A format of one column 2C = A format of two column 3C = A format of three column	LJ = Left justification LRJ = Left-Right justification

Order/ Participant No.	1	2	3	4	5	6
Participant 1	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ
	T1	T2	T3	T4	T5	T6
Participant 2	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ
	T2	T3	T4	T5	T6	T1
Participant 3	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ
	T3	T4	T5	T6	T1	T2
Participant 4	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ
	T4	T5	T6	T1	T2	T3

Order/ Participant No.	1	2	3	4	5	6
Participant 5	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ
	T5	T6	T1	T2	T3	T4
Participant 6	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ
	T6	T1	T2	T3	T4	T5
Participant 7	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ
	T2	T3	T4	T5	T6	T1
Participant 8	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ
	T3	T4	T5	T6	T1	T2
Participant 9	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ
	T4	T5	T6	T1	T2	T3
Participant 10	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ
	T5	T6	T1	T2	T3	T4
Participant 11	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ
	T6	T1	T2	T3	T4	T5
Participant 12	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ
	T1	T2	T3	T4	T5	T6
Participant 13	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ
	T3	T4	T5	T6	T1	T2
Participant 14	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ

Order/ Participant No.	1	2	3	4	5	6
	T4	T5	T6	T1	T2	T3
Participant 15	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ
	T5	T6	T1	T2	T3	T4
Participant 16	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ
	T6	T1	T2	T3	T4	T5
Participant 17	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ
	T1	T2	T3	T4	T5	T6
Participant 18	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ
	T2	T3	T4	T5	T6	T1
Participant 19	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ
	T4	T5	T6	T1	T2	T3
Participant 20	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ
	T5	T6	T1	T2	T3	T4
Participant 21	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ
	T6	T1	T2	T3	T4	T5
Participant 22	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ
	T1	T2	T3	T4	T5	T6
Participant 23	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ
	T2	T3	T4	T5	T6	T1

Order/ Participant No.	1	2	3	4	5	6
Participant 24	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ
	T3	T4	T5	T6	T1	T2
Participant 25	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ
	T5	T6	T1	T2	T3	T4
Participant 26	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ
	T6	T1	T2	T3	T4	T5
Participant 27	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ
	T1	T2	T3	T4	T5	T6
Participant 28	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ
	T2	T3	T4	T5	T6	T1
Participant 29	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ
	T3	T4	T5	T6	T1	T2
Participant 30	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ
	T4	T5	T6	T1	T2	T3
Participant 31	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ
	T6	T1	T2	T3	T4	T5
Participant 32	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ
	T1	T2	T3	T4	T5	T6
Participant 33	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ

Order/ Participant No.	1	2	3	4	5	6
	T2	T3	T4	T5	T6	T1
Participant 34	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ
	T3	T4	T5	T6	T1	T2
Participant 35	1C-LRJ	2C-LJ	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ
	T4	T5	T6	T1	T2	T3
Participant 36	2C-LRJ	3C-LJ	3C-LRJ	1C-LJ	1C-LRJ	2C-LJ
	T5	T6	T1	T2	T3	T4

Appendix U: The effect of tablet orientation on reading performance for younger and older people

1. Introduction

As the text presentation studies had the different tablet orientations for participants' reading in the experiments. Participants read the texts on the tablet in portrait view in study 2 and 3 while participants read the texts on the tablet in landscape view in study 4. Thus, this is a preliminary study to investigate the effect of tablet orientation on reading performance in order to support the tablet orientation for my programme of research.

2. Method

This study used data from study 2 and study 4 as the researcher used one text as the same text (as Flamingo text) for both studies. However, two studies used different text presentation variables as independent variables. The study 2 focused on the effect of font type and font size on reading performance for younger and older people. (see Chapter 4). The study 4 focused on the column formats and text justifications on reading performance for younger and older people (see Chapter 6). Although, two studies had different text presentation variables, but the research selected only the data of UK participants in order to control the text presentation variables (such as font type, font size) for the analysis of the effect of tablet orientation on reading performance.

For study 2, participants read the texts on the tablet in portrait view. The texts were presented in different combinations of font type and font size, but they were presented in one column and left justification. Thus, the data of younger and older UK participants who read the flamingo text in Arial font with 18 point were used in this analysis.

For study 4, participants read texts on the tablet in landscape view. The texts were presented in different combinations of column format and text justification, but they were presented in Arial font, 18 point. The data of younger and older UK participants who read the flamingo text in one column with left justification were used in the analysis.

The text of this study was presented in 18 point Arial font and in one column format with left text justified. The materials and procedures of the two studies were the same, except only of the tablet orientation for participants' reading.

Therefore, the independent variables were the tablet orientations (Portrait and Landscape) and age groups (younger and older people). Reading time and the comprehension scores were analysed as dependent variables.

3. Participants

Twenty-four UK participants took part in the study, 12 younger participants and 12 older participants. The younger participants comprised 6 men and 6 women, their ages ranged from 18 to 22 years (a mean of 19.83 years). The older participants comprised 6 men and 6 women, their ages ranged from 65 to 82 years (a mean of 70.58 years). Three younger participants and nine older participants and wore the glasses for reading. Two younger participants and one older participant wore contact lenses for reading.

Although seven older participants and three younger participants participated in both study 2 and 4 but this was not affected with reading the same text. Due to both studies had a year gap between each study (as study 2 conducted in 2018 and study 4 conducted in 2019). Moreover, the research did ask all participants about the reading experience with the texts for every study (study 2, 3 and 4). They stated the they have not read the texts before the studies.

4. Data analysis

A Shapiro-Wilk test showed that reading times was normally distributed ($p > .05$) while comprehension was not normally distributed ($p < .05$). Thus, two-way ANOVA was used for reading time analysis and Mann-Whitney U test was used for comprehension scores analysis.

5. Results

1) Reading time

Two-way ANOVA revealed that there was no significant main effect for tablet orientation in reading time ($F_{(1, 20)} = 3.89$, $p = >.05$, $\eta_p^2 = .16$). The mean reading time for portrait was 47.08 seconds ($SD = 16.46$) whereas the mean reading time for landscape was 63.75 seconds ($SD = 26.04$). There was also no significant main effect for age group ($F_{(1, 20)} = 1.75$, $p = >.05$, $\eta_p^2 = .08$). The mean reading time of younger participants was 49.83 seconds ($SD = 18.71$) while the mean reading time of older participants was 61.00 seconds ($SD = 26.12$). In addition, there was no significant interaction between these variables ($F_{(1, 20)} = 2.62$, $p = > .05$, $\eta_p^2 = .12$).

2) Comprehension score

The Mann-Whitney U test revealed that there was no significant diffidence in comprehension scores overall between portrait and landscape views. ($U = 64.00$, $p = .61$, $r = .10$). The median comprehension score overall for portrait view was 2.00 points out of 3.00 points ($IQR = 1.00$) whereas the median comprehension score overall for landscape view was 3.00 points ($IQR = 1.00$). In addition, there was no significant diffidence in comprehension scores overall between younger and older participants (U = 55.00, p = .28, r = .22). The median comprehension score overall of younger participants was 3.00 points out of 3 (IQR = 1.00) while the median comprehension score overall of older participants was 2.00 points (IQR = 1.00).

6. Discussion and Conclusion

This study focused on the effect of tablet orientation for reading on a tablet computer that investigated reading performance in order to support the use of tablet orientation for this programme of research. Overall, this can be seen that tablet orientation no effect on reading time and comprehension scores for both younger and older UK participants. However, this study had a small number of participants and all participants were UK people. These results may be difference with a big number of participants or with participants in other countries. Moreover, this study had some limitations as discussed in the Studies 2 and 4 (Chapter 4 see and Chapter 6).

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