The impact of bilingual subtitles on attention distribution and cognitive load: An eye tracking study

Sixin Liao

BA, Guangdong University of Foreign Studies, 2014

MA, University of Manchester, 2015

Faculty of Human Sciences

Department of Linguistics Macquarie University

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Abstract

This study investigated the impact of subtitle mode on viewers' visual attention distribution, cognitive load and overall comprehension of the video's content. Twenty Chinese native speakers watched four videos with English narration, each in a different condition: with English subtitles (intralingual subtitles), with Chinese subtitles (interlingual subtitles), with both Chinese and English subtitles (bilingual subtitles), and without subtitles. Their eye movements were recorded by means of a remote eye tracker while watching the video. After watching each video, they were asked to complete a post hoc Likert scale questionnaire to self-report three types of cognitive load and mental effort in information acquisition. A free recall test was also used to evaluate viewers' comprehension of the video. Results showed that viewers' visual attention to L1 subtitles was more stable than that to L2 subtitles and less sensitive to the increased visual competition in the bilingual condition, which could be attributed to the language dominance of their native language. Bilingual subtitles did not create more cognitive load or produce more cognitive gain than monolingual subtitles. However, compared with the no subtitles condition, bilingual subtitles were found to be more beneficial as they provided linguistic support to make the video easier to comprehend and facilitate the learning process.

Statement of Candidate

I certify that the work in this thesis entitled "The impact of bilingual subtitles on attention distribution and cognitive load: An eye tracking study" has not previously been submitted for a degree, nor has it been submitted as part of requirements for a degree, to any university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and that it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

The research presented in this thesis was approved by Macquarie University Ethics Review Committee (reference number: 5201700464).

Sixin Liao Sixin Liao 廖思欣

Student ID: 44724276

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Chapter 1. Introduction

This chapter consists of three sections. It begins with an introduction to the research background (1.1), underlining the unexplored and yet valuable research issues that inspired the current study. The second section outlines three research questions that this study sets out to address (1.2), followed by a structure of the thesis in the last section (1.3).

1.1 Research Background

Advances in technologies have facilitated the production and dissemination of audiovisual products around the world, for instance, videos distributed through online video sharing platforms such as TED Talks or online programs from educational institutions. In order to minimize the language barrier for audiences of diverse linguistic backgrounds, subtitling, which provides transcription or translation of the spoken dialogue, has become increasingly widespread (Aparicio & Bairstow, 2016; Kruger & Doherty, 2016).

Based on linguistic parameters, subtitles can be categorized into three types, namely intralingual subtitles (subtitles in the same language as the spoken dialogue), interlingual subtitles (subtitles in a different language from the spoken dialogue), and bilingual subtitles (encompassing both intralingual and interlingual subtitles) (Díaz Cintas & Remael, 2007). Compared with intralingual and interlingual subtitles, bilingual subtitles are less explored as they are normally used in a small number of

multilingual countries such as Belgium and Finland (Kuo, 2014; Pedersen, 2011). However, recent years have seen an increase in the use of bilingual subtitles, particularly in Mainland China. This is beginning to draw more scholarly attention to this particular subtitle mode.

One distinct advantage of bilingual subtitles is that they make audiovisual products accessible to both native and foreign audiences at the same time by providing dual communication channels in two different languages. For this reason China Central Television (known as CCTV), the dominant TV broadcaster in China, is promoting the use of bilingual subtitles in TV programs to attract a wider audience ("CCTV's efforts to produce bilingual subtitles," 2015). Bilingual subtitles have also been hailed as an effective tool in language learning as they combine the benefits of both intralingual and interlingual subtitles, with intralingual subtitles providing the written forms of spoken words that can facilitate vocabulary learning and interlingual subtitles providing the meaning (translation) of words that can enhance viewers' comprehension and absorption of the content (García, 2017). Bilingual subtitles are therefore particularly favored by language learners in China (Li, 2016; Liu, 2014).

While subtitling has long been a focus of investigation, previous studies mostly focused on the effects of subtitles on language learning. Few have attempted to explore their impact on viewers' cognitive load. Research along these lines is of significant value because a more nuanced understanding of the impact of subtitles on the management of cognitive resources allows us to ascertain *how* subtitles affect comprehension and learning outcomes. Watching subtitled videos can place high demands on viewers' attentional and cognitive resources because viewers have to cope with a rich combination of multimodal and multiple-source information: the visual image (visual-

nonverbal), the spoken dialogue (audio-verbal), subtitles (visual-verbal) and background sounds (audio-nonverbal). Processing too much information simultaneously may exceed the limited capacity of working memory and result in cognitive overload (Kalyuga, Chandler, & Sweller, 1999). Additionally, as subtitles compete for visual attention (cf. automatic subtitle reading behavior as demonstrated by d'Yewalle et al. in 1991), the mere presence of subtitles as additional written texts may overburden the visual processing channel and interfere with the processing of other visual elements that could be essential for comprehension (Van der Zee, Admiraal, Paas, Saab, & Giesbers, 2017).

Furthermore, subtitles generate a level of redundancy as they contain information that is partially or completely overlapping with the information presented in other channels (e.g., the visual image and the spoken dialogue). Processing redundant information that is not necessary for learning will take away cognitive resources that could have been available for the processing of essential information and comprehension could therefore be inhabited (Kalyuga & Sweller, 2005). This is sometimes called the redundancy effect.

Although recent years have seen some research endeavors in examining the impact of subtitles on cognitive load (Kruger, Hefer, & Matthew, 2014; Kruger & Doherty, 2016; Kruger, Hefer, & Matthew, 2013; Kruger, Matthew, & Hefer, 2013), progress in this field is still limited by the types of subtitles that are investigated and the measurement of cognitive load. Previous studies have been centered on monolingual subtitles, with little attention being paid to the effects of bilingual subtitles on cognitive load. Compared with monolingual subtitles, processing bilingual subtitles could be more cognitively demanding as the concurrent presence of subtitles in two different

languages are likely to impose a heavy load on working memory and cause cognitive overload.

1.2 Research Objectives

The current study had two objectives. The first objective was to compare the impact of bilingual subtitles to that of monolingual subtitles in terms of viewers' visual attention to subtitles and image. The second objective was to determine whether bilingual subtitles will result in more cognitive gain by combining the benefits of intralingual and interlingual subtitles and thus facilitate comprehension or, alternatively, cause more cognitive load as a result of increased redundancy thus impairing comprehension.

Making use of eye tracking technology and drawing upon Cognitive Load Theory, this study therefore set out to answer the three research questions below.

R1: What is the impact of subtitle mode on visual attention allocation?

(1) Is there any difference in the visual attention allocated to L1 and L2 subtitles between bilingual and monolingual conditions?

(2) Is there any difference in the attention allocated to the visual image between bilingual and monolingual conditions?

R2: What is the impact of subtitle mode on cognitive load? More specifically, do bilingual subtitles give viewers more cognitive benefits or generate more cognitive burdens compared with monolingual subtitles?

R3: What is the impact of subtitle mode on content comprehension? (Do bilingual subtitles enhance or hinder viewers' comprehension of the video compared with monolingual subtitles?)

1.3 Thesis Outline

The remainder of this thesis is structured as follows: Chapter 2 provides a literature review of relevant research in monolingual and bilingual subtitling, cognitive load and eye tracking. Chapter 3 presents the methodology of this study, including sampling, materials, data collection and statistical analyses. Results of data analysis are presented in Chapter 4, followed by a discussion of results in Chapter 5. Chapter 6 concludes with a discussion of findings and contributions of the current study, as well as suggestions for future research.

Chapter 2. Literature Review

This chapter is composed of five sections. The first section begins with a discussion of the advantages and disadvantages of subtitles with reference to the verbal redundancy effect (2.1). The next section (2.2) gives an introduction to three types of subtitles, namely intralingual, interlingual and bilingual subtitles, and reviews the effects of different subtitle modes on comprehension. The third section (2.3) provides an introduction to three types of cognitive load as identified in Cognitive Load Theory and then reviews previous studies that explored the impact of subtitles from a cognitive load perspective. In the fourth section (2.4), the value and use of eye tracking technology in subtitling research are discussed. It concludes with a summary of identified research gaps in the last section (2.5).

2.1 Pros and Cons of Subtitles: Does Redundancy Help or Harm?

Initially used to provide deaf and hard-of-hearing audiences with access to audiovisual products (Gottlieb, 2012), subtitling is a mode of audiovisual translation that transfers orally delivered information to a written text which is usually presented at the bottom of the screen simultaneously with the auditory information (Di Giovanni, 2016; Díaz Cintas & Remael, 2007). The proliferation and global dissemination of audiovisual products that are made possible by online video sharing websites and platforms such as Coursera and TED Talks have led to a wider application of subtitles. Subtitling is currently used widely as an effective method to minimize the language barrier and make

audiovisual products more accessible to global audiences (Aparicio & Bairstow, 2016; Gottlieb, 2012; Kruger et al., 2014). In addition to the lower cost of production compared with dubbing (Moreno, 2017), the growing popularity of subtitling is also attributed to its advantage of giving audiences an authentic taste of the foreign culture through the original auditory dialogue (Hsiao, 2014).

In spite of the widespread use of subtitles, there are divergent views regarding the effects of subtitles. One the one hand, it is believed that subtitles provide on-screen linguistic support that enables viewers, especially foreign language learners, to segment the verbal stream and obtain the meaning of words with greater ease, thus more cognitive resources can be devoted to deeper processing of the video content (cf. Mayer, Lee, & Peebles, 2014). On the other hand, it is argued that subtitles (as a written form of the spoken dialogue) generate redundant information which may not contribute to comprehension but instead distract viewers from effective comprehension or deplete their limited cognitive resources that could have been used to process other essential information (Zheng et al., 2016).

As subtitles represent a form of verbal redundancy[1], a review of the redundancy effect (or to be more specific, the verbal redundancy effect) is necessary to better understand the effects of subtitles. The redundancy effect has been explored extensively in the field

[1] Subtitles do not constitute verbal redundancy when it is the only means to convey verbal information, such as in the case of deaf or hard-of-hearing audiences. However, as this study focused on hearing audiences who had intermediate language proficiency of the spoken dialogue, subtitles thus can be seen as a form of verbal redundancy to these audiences who had access to identical verbal information from both the auditory channel and the visual channel.

of educational psychology, and occurs when presenting the same information in multiple forms and modalities that are not necessary for learning results in less effective learning (Kalyuga & Sweller, 2005; Sweller, Ayres, & Kalyuga, 2011). The redundancy effect has been found in numerous studies using concurrent presentation of written and spoken words in multimedia learning. For instance, Mayer, Heiser and Lonn (2001) found that when students watched narrated video with concurrent on-screen text that summarized or duplicated the narration, they performed worse in retention and transfer texts than did those who only got access to narration. They claimed that the concurrent presentation of on-screen text, narration and other visual information overloaded students' visual information processor, forcing students to split their attention between visual information and causing less cognitive resources available for learning.

Using spoken texts as redundant information, Diao and Sweller (2007) found that concurrent written and verbatim spoken presentation rendered worse comprehension performance at both lexical and text level and caused a higher mental load than the written only presentation when reading in English as a foreign language, which was more obvious when the test was more complex. Based on Cognitive Load Theory, they explained that as novice learners were not able to recognize the sound-symbol relations established by the written text and narration, processing the same information in multiple forms increased extraneous cognitive load that interfered with the comprehension of the information.

However, a number of studies revealed that the redundancy effect does not always manifest itself when written and spoken words are presented concurrently. For instance, a study conducted by Moreno and Mayer (2002a) found that presenting both spoken and written explanations with animation did not hurt learning compared with presenting

only spoken or only written explanations with animation in a multimedia learning environment. They suspected that students may have avoided reading on-screen text and only used spoken narration for verbal information. While this explanation could reasonably account for the absence of the redundancy effect, it needs to be tested by an analysis of students' eye movements.

In an attempt to reconcile the contrasting findings in verbal redundancy research, Adesope and Nesbit (2012) conducted a meta-analysis to examine the effects of verbal redundancy in multimedia learning. Based on statistical analyses of the results of 57 studies, they reported that spoken-written presentations were more advantageous than spoken-only presentation and this advantage was dependent on various moderating factors such as the absence of pictures or animation and the lack of control over the pace of display[2]. They argued that "[a] meaningful interpretation of verbal redundancy effects can only be made by considering moderating conditions including pacing of presentation, degree of correspondence between audio and text, reading fluency of learners, and inclusion of images or animation" (p. 259).

Likewise, Kalyuga (2012) proposed some factors that may moderate the verbal redundancy effect. For instance, he suggested that presenting textual information in small segments could eliminate the negative consequences of cognitive load caused by

[2] They explained that learners could use other channels to enhance comprehension if they misperceive information in one channel when they do not have control over the presentation pace. When learners have control over the presentation pace, they may only use one channel to repeat information for effective comprehension, thus resulting in less obvious benefits of verbal redundancy.

the need to reconcile the written text with the transient spoken words within limited time.

Although the studies of Adesope and Nesbit (2012) and Kalyuga (2012) provide us with a more precise and comprehensive understanding of the verbal redundancy effect by identifying some conditions in which verbal redundancy benefit instead of hindering learning, it remains complicated to determine the effects of subtitles as verbal redundancy. This is the case because subtitles are associated with a combination of the conditions in which verbal redundancy has a facilitative effect (e.g., lack of control over the pace of display and segmented written texts) and conditions in which verbal redundancy has a detrimental effect (e.g., concurrent presence of pictures or animation). Furthermore, as pointed out by Bisson et al. (2014) and Hinkin, Harris and Miranda (2014), research on verbal redundancy mostly focused on multimedia learning using expository prose as experimental materials; relatively less attention has been paid to the redundancy effect in entertainment media, such as films with subtitles.

Although the benefits of subtitles have been well documented, most of these benefits are associated with language learning, such as improving listening comprehension, word recognition, vocabulary acquisition and speech perception (Almeida & Costa, 2014; Bird & Williams, 2002; Gernsbacher, 2015; Linebarger, Piotrowski, & Greenwood, 2010; Matielo, D'Ely, & Baretta, 2015; Mitterer & McQueen, 2009; Saed, Yazdani, & Askary, 2016; Vanderplank, 2013; Wang, 2014). Language gains do not necessarily translate into a gain in overall comprehension as subtitled videos are multimodal in nature and viewers are required to integrate both pictorial and linguistic content for effective comprehension. This view can be supported by previous research

that set out to investigate whether there exists a significant tradeoff between subtitle processing and image processing (Perego, Del Missier, Porta, & Mosconi, 2010).

Going beyond language learning, Lång (2016) investigated the effectiveness of subtitles from the perspective of information acquisition. Fourteen Finnish natives with no knowledge of Russian and twenty Russian natives with sufficient Finnish language skills watched a short documentary narrated in Russian with Finnish subtitles. All viewers were asked to complete a comprehension test that consisted of three types of questions related to details provided by different sources of information, namely narration-related questions (information not included in subtitles), image-related questions (information not included in narration or subtitles) and subtitle-related questions (information included in both subtitles and narration). The Russian group which could acquire information from both L1 narration and L2 subtitles obtained significantly higher scores in the subtitled-related questions than the Finnish group which could only rely on L1 subtitles for verbal information. Lång (2016) therefore concluded that overlapping auditory-verbal (narration) and visual-verbal channels (subtitles) enhanced the acquisition of information[3].

Using similar stimuli (entertainment media content) and testing method (source-specific comprehension test), the study of Lavaur and Bairstow (2011) took a further step to explore whether the comprehension of subtitled films is related to viewers'

[3] It should be noted that the Russian group may not have acquired information from both channels. As narration was provided in the viewer's native language and subtitles in a second language, there could be a possibility that viewers have mainly acquired information from the audio-verbal channel (narration) and did not pay much attention to subtitles, especially when they were not familiar with subtitle reading.

language proficiency. Ninety French native high school students were divided into beginner, intermediate and advanced groups based on their English proficiency. They were asked to watch an English narrated movie extract without subtitles, with English subtitles and with French subtitles, after which they were required to complete a comprehension test that consisted of dialogue-based and visual information. It was found that when watching a movie in a foreign language, subtitles served as a crucial tool for comprehension for viewers with low language proficiency but had a distracting effect on advanced leaners.

An important implication of the study by Lavaur and Bairstow (2011) is that, as is the case with verbal redundancy effects, the effects of subtitles can be influenced by various factors, such as viewers' language proficiency. In addition to language proficiency, factors that have been found to influence the processing and effects of subtitles include age (d'Ydewalle & De Bruycker, 2007; Munoz, 2017), translation strategy of subtitles (Ghia, 2012), text chunking (Rajendran, Duchowski, Orero, Martínez, & Romero-Fresco, 2013), subtitle position (Fox, 2016), and the relation between the language of subtitles and the native language of the viewer (Mitterer & McQueen, 2009).

The current study aims at examining whether the linguistic format of subtitles (i.e., subtitle mode) affects viewers' overall comprehension of video. In particular, by investigating subtitles that feature a higher degree of redundancy, namely bilingual subtitles, this study hopes to shed some light on the role of redundancy in processing subtitled materials.

2.2 Subtitles in Different Linguistic Formats

Based on linguistic parameters, subtitles can be categorized into three types, namely intralingual subtitles, interlingual subtitles and bilingual subtitles (Corrizzato, 2015). Intralingual subtitles (or same-language-subtitles/bimodal subtitles) refer to subtitles that are in the same language as the spoken dialogue, which are primarily used by deaf or hard-of-hearing viewers. Intralingual subtitles that are in viewers' foreign or second language are known as L2 subtitles. Intralingual subtitles are similar to captions and these two terms are used interchangeably in some studies. Both intralingual subtitling and captioning provide a written form of the spoken dialogue in the same language, except that the former does not provide a transcription or translation for nonverbal information such as sound effects or identify speakers (Garza, 1991; Specker, 2008). Interlingual subtitles (or translated subtitles) refer to subtitles that are displayed in a language different from that of the dialogue, normally in viewers' native language. Interlingual subtitles are also known as standard subtitles or L1 subtitles (Raine, 2012).

Different from intralingual and interlingual subtitles which consist of subtitles in only one language, bilingual subtitles (or dual subtitles) present subtitles simultaneously in two different languages. This type of subtitles are used in multilingual countries or regions where two or more languages are spoken, such as Finland, Belgium, Israel, Singapore, Malaysia and Hong Kong (Corrizzato, 2015; Gottlieb, 2004; Kuo, 2014).

In Mainland China, bilingual subtitles are gaining currency as China's dominant TV broadcaster is stepping up its effort to present television programs with subtitles in both English and Chinese in order to attract a wider audience. The increasing usage of bilingual subtitles in online videos is also attributed to the efforts of amateur subtitlers

who translate online foreign language videos on a voluntary basis (Hsiao, 2014; Zhang, 2013). These amateur subtitlers form their own online translation groups (known as fansubbing groups), produce different formats of subtitles and upload subtitled videos to their websites for free download[4].

2.2.1 Monolingual subtitles: intralingual and interlingual subtitles

The benefits of intralingual subtitles and interlingual subtitles have been explored extensively in numerous studies. The earliest large-scale empirical research on the effects of subtitles was conducted by Price (1983). Nearly 500 participants of 20 native language backgrounds were randomly assigned to two groups watching four English excerpts: one group with captions (English language subtitles) and one without captions. Results showed that viewers in the captioned group achieved significantly better comprehension of the linguistic content of the video.

Price's findings are corroborated by the study of Garza (1991), who used a comprehension test and comparative interview to evaluate the effects of captioned video materials on foreign language learning for advanced learners. Participants included seventy English native speakers who used Russian as a foreign language and

[4] Fansubbing groups often create their own websites for video sharing, such as YYets (http://www.yyets.cc/kanview/kanindex47637.html), one of the largest subtitle groups in China.

forty students who used English as a foreign language. It was found that all students performed better in comprehending the linguistic content of the video material when they were provided with captions. He concluded that the use of captions benefited advanced foreign language learners by "bridg[ing] the often sizable gap between the development of skills in reading comprehension and listening comprehension" (p. 246). His study is one of the few that explored subtitles in a language that has significantly different syntactic structure and orthography from that of English and is therefore particularly relevant to this study.

The study of Borras and Llafayette (1994) also found that intralingual subtitles facilitated foreign language learners' comprehension of linguistic content and oral communicative performance. They contended that intralingual subtitles could help viewers "associate the aural and written forms of words more easily and quickly" (p. 70).

In an attempt to provide a quantitative measure of the overall effect of intralingual subtitles on listening comprehension and vocabulary learning, Perez, Noortgate and Desmet (2013) conducted a meta-analysis that synthesized and calculated the effect sizes of primary research on the effectiveness of intralingual subtitles on listening comprehension and vocabulary learning. Their results showed a large effect of intralingual subtitles on listening comprehension and vocabulary acquisition, which confirms previous claims in support of the benefits of intralingual subtitles in language learning.

In spite of the superiority of L2 subtitles over L1 subtitles as demonstrated in a number of studies (see e.g., Markham & Peter, 2003; Markham, Peter, & Mccarthy, 2001), some researchers hold an opposite view, arguing that L1 (interlingual) subtitles are more

beneficial as they prevent inaccurate inferences of word meaning (Aloqaili, 2014; Mitterer & McQueen, 2009). Moreover, it is believed that interlingual subtitles produce more comprehensible input when the written/spoken language is beyond the language proficiency of viewers and the translation of the spoken dialogue can provide viewers with more paths for information retrieval (Danan, 2004).

As pointed out by Borras and Llafayette (1994), the extent to which viewers benefit from intralingual and interlingual subtitles may depend on their language proficiency. For instance, Bianchi and Ciabattoni (2008) reported that L1 subtitles were more facilitative for viewers with lower proficiency and L2 subtitles were more beneficial for advanced language learners.

Vulchanova et al. (2015) carried out a study to investigate the effects of different subtitles on viewers with different language proficiency. Forty-nine 17 year-old and sixty-five 16 year-old Norwegian learners of English were asked to watch an English episode in one of three conditions: without subtitles, with interlingual subtitles (Norwegian subtitles) and with intralingual subtitles (English subtitles). Comprehension questionnaire results showed that both intralingual and interlingual subtitles had positive short-term effects on viewers' plot and content comprehension of the audiovisual materials compared with the no subtitle group. While the 16 year-old age group benefited more from L2 subtitles, the 17 year-old age group seemed to comprehend the video equally well in both L1 and L2 subtitles, a similar result as found for the intermediate language learners in the study of Lavaur and Bairstow (2011).

In a study conducted by Birulés-Muntané and Soto-Faraco (2016), it was found that viewers benefited from intralingual and interlingual subtitles in different ways. While Intermediate Spanish students of English as a foreign language had more significant

improvement in their listening skills after watching L2 subtitled English material, viewers in the L1 subtitled group performed better in plot comprehension.

A review of previous research on monolingual subtitles shows that both intralingual and interlingual subtitles appear to serve as a beneficial tool in comprehension and learning. However, no consensus can be made regarding the superiority of intralingual and interlingual subtitles as the benefits of these two types of monolingual subtitles are subject to certain conditions such as the viewer's language proficiency and can be manifested in different ways. Given that intralingual and interlingual subtitles have distinctive benefits as supported by extensive empirical evidence, it raises an interesting question as to whether these benefits can be combined when these two types of subtitles are presented simultaneously in the form of bilingual subtitles. Following this question, the next section provides a review of studies on the effects of bilingual subtitles.

2.2.2 Bilingual subtitles: dual cognitive benefits or dual cognitive burden?

While the potential educational benefits of intralingual and interlingual subtitles have been explored extensively and are well documented, the effects of bilingual subtitles attract little research interest. On the one hand, bilingual subtitles (as a combination of intralingual and interlingual subtitles) can be a valuable aid in learning by combining the benefits of both intralingual and interlingual subtitles (García, 2017; Kovacs & Miller, 2014). On the other hand, bilingual subtitles may generate more redundancy because there is not only overlapping information between subtitles and information in other modalities such as the visual image and the spoken dialogue, but also between

subtitles in two different languages (if the viewer has some level of proficiency in both languages). Processing too much redundant information may result in insufficient cognitive resources for effective comprehension (Kalyuga & Sweller, 2005). Although it has been found that intralingual or interlingual subtitles do not cause cognitive overload (Kruger et al., 2014; Kruger et al., 2013), these findings may not apply to bilingual subtitles in which more redundancy exists.

In an investigation into the effects of multimodal input of subtitled video on learners' comprehension, Yekta (2010) compared ESL viewers' comprehension performance in four experimental groups, each of which watched a subtitled movie in one of four conditions: with intralingual subtitles, with bilingual subtitles, with intralingual displayed subtitles, and with only transcript of the dialogue. Results showed that the bilingual condition had the highest comprehension scores, although no significant difference was found between intralingual and bilingual conditions. A major shortcoming of Yekta's study is the very small sample size. With five participant excluded, only 12 participants were investigated. Each experimental group had only three participants. This makes it impossible to arrive at any meaningful conclusions.

Using a much larger sample size, the study of Wang (2014) sheds light on the potential benefits of bilingual subtitles in language learning. Eighty Chinese ESL students were divided into four groups and each group watched four video clips in one of four treatments: with L1 Chinese subtitles, with L2 English subtitles, with bilingual (L1 and L2) subtitles, and without subtitles. A vocabulary and a comprehension test were administered to viewers after watching each video. Bilingual subtitles were found to be the most effective mode in both vocabulary and comprehension performance in comparison with monolingual and no subtitles conditions. Wang (2014) contended that

bilingual subtitles could enhance students' confidence, facilitate the learning of new words and allowed them to confirm their comprehension by comparing the original subtitles and their translation equivalence. However, due to the lack of evidence on the extent to which subtitles were processed, Wang's study has the same limitation as most performance-based studies on the impact of subtitles.

With the same focus on Chinese and English language groups, the study of Yang (2013), however, yielded different results. One hundred and twenty one Chinese students were divided into four groups, each of which watched an English video in one of four conditions: without subtitles, with Chinese subtitles, with English subtitles, and with bilingual subtitles (both Chinese and English). While the group that saw subtitled video performed significantly better in the comprehension test than those who saw the video without subtitles, no significant difference was observed in comprehension performance between bilingual subtitles and monolingual subtitles. It should be noted that in Yang's study (2013), participants were from non-English majors while Wang's study (2014) used participants from English majors. The different language proficiency of participants may account for the divergent results of these two studies.

In addition to performance data, Raine (2012) also made use of attitudinal data to investigate the effectiveness of different subtitle modes on vocabulary learning and language leaners' preferences for subtitle modes based on enjoyment and vocabulary learning. Thirty-nine Japanese students of English as a foreign language were assigned to four different groups: English subtitles group, Japanese subtitles group, bilingual subtitles group (English and Japanese), and a no subtitle group. Vocabulary test results showed no significant differences between different groups. However, opinion survey

results showed that the majority of viewers preferred bilingual subtitled for vocabulary learning and found them easier to read than L2 monolingual subtitles.

Aloqaili (2014) conducted a similar study to the study of Raine (2012) in a different linguistic context. Forty-eight Arabic secondary students of English as a foreign language were divided into four groups: no subtitles, with interlingual subtitles (Arabic), with intralingual subtitles (English), and with bilingual subtitles (Arabic and English). The pre- and post- test scores for the vocabulary knowledge scale showed that subtitles had a positive effect on viewers' intentional vocabulary learning. Although no significant difference was found between different subtitled conditions, 66.6% participants reported in the questionnaire survey that they preferred bilingual subtitles for vocabulary learning.

In a study conducted by Chang (n.d., retrieved from Vanderplank's research in 2016), it was found that viewers who were provided with bilingual subtitles (both Chinese and English subtitles) outperformed those who received Chinese only or English only subtitles in word recognition, factual understanding and inductive inference. Chang claimed that in bilingual subtitles, the two different subtitles can "complement one another, the one bridging different concepts and meaning, the other compensating for poor listing and aural word recognition" (p. 93).

Combing both quantitative and qualitative methods, Li (2016) conducted a longitudinal study to examine the effects of different subtitle modes (intralingual, interlingual and bilingual subtitles) on Chinese L1 students' learning of English vocabulary through vocabulary test, and explored students' attitudes towards the usefulness of different types of subtitles in language learning through questionnaires. It also found that students in bilingual conditions performed significantly better in word recognition and

recall tests than those in the no subtitle condition and this advantage was maintained in the delayed tests three weeks later. She explained the better performance in word recognition and recall tests in the bilingual subtitle condition was achieved probably because viewers automatically switched between L1 and L2 subtitles to match the sound with both written form and meaning, thus establishing a more stable mental representation of the new words. Although the lack of data on the visual processing of viewers limits the value of Li's study, it provides some evidence for the educational benefits of bilingual subtitles based on a longitudinal analysis.

Compared with intralingual and interlingual subtitles, the existing literature on bilingual subtitles is relatively limited. Much of research in this field has been centered on language learning, a similar limitation as identified in the research on monolingual subtitles. Moreover, while findings of these studies are based on analyses of either attitudinal or performance data, the interpretations of findings are often related to the visual processing of subtitles. A methodology that combines both performance and visual processing data is therefore required to produce more convincing evidence for the effects of bilingual subtitles.

In addition to visual processing, a better understanding of the cognitive processing of subtitles allows us to elucidate the mixed results regarding the effects of subtitles on comprehension because the management of cognitive resources is of critical importance to the learning outcome as demonstrated in educational psychology studies. Drawing upon Cognitive Load Theory, one of the most influential theoretical frameworks that is used to account for the cognitive processing during learning (Martin, 2014), the next section illustrates how the concept of cognitive load has been explored in subtitling research.

2.3 Subtitles and Cognitive Load

2.3.1 Cognitive Load Theory (CLT)

Developed by John Sweller (1988) in the field of educational psychology, Cognitive Load Theory (CLT) is an instructional theory that provides guidelines for instructional design to deal with the processing limitations of the human cognitive system. CLT is based on the assumption that the human cognitive architecture is composed of two major processing components, namely working memory which is limited in capacity and duration when dealing with novel information, and long-term memory which has unlimited storage capacity. Different information elements are first processed in the working memory and then transformed into knowledge in the form of schema stored in the long-term memory (Sweller et al., 2011). Learning will be inhibited if working memory is overloaded with too many information elements that need to be processed simultaneously. Working memory load can be reduced through schema construction, a process of converting multiple information elements into a single entity to make it easier to process, or through schema automation, a process of bringing schema from long-term memory to working memory to assist with information organization (Low & Sweller, 2005).

Cognitive load refers to the load that is imposed on the learner when performing a particular task (Chandler & Sweller, 1991). Three components of cognitive load have been identified in the literature, namely intrinsic cognitive load, extraneous cognitive

load and germane cognitive load. Intrinsic cognitive load is created by dealing with the inherent complexity of the task which is determined by the number of information elements that need to be processed simultaneously in working memory (i.e., element interactivity) (Sweller, 2010, p. 124; Van Merriënboer & Sweller, 2005, p. 150). For learners with the same level of expertise, materials that have high element interactivity impose a heavy load on working memory because they generate high intrinsic cognitive load. Intrinsic cognitive load is also determined by the learner's prior knowledge or level of expertise. More experienced learners may experience less intrinsic cognitive load than those with less experience as they have more advantages in schema automation.

Extraneous cognitive load is generated by dealing with instructional features that do not contribute to learning. For instance, extraneous cognitive load is increased when multiple sources of essential information that are unintelligible in insolation are presented temporally or spatially separated, forcing the learner to consume extra cognitive resources in searching, coordinating and integrating information (Ayres & Sweller, 2005). Learners are also likely to experience high extraneous cognitive load when they make efforts to process redundant information that is unnecessary for learning (Kalyuga & Sweller, 2005).

Different from intrinsic and extraneous cognitive load, germane cognitive load refers to the cognitive resources devoted to schema construction and automation (Sweller, 2010; Sweller, Van Merrienboer, & Paas, 1998). It is created when learners are engaged in processing essential information that contributes to learning. As human beings have limited cognitive resources in working memory, the more intrinsic and extraneous cognitive load are produced, the less cognitive resources are left for the learner to form

schema and thus less germane cognitive load is generated (see Figure 1 for a visualization of three types of cognitive load). As a result, less learning is gained. Given that intrinsic cognitive load cannot be manipulated by instructional design (Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013), a vital principle in learning instruction is to reduce extraneous cognitive load caused by poor instructional design so as to free up more cognitive resources for germane cognitive load.

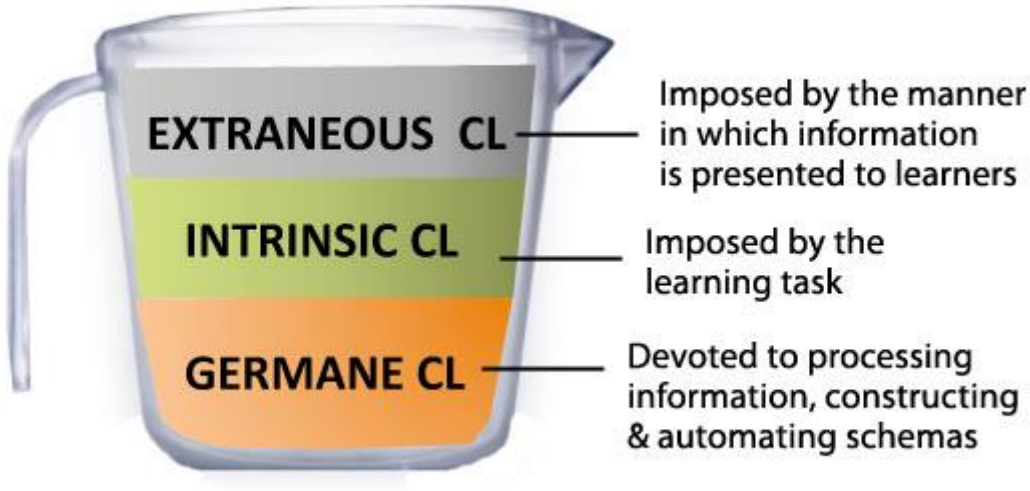


Figure 1. Three types of cognitive load (Malamed, n.d.)

2.3.2 Cognitive processing of subtitles

As previously mentioned, while subtitles have been widely investigated, research in this field has been centered on the effects of subtitles on language learning (see e.g., Bird & Williams, 2002; Danan, 2004; Saed et al., 2016; Wang, 2014; Yekta, 2010; Yoshino, Kano, & Akahori, 2000) or factors that may influence the processing of

subtitles (see e.g., d'Ydewalle & De Bruycker, 2007; Ghia, 2012; Hefer, 2013a). Few attempts have been made to explore the effectiveness of subtitles from a cognitive perspective.

In order to determine the cognitive effectiveness of subtitle processing, Perego et al. (2010) carried out a study to investigate whether subtitle reading would interfere with the processing of the visual image. Forty-one Italian native speakers were recruited to watch a 15-minute video excerpt narrated in Hungarian with Italian subtitles, after which they were asked to complete a gist comprehension questionnaire, a subtitle recognition test and a scene recognition test. Results showed that viewers achieved a good comprehension of the video content without causing a significant tradeoff between image processing and subtitle processing. They therefore drew a conclusion that subtitle processing was cognitively effective and individuals had the ability to process, integrate and remember information from multiple sources. However, they pointed out that the effectiveness hypothesis for subtitle processing may not apply to situations in which viewers are required to cope with very complex visual images. Moreover, it should be noted that in their study, viewers could only rely on subtitles for verbal information due to their lack of knowledge of the foreign language in the soundtrack. A different picture could be drawn when viewers are less compelled to read subtitles in order to understand the video, for instance, when they are able to understand the languages in both subtitles and the spoken dialogue.

As the usage of subtitles is increasing in educational activities (see Kruger & Doherty, 2016), recent years have seen a growing body of research that sets out to explore the effects of subtitles on cognitive load and learning outcomes. Using a combination of direct and indirect cognitive load measurements, which included eye tracking,

electroencephalography (EEG), self-report scales and performance data, Kruger et al. (2013) found that the presence of same language subtitles in a recorded academic lecture could reduce ESL students' cognitive load and did not cause cognitive overload.

In a subsequent study, Kruger et al. (2014) explored the impact of subtitle language on cognitive load and comprehension. Sixty-eight Sesotho speaking participants were randomly assigned to three groups, each of which watched an English lecture in one of the three conditions: without subtitles, with English (L2) subtitles or with Sesotho (L1) subtitles. Using eye tracking measurements, self-reported questionnaires and electroencephalography (EEG) data, they found that students' comprehension performance was not significantly affected by the presence or the language of subtitles and participants in the L1 subtitles group reported lower comprehension effort. They also found that the language of subtitles had an impact on attention distribution, with less time being spent on L1 subtitles than on L2 subtitles. They explained that as the concurrent presence of L2 audio information made the L1 subtitles less necessary and redundant for comprehension, students might use L1 subtitles only to check information rather than to follow the lecture.

Compared with intralingual and interlingual subtitles, processing bilingual subtitles could be more complicated and cognitively demanding. In addition to processing information from multiple channels such as sound and image, viewers also have to assign attention to subtitles in two different languages that appear on the screen simultaneously. However, so far little empirical research has been conducted to investigate the impact of bilingual subtitles on cognitive load, which limits our understanding of the effectiveness of this particular subtitle mode.

2.4 Eye Tracking in Subtitling Research

Eye tracking is a psychophysiological measure that is used to study human reading behavior, attention allocation and cognitive activities (Hvelplund, 2017; Moreno, 2017). While the use of eye movement data has been well established in the context of static reading (see e.g., Rayner, 2009, 2012), the application of eye tracking technology to subtitling research has a relatively short history. The challenge of using eye tracking to study subtitle processing lies in the dynamic nature of subtitles which are presented as fleeting texts (Kruger, Szarkowska, & Krejtz, 2015).

In the existing literature, eye tracking has been mostly used to investigate the visual and cognitive processing of multimodal and multimedia information when watching subtitled videos (see e.g., d'Yewalle et al., 1991; Kruger, 2016; Kruger et al., 2014; Kruger et al., 2013; Perego et al., 2010) and to explore how the reading behavior of viewers is influenced by different factors such as age, language proficiency, language combination between the spoken dialogue and subtitles, translation strategies, text chunking and line segmentation, etc. (see e.g., d'Ydewalle & De Bruycker, 2007; Ghia, 2012; Hefer, 2013b, 2013a; Lång, Mäkisalo, Gowases, & Pietinen, 2013; Mangiron, 2016; Rajendran et al., 2013).

In an empirical study conducted by d'Ydewalle and De Bruycker (2007), they investigated the eye movement patterns of children and adults when watching a movie excerpt in two different subtitling conditions, namely standard subtitling (foreign language soundtrack and native language subtitles) and reversed subtitling (native language soundtrack and foreign language subtitles). Twelve adults and eight children participated in the experiment, all of whom are native Dutch speakers and had no

knowledge of the foreign language in the movie excerpt (Swedish). They found that viewers showed a more irregular reading pattern in reversed subtitling as there were more subtitles skipped, fewer fixations and longer latencies. They also found that viewers spent less time on one-line subtitles than on two-line subtitles in the standard subtitling condition. They suggested that this was because one-line subtitles contained less redundant information and thus required less visual attention. If these findings can be applied to the present study, viewers should spend more time on bilingual subtitles compared with monolingual subtitles as there are more redundant information sources in bilingual subtitles.

In an eye tracking study carried out by Perego et al. (2010), they found that viewers spent more time (67% of the fixation time) examining the subtitled area while fixations on the visual area were longer. However, due to a lack of No Subtitles control group in their study, it is still unclear whether the presence of subtitles has a significant impact on the viewer's attention distribution to the visual image.

The study of Ross and Kowler (2013) also found that viewers spent a large portion of time (more than 40%) on the subtitled area, even in the presence of redundant audio information. They suggested that the way viewers allocated their attention between subtitles and the visual image was dependent on their inherent habits of being attracted to text-based information, their continuous judgement and comparison of the importance of information from different sources, as well as their tendency to integrate verbal information form the visual and audio channels.

Based on an analysis of eye movement data, Orrego-Carmona (2014) found that viewers' L2 language proficiency had a significant impact on their visual attention allocated the subtitles and image. When watching three videos with L1 subtitles (one

video with professional subtitles and two with non-professional subtitles), viewers with high language proficiency in English had less fixations on the subtitled area than on the image and the data showed less dispersion than the viewers with low language proficiency, indicating that viewers who had high language proficiency and were able to acquire verbal information from the soundtrack effectively would rely less on subtitles as an aid for comprehension.

Winke, Gass and Sydorenko (2013) made the first attempt to investigate the how the difference between L1 and L2 affects L2 learners' reading of subtitles and the benefits they gain from intralingual subtitles. They compared the time spent on the subtitle area and the rest of the screen by English L1 learners of Arabic, Chinese, Russian and Spanish. It was found that Chinese learners spent less time on subtitles when watching unfamiliar content than familiar content, indicating that processing difficult visual-verbal information could cause a splitting of attention for Chinese learners.

Bisson et al. (2014) investigated sixty-four viewers' subtitle reading behavior in three video conditions: standard subtitling (i.e., foreign language soundtrack with native language subtitles), reversed subtitling (i.e., native language soundtrack with foreign language subtitles), and intralingual subtitling (foreign language soundtrack with foreign language subtitles). They found that viewers spent more time on the subtitle area when the soundtrack was in an unknown foreign language with subtitles in either native or foreign language. No significant differences were found in terms of the fixation duration, the number of fixations in the subtitle area and the number of skipped subtitles between standard and intralingual subtitling conditions. In other words, viewers read subtitles in a similar way irrespective of the subtitle language when the soundtrack was in an unknown foreign language. Their study also revealed that viewers

did not use all the subtitle presentation time to read subtitles but instead spent some time on the image area, which supports Perego et al. (2010)'s finding that subtitle processing does not interfere with image processing.

By means of eye tracking, Hefer (2013a) investigated the difference in L1 and L2 subtitle reading. Thirty Sesotho L1 students were randomly assigned to three groups: two test groups (TSE and TES) and one control group (CSS). The TSE group watched a French video clip with Sesotho (L1) subtitles in the first half and English (L2) subtitles in the second half of the video while the TES group watched the same video with L2 subtitles in the first half and L1 subtitles in the second half. The CSS group watched the same video with only L1 subtitles. Ten English L1 students formed another control group. All students had no knowledge of the language of the soundtrack and their eye movements were recorded by an eye tracker during video playing. Analysis results of fixation time, dwell time and fixation count in the subtitled area revealed that L1 and L2 subtitles were processed differently by Sesotho L1 viewers in that Sesotho L1 viewers read L2 subtitles with greater ease. Hefer (2013a) explained that the reason why viewers spent more time and had greater difficulty reading L1 subtitles was because they had lower literacy and reading speed in L1 text, although native language was found to better assist their comprehension.

Interestingly, the study of Kruger et al. (2014) which also investigated attention distribution of Sesotho L1 students reported different results. Kruger et al. (2014) found that viewers spent less time reading L1 subtitles than L2 subtitles and the proportion of time spent on subtitles was smaller than what was found in the study of Hefer (2013a). A possible explanation for these different results is that viewers may reduce their reliance on subtitles because of their access to the L2 spoken dialogue in the study of

Kruger et al. (2014). However, this assumption needs further investigation as d'Yewalle et al. (1991) found that the knowledge of soundtrack did not affect the time spent on subtitles.

Using eye tracking methodology, Munoz (2017) examined the effects of age and proficiency on subtitle reading behavior. Forty Spanish-Catalan learners of English were divided into three age groups: children (mean age 11.1), adolescents (mean age 14.6), and adults (mean age 25.8). Participants were also assigned to three language groups based on their language proficiency: the beginner group, the intermediate group and the advanced group. Participants were asked to watch two video clips with English soundtrack, one of each clip with either English subtitles (L2) or Spanish subtitles (L1). Participants' eye movements were recorded by a Tobii T120 integrated eye-tracker during video watching. Results showed that children spent more time reading subtitles in L2 than L1 while adults skipped more L1 subtitles than L2 subtitles, which is consistent with the results of Kruger et al. (2014) that students who were able to obtain verbal information from the L2 spoken dialogue spent less time reading L1 subtitles. It was also found that intermediate and advanced groups skipped more L1 subtitles than L2 subtitles, which is probably due to the large overlap between the age and language proficiency grouping (the beginner group was mainly composed of children and the advanced group was mainly formed by adults). Munoz (2017) and Kruger et al. (2014) hold a similar view that L1 subtitles are skipped more often by viewers of relatively high language proficiency because subtitles in L1 are redundant to viewers for comprehension as they are able to acquire verbal information from the L2 soundtrack.

2.5 Summary

Based on the literature review, a number of research gaps can be identified. First, most studies focus on monolingual subtitling; bilingual subtitling remains underexplored. The limited existing research on bilingual subtitles has been centered on their effects on language learning. Little is known about the effects of bilingual subtitles on the management of cognitive resources. Overall, cognitive processing of bilingual subtitles has not been investigated with the same vigor as the processing of monolingual subtitles.

Second, so far only a very limited number of studies have attempted to investigate the impact of subtitles from a cognitive load perspective (Kruger et al., 2014; Kruger, 2013; Kruger et al., 2013; Kruger et al., 2013). More research is needed in order to help us better understand how viewers may benefit from subtitles and optimize the use of subtitles (Gernsbacher, 2015).

Furthermore, previous studies on subtitling mostly used materials in English or European languages that are in the same language family (Lwo & Lin, 2012); little research has been conducted to examine Chinese subtitles which are based on very different orthographical and phonological systems, although the value of examining language pairs with minimal orthographic and phonological similarities has long been acknowledged by some scholars (see e.g., Bisson et al., 2014; Garza, 1991; Hinkin et al., 2014; Plass, Chun, Mayer, & Leutner, 2003).

Chapter 3. Methodology

This chapter is composed of six sections. The first section provides information about the samples used in this study (3.1). The second section (3.2) illustrates the selection criteria of stimuli for the eye tracking experiment, production guidelines of subtitles, compiling of biographical questionnaire and cognitive load questionnaire. The next section (3.3) provides information on the apparatus used in the eye tracking experiment, followed by a description of procedures of the whole experiment (3.4). The last two sections (3.5 and 3.6) describes how data collected from the eye tracking device are processed and analyzed, providing details on the exclusion of invalid eye movement data, the defining of Areas of Interest (AOIs) and the selection of eye tracking measures to address three research questions. It also discusses the criteria and procedure of scoring the free recall test which is used to evaluate viewers' overall comprehension of the video.

3.1 Sample

Twenty Chinese native speakers in Australia who used English as their second language were recruited as participants (14 females and 6 males). Eighteen participants were postgraduate students and one was undergraduate at Macquarie University, Sydney, Australia. One participant was a visiting scholar with above postgraduate-level qualification. The average age of participants was 25.7. Ethics approval was gained for conducting this study.

3.2 Materials

3.2.1 Stimulus

Four English videos clips, each lasting approximately five minutes, were used as stimuli in the eye tracking experiment. These videos clips were from four episodes of a BBC documentary series (*Planet Earth*, 2006). The whole documentary series consists of eleven episodes, each of which features a global overview of a habitat on the planet. The topics of the four video clips were "Mountains" (Episode Two), "Great Plains" (Episode Seven), "Jungles" (Episode Eight) and "Shallow Seas" (Episode Nine). These videos were selected because they were comparable in terms of the density and complexity of pictorial content, the level of correlation between visual information (image) and verbal information (narration), as well as the presentation rate of auditory information. To ensure that all video clips were comparable in terms of the difficulty of verbal information, a readability test was performed for the transcription of each video clip using Coh-Metrix, a computational tool that evaluates linguistic characteristics at multiple levels of language and discourse (Graesser, McNamara, Cai, Mark, & Li, 2014). Results of Flesch Reading Ease of four videos were 75.71, 69.65, 71.65, and 71.88, which showed that four videos had a similar level of reading ease. All video clips were examined by the researcher to ensure that there were no inappropriate scenes that may cause discomfort to viewers.

Four experimental conditions were developed for each video clip (see Figure 2):

1. English narration without subtitles (NS),

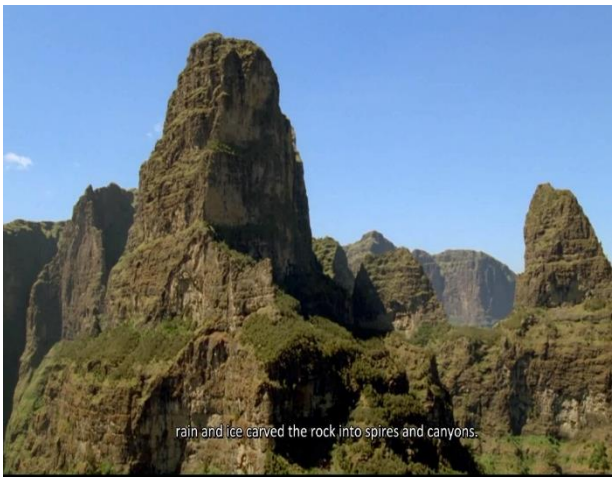
2. English narration with Chinese subtitles (CS),
3. English narration with English subtitles (ES),
4. English narration with both Chinese and English subtitles (BS).

Subtitles were produced using Aegisub subtitling software[5]. Bilingual subtitles were first produced, after which Chinese subtitles and English subtitles were removed separately to constitute the CS and ES conditions. The display time of subtitles in the CS, ES and BS groups were the same in order to minimize the impact of other variables (e.g., display time) and investigate the effects that different subtitles themselves have on attention distribution and cognitive load.

NS

CS

[5] Software available at http://www.aegisub.org/.



ES

BS

Figure 2. Screenshots of four video conditions: NS, CS, ES and BS.

In this study, bilingual subtitles were presented in two lines to avoid excessive pollution of the image in accordance with conventions (Díaz Cintas & Remael, 2007; Kuo, 2014), with one line in the same language as the original speech (English) and the other one in a translated language (Chinese). In accordance with the subtitling convention of keeping the upper line shorter to limit the obstruction of other visual information (Díaz Cintas & Remael, 2007), Chinese subtitles were displayed above English subtitles because they normally occupy less space than English subtitles due to the different writing systems. While English characters are represented by sound symbols that are made of alphabets, Chinese characters are based on a logographic writing system in which ideas or words are represented directly by symbols (Cheng, 2014). The Chinese writing system has therefore been found to be more efficient and information rich (Chang & Chen, 2002; Zhao & Baldauf, 2007), and in practical terms, simply occupy less space. Subtitles were displayed at the bottom center of the screen. Chinese subtitles

and English subtitles in the BS condition were positioned at (x: 988, y: 1004) and (x: 988, y: 954) respectively. In the CS and ES conditions, subtitles were positioned at (x: 988, y: 1004).

English subtitles were presented at a rate of 10 to 14 characters per second (CPS)[6], which produced a near verbatim transcript of the spoken text. Each English subtitle contained no more than 55 characters. The standard number of characters per line in most guidelines is 37 characters (Díaz Cintas & Remael, 2007; Ivarsson & Carroll, 1998). However, since only one line was used per language, and due to the wider format of the screen, a line length of 50% longer than the convention was considered to be functional, particularly since the subtitles were created for use on a computer screen with the user at a distance of approximately 70cm from the screen (see Figure 3). Line breaks between subtitles were made to preserve semantic units where possible, in accordance with standards. Chinese subtitles were produced as a literal translation of English subtitles, which reproduced the original text as much as possible in both lexical and syntactic terms[7] (Ghia, 2012, p. 167). Each Chinese subtitle contained no more than 20 Chinese characters according to conventions (Kuo, 2014).

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[6] While 12 CPS has long been regarded as an appropriate speed for subtitle reading (Díaz-Cintas & Remael, 2007), viewers in the information age are likely to have a faster reading speed (Szarkowska, 2016).

[7] Here are a few examples drawn from the subtitle extracts produced for this experiment:

a) English ST: The great mountain range acts as a barrier

Chinese TT: 雄伟的山脉犹如一道屏障 (“The great mountain range is like a barrier”)

b) English ST: preventing clouds moving in from the south

Figure 3. Screenshot of English subtitles. The number of characters was 55 characters and the font size was 50.

3.2.2 Biographical questionnaire

A biographical questionnaire was used to obtain some biographical information of participants, such as age, major, English language proficiency (IELTS scores), etc. (see Appendix A).

Chinese TT: 阻挡了从南飘来的浮云 (“Prevent clouds moving from the south”).

3.2.3 Cognitive load questionnaire

A self-report cognitive load questionnaire used in this study was adapted from the questionnaire developed and validated by Leppink et al. (2014) to differentiate three types of cognitive load (see Appendix B). This instrument was selected because it has been validated and is the first one to differentiate between different types of load. As this study was based on a context of film comprehension, which was different from the problem-solving context in which the study by Leppink et al. (2014) was situated, some adjustments were made to the scale items to reflect the variations of cognitive load.

The cognitive load questionnaire was composed of twelve items with a 0-10 rating scale. Intrinsic cognitive load (IL) was measured with three items that were related to the complexity of the video (e.g., "The information covered in this video was very complex") and one item concerning the effort invested to cope with the complexity ("I invested a very high mental effort in the complexity of this video"). Extraneous cognitive load (EL) was evaluated with three items that were related to the presentation design (e.g., "The presentation of information in this video was very unclear") and one item concerning the effort invested to deal with the presentation design ("I invested a very high mental effort in unclear and ineffective presentation of information in this video"). Germane cognitive load (GL) was evaluated with three items referring to the contribution of the video to information acquisition (e.g., "This video really enhanced my understanding of the information that was presented") and one item related to the effort invested in information acquisition ("I invested a very high mental effort during this video in enhancing my knowledge and understanding").

An analysis of internal consistency was performed, which yielded Cronbach's alpha coefficient as an indication of reliability (see Table 1). Cronbach's alpha coefficient of 0.7 or above is generally regarded to reflect a good level of internal consistency and reliability (DeVellis, 2003; Kline, 2005). Cronbach's alpha coefficients of IL and EL across four conditions were high, revealing a high level of reliability of the items used to measure these two types of cognitive load. However, Cronbach's alpha coefficients were low for GL in three conditions. In order to increase the internal consistency, the last item (item 12) which was related to the mental effort in information acquisition was removed from GL measurement[8]. The cognitive load that was evaluated by the remaining three items was referred to as GL*. Item 12 was discussed separately as mental effort in information acquisition (ME).

Table 1. Cronbach's Alpha Coefficients for IL, EL and GL* in Four Conditions

	NS	CS	ES	BS
IL	0.921	0.861	0.947	0.923
EL	0.845	0.721	0.809	0.739
GL (with item 12)	0.779	0.043	0.208	0.342
GL* (without item 12)	0.944	0.774	0.910	0.801

[8] Leppink et al. (2014) also reported in their study that adding the last item regarding the mental effort in understanding the video did not increase the internal consistency of the scales used to measure germane cognitive load.

3.3 Apparatus

The eye tracking experiment was conducted on an SMI RED eye tracker with a sampling rate of 250 Hz. The screen resolution of the eye tracker's monitor was 1920 × 1080 pixels and the stimulus covered the entire 23-inch screen. Data were collected with SMI iViewX and Experiment Centre 3.0.

3.4 Procedure

All participants completed the eye tracking experiment individually. They were asked to sign a participation consent form prior to the start of the experiment (see Appendix C), which gave them a brief introduction to the study and what to expect during the experiment. The purpose of the study was revealed to participants, but they were not asked to pay particular attention to subtitles.

They were then seated comfortably on a stable chair 700 mm from the stimulus screen in a sufficiently illuminated room at Macquarie University, Sydney, Australia. Participants were asked to turn off their mobile phones during the experiment and there was no noise from outside.

This is a within-subject study with each participant seeing all 4 videos, each in a different condition (NS, CS, ES, and BS). In order to be able to randomize the texts and the conditions and ensure that no participant would see the same text more than once or be exposed to any condition more than once, the video clips, their treatments, and

the order in which viewers watched videos were counterbalanced using Latin Squares. Participants were randomly assigned to one of 4 groups, each group seeing 4 videos in 4 conditions (see Table 2 for experimental design).

When participants were ready, they were asked to fill in a biographical questionnaire on the computer, after which they were given written instructions on the screen (see Figure 4). Each participant's eyes were calibrated using a five-point calibration and validated to ensure that their eye movements could be accurately recorded. After that, a video clip began to play. When the video finished, they were asked to complete a cognitive load questionnaire on the computer. Then they were asked to recall and write down in English as much information as they could remember about the video they watched. There was no time limit for the recall test. When the participants finished the recall test, they did the calibration and validation again before watching the next video. Each participant watched four videos clips separately and the order of video was randomized in order to keep the unsystematic variation as small as possible (Field, 2009). The whole experiment for each participant lasted about one and a half hours.

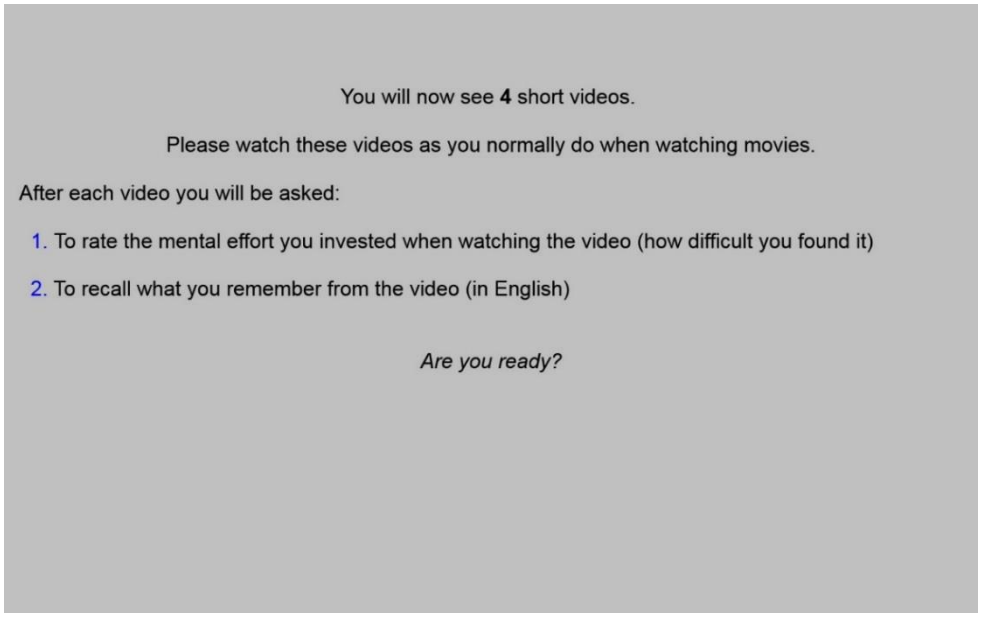

Figure 4. Screenshot of instructions for the eye tracking experiment.

Table 2. Experiment Design of Eye Tracking Experiment

	Episode Nine	Episode Seven	Episode Eight	Episode Two
Group 1	NS	CS	ES	BS
Group 2	CS	ES	BS	NS
Group 3	ES	BS	NS	CS
Group 4	BS	NS	CS	ES

3.5 Data Processing

3.5.1 Eye movement data

Twenty participants were coded from P03 to P22 (the first two participants P01 and P02 were for pilot study and not included in the analysis). Eye tracking data with a tracking ratio of lower than 85% were discarded (see Figure 5). Three participants' eye movement data were therefore excluded. One participant's data in the BS condition was also excluded because of a technical problem during data collection. To sum up, seventeen participants in the NS, CS, and ES conditions and sixteen in the BS condition produced valid eye movement data.

Subtitles and the whole screen in the ES, CS and BS conditions were marked as different Areas of Interest (AOIs). In the BS condition, subtitles in two different languages were marked as two separate AOIs. The AOI of Chinese subtitles in BS were marked as "CS_B" and English subtitles as "ES_B". There was no space between these two AOIs (see Figure 6 and 7).

This study used three eye movement parameters: dwell time, visible time and mean fixation duration. According to the BeGaze 3.0 manual (SensoMotoric Instruments, 2011), dwell time was calculated as the sum of all fixations and saccades within an AOI. Visible time was calculated as the display time of an AOI. The event detection parameter for a fixation was a minimum duration of 50ms.

Data in all AOIs for each participant were extracted from SMI BeGaze 3.0 (SensoMotoric Instruments GmbH), a software for eye tracking data analysis. Dwell time percentage of visible time (DT%) was used as a measure of visual attention allocation. Mean fixation duration (MFD) was analyzed as an indirect indication of cognitive load (Debue & Van De Leemput, 2014). DT% in subtitles was calculated by dividing the dwell time in subtitles by the visible time of subtitles and multiplying that by 100 to arrive at a percentage. Visual attention to the rest of the screen (DT% on the visual image) was calculated by dividing the dwell time on the screen (with the dwell time of subtitles subtracted) by the visible time of the video and multiplying that by 100 for a percentage.

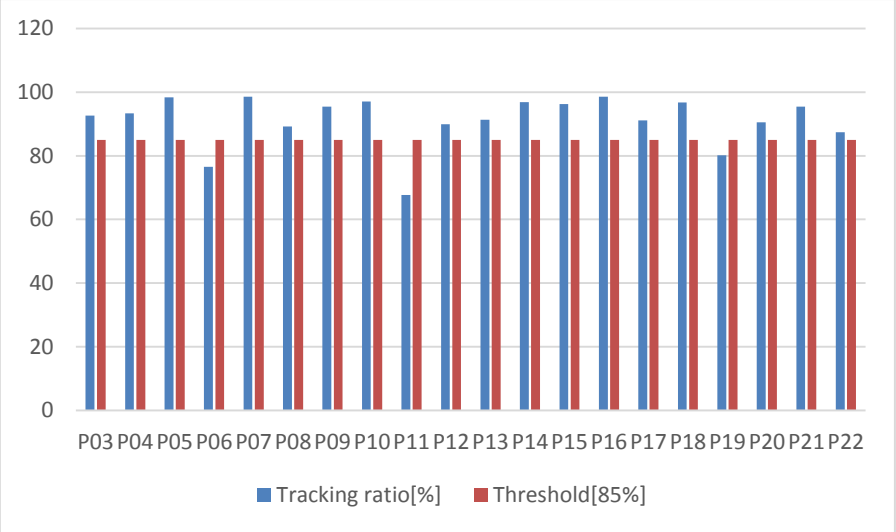

Figure 5. Eye movement tracking ratio of all participants.

Figure 6. Screenshot of AOI of the screen.

Figure 7. Screenshot of AOIs of bilingual subtitles.

3.5.2 Free recall test

Each recall test was analyzed into a set of idea units. Each idea unit contained one major idea. One point was given in the recall test for each corresponding idea unit that was identified or implied in the image, subtitles or the spoken dialogue regardless of grammatical mistakes and minor misspellings. 0.5 point was given if specific names were not given correctly in the recall test. Three participants' recall scores were discarded because they only noted a few isolated words. One participant's data in the ES and one in the BS condition were also discarded because of technical problems in video playing. In total, 17 recall tests in the NS and CS conditions and 16 in the ES and BS conditions were scored. Two researchers scored the recall test separately after first scoring a sample test, discussing discrepancies and reaching agreement on the scoring criteria. The average of the two researchers' scores was used as an evaluation of the participant's comprehension performance.

3.6 Statistical Analyses

This chapter presents statistical analyses that were carried out using IBM SPSS Statistics (version 22). Video condition (NS, CS, ES and BS) was used as independent variable and dependent variables included dwell time percentage of visible time in subtitles (DT% in subtitles), dwell time percentage of visible time on the visual image (DT% on the visual image), mean fixation duration in subtitles (MFD), self-reported cognitive load and comprehension performance (score of free recall test). A significance level of 0.05 was adopted for all statistical analyses.

Since eye-tracking data often violate the normal distribution requirement of inferential statistical tests like the ANOVA, or t-test, data that were not normally distributed were subjected to non-parametric tests. Statistical tests were performed to address the research questions as explained below.

3.6.1 What is the impact of subtitle mode on attention allocation?

(1) Is there any difference in the visual attention allocated to L1 and L2 subtitles between bilingual and monolingual conditions?

The DT% in subtitles between three subtitled conditions, namely ES, CS, and BS, were compared using statistical analysis tools. As there was no outlier in the data as assessed by inspection of a boxplot and data were normally distributed in three conditions as assessed by Shapiro-Wilk's test ($p > 0.05$), a one-way repeated measures ANOVA was

conducted. To confirm the ANOVA results, paired sample t-tests were also performed on the data.

To examine the difference in the visual attention to L1 subtitles between the monolingual and bilingual conditions, DT% in L1 subtitles between the CS and BS conditions were compared. There were no outliers in the data as assessed by inspection of a boxplot and the differences of DT% between two conditions were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$), which makes it possible to run a paired samples t-test.

In order to examine the difference in the visual attention to L2 subtitles between the monolingual and bilingual conditions, DT% in L2 subtitles between the ES and BS conditions were compared. As there were no outliers in the data as assessed by inspection of a boxplot and the differences of DT% between two conditions were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$), a paired samples t-test was conducted.

To investigate the difference in the visual attention to L1 and L2 subtitles in the BS condition, DT% in L1 subtitles and DT% in L2 subtitles in the BS condition were compared. Given that there was no outlier in the data, as assessed by inspection of a boxplot and the differences of DT% were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$), a paired samples t-test was performed.

(2) Is there any difference in the attention allocated to the visual image between bilingual and monolingual conditions?

To answer this question, DT% on the visual image in four conditions were compared. As there was no outlier in the data, as assessed by inspection of a boxplot and no violation of normality, as assessed by Shapiro-Wilk's test ($p > 0.05$), a one-way repeated measures ANOVA was performed.

3.6.2 What is the impact of subtitle mode on cognitive load?

To determine the effect of subtitle mode on intrinsic cognitive load (IL), reported values of IL in four video conditions were compared. One outlier was detected in the BS condition by an inspection of boxplot. It was kept in the analysis as an inspection of their values did not reveal it to be extreme. Data were normally distributed in NS, CS and ES, as assessed by Shapiro-Wilk's test ($p > 0.05$). There was violation of normality in BS as assessed by Shapiro-Wilk's test ($p = 0.008$). However, Kolmogorov-Smirnov test did not reveal any violation of normality ($p > 0.05$) in BS. A one-way repeated measures ANOVA was conducted, and to validate the results, a non-parametric test (Friedman test) was also performed. Both ANOVA and Friedman test produced the same results.

To determine the effect of subtitle mode on extraneous cognitive load (EL), reported values of EL in four video conditions were compared. One outlier in ES and one in BS were detected by an inspection of boxplot. They were kept in the analysis as an inspection of their values did not reveal them to be extreme. Shapiro-Wilk's test revealed that EL scores were normally distributed in NS and CS ($p > 0.05$) while violations of normality were observed in ES ($p = 0.019$) and BS ($p = 0.04$). But

Kolmogorov-Smirnov test did not reveal any violation of normality in four conditions ($p > 0.05$). A one-way repeated measures ANOVA was first performed, which found significant differences between NS and CS, NS and BS. A non-parametric test (Friedman test) was then conducted to validate the results. Friedman test only found significant difference between BS and NS, but no difference between NS and CS. As the data in the NS and CS conditions were normally distributed, a paired-samples t-test was performed, which found significant difference between NS and CS (t (19) = 3.359, $p = 0.003$). As the one-way ANOVA results were confirmed by the paired samples t-test, analysis was based on the one-way ANOVA results.

To determine the effect of subtitle mode on germane cognitive load (GL*), reported values of GL* in four video conditions were compared. There were no outliers in the data, as assessed by inspection of a boxplot, and data were normally distributed in four conditions, as assessed by Shapiro-Wilk's test ($p > 0.05$), which makes it possible to run a one-way repeated measures ANOVA.

To examine the effect of subtitle mode on mental effort in information acquisition (ME) reported values of ME in four video conditions were compared. No outlier in the data was detected, as assessed by inspection of a boxplot. However, Both Shapiro-Wilk's test and Kolmogorov-Smirnov test revealed violations of normality in CS and BS. A non-parametric test (Friedman test) was therefore conducted.

Data of mean fixation duration (MFD) in subtitles in four conditions were also compared to provide more information on cognitive load. Three outliers were kept in the analysis as an inspection of their values did not reveal it to be extreme. No violation

of normality was observed, as assessed by Shapiro-Wilk's test ($p > 0.05$). A one way repeated measures ANOVA was therefore performed.

3.6.3 What is the impact of subtitle mode on content comprehension?

To ascertain the effect of subtitle mode on content comprehension, scores of free recall test in four conditions were compared. Two outliers (one in ES and one in CS) were detected by an inspection of boxplot. They were kept in the analysis as an inspection of their values did not reveal them to be extreme. Data were normally distributed in four conditions, as assessed by Shapiro-Wilk's test ($p > 0.05$). A one-way repeated measures ANOVA was conducted and paired samples t-tests were run to validate the results.

Chapter 4. Results

This chapter presents the results of statistical analyses to address three research questions. To address the first question regarding the impact of subtitle mode on attention allocation, statistical analysis results of dwell time percentage of visible time (DT%) in subtitles and on visual image are discussed. To answer the second question regarding the impact of subtitle mode on cognitive load, statistical analysis results of three types of cognitive load (i.e., intrinsic cognitive load, extraneous cognitive load, germane cognitive load) as well as mental effort are discussed. The third question regarding the impact of subtitle mode on content comprehension is addressed through a discussion of the statistical analysis results of free recall test scores.

4.1 The Impact of Subtitle Mode on Attention Allocation

4.1.1 DT% in subtitles

The one-way repeated measures ANOVA showed significant differences in the DT% in subtitles between different subtitling conditions (F (2, 30) = 3.944, p = 0.030). Post hoc analysis with a Bonferroni adjustment for multiple comparisons revealed that there was significance between BS and CS (p = .034). A paired samples t-test found significant difference between ES and CS (t (16) = -2.442, p = 0.027). BS (M = 33.62%) and ES (M = 32.14%) had similar DT% in subtitles (see Table 3).

Table 3. Means of DT% in Subtitles in Monolingual and Bilingual Conditions

Subtitled condition	M (*SD*)	N
CS	21.55 (13.24)	16
ES	32.15 (17.50)	16
BS	33.62 (16.43)	16
CS_B	18.33 (15.91)	16
ES_B	15.29 (15.91)	16

Note. CS = Chinese monolingual subtitles. ES = English monolingual subtitles. BS = bilingual subtitles. CS_B = Chinese subtitles in the bilingual condition. ES_B = English subtitles in the bilingual condition.

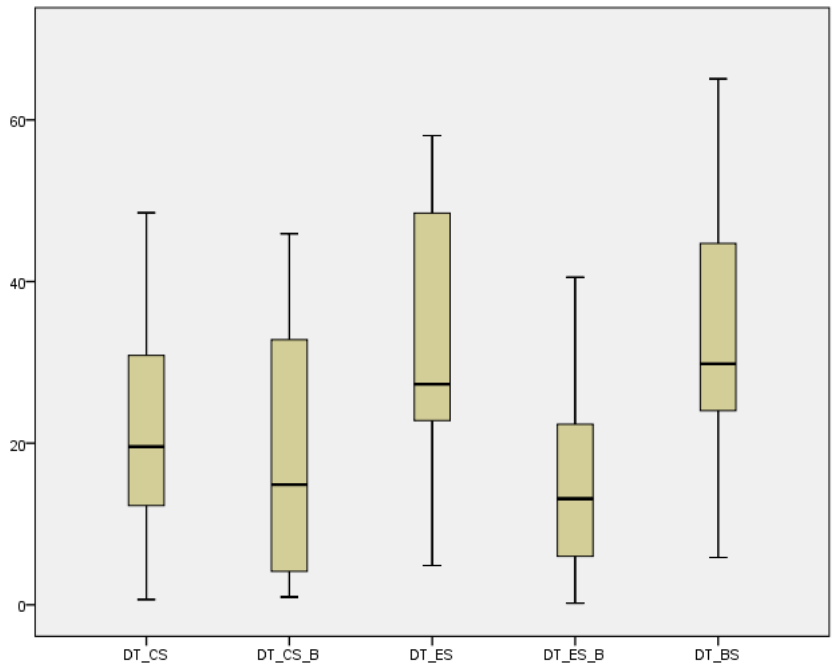

Figure 8. DT% in subtitles in monolingual and bilingual conditions.

As can be seen from Figure 8, in the monolingual conditions in which subtitles were presented in only one language, L2 (English) subtitles attracted more visual attention than L1 (Chinese) subtitles. Figure 9 shows that a majority of viewers (68.75%) had

higher DT% in L2 subtitles than in L1 subtitles. Both DT% in Chinese subtitles and English subtitles decreased from the monolingual condition (CS and ES) to the bilingual condition (CS_B and ES_B). Paired samples t-tests were run to determine whether there were significant differences in the DT% when subtitles were presented alone as in monolingual conditions and when presented together with subtitles in another language as in the bilingual condition. A significant difference was observed between ES and ES_B (t (15) = 2.815, p = 0.013), but this was not the case between CS and CS_B (t (15) = 0.772, p = 0.452). In other words, viewers spent much less time looking at L2 subtitles in the bilingual condition than in the monolingual condition whereas they spent a similar amount of time reading L1 subtitles in both conditions.

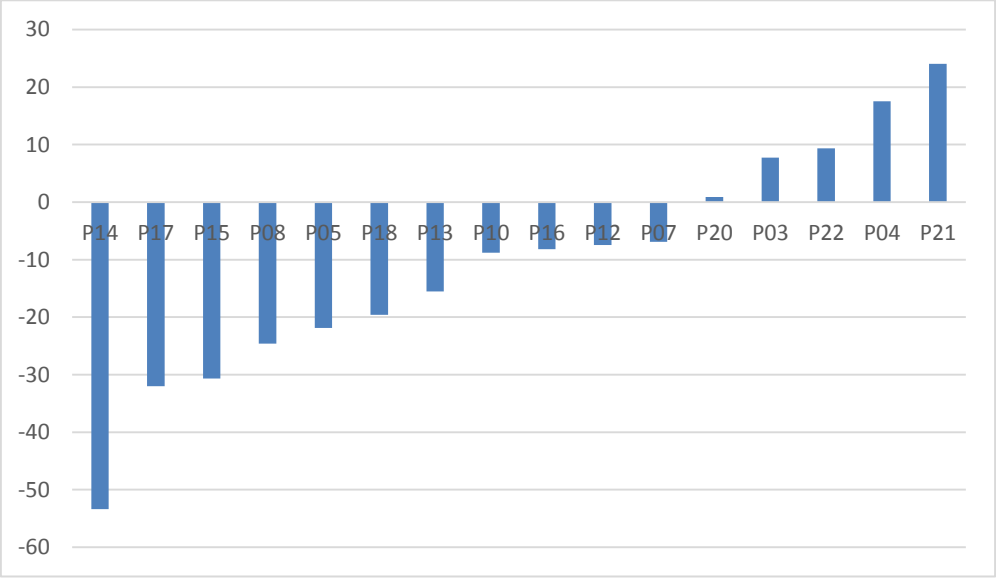

Figure 9. Comparison of DT% in L1 and L2 subtitles in monolingual conditions. Negative values = higher DT% in English subtitles. Positive values = higher DT% in Chinese subtitles.

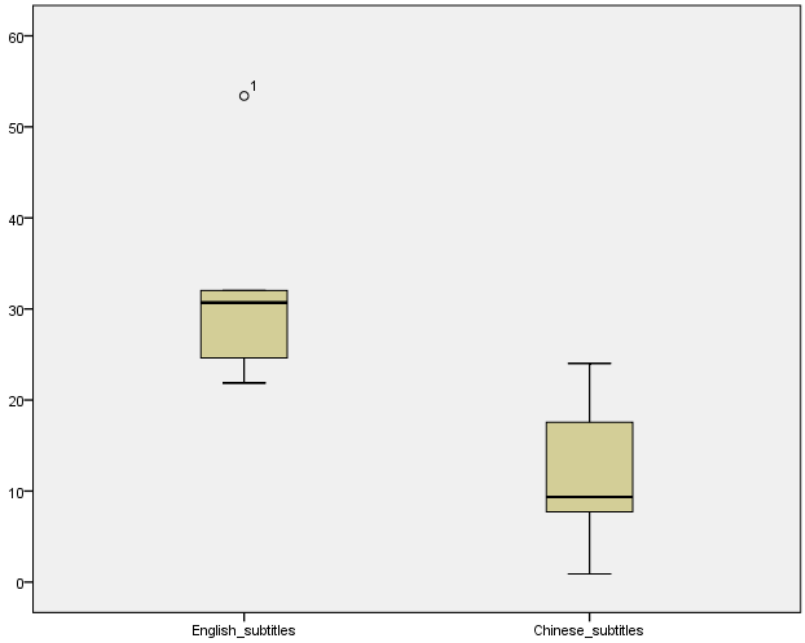

Figure 10. Differences of DT% in L1 and L2 subtitles in monolingual conditions. "English_subtitles" = absolute values of the difference in DT% between English subtitles and Chinese subtitles in monolingual conditions with higher DT% in English subtitles. "Chinese_subtitles" = absolute values of the difference in DT% between English subtitles and Chinese subtitles in monolingual conditions with higher DT% in Chinese subtitles.

As can be seen from Figure 10 which compares DT% in subtitles between Chinese (L1) monolingual and English (L2) monolingual conditions, the difference between the time spent on L1 and L2 subtitles is larger and is also less variable when viewers spent more time reading L2 subtitles than when they spent more time reading L1 subtitles.

In the bilingual condition where Chinese subtitles and English subtitles coexisted, no significance in the DT% was identified between CS_B and ES_B (t (15) = 0.539, p = 0.598). Similar DT% in the Chinese subtitles (M = 18.3%, SD = 15.9) and English subtitles (M = 15.3%, SD = 15.9) indicates that viewers spent an approximately equal amount of time on two different subtitles when watching videos with bilingual subtitles. However, on closer inspection of the individual data, nearly half of participants had

higher DT% in English subtitles while half of them had higher DT% in Chinese subtitles (see Figure 11).

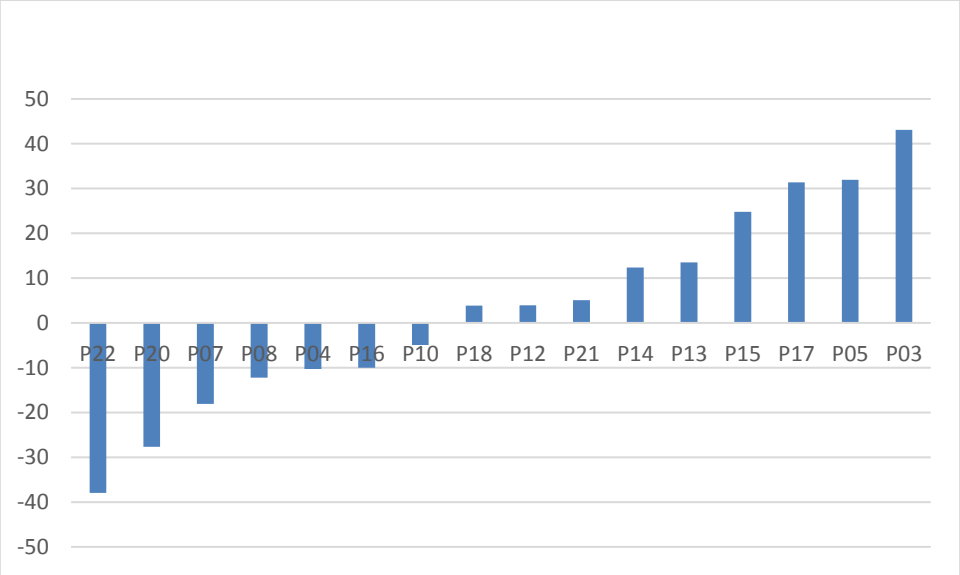

Figure 11. Comparison of DT% in L1 and L2 subtitles in the bilingual condition. Negative values = higher DT% in English subtitles. Positive values = higher DT% in Chinese subtitles.

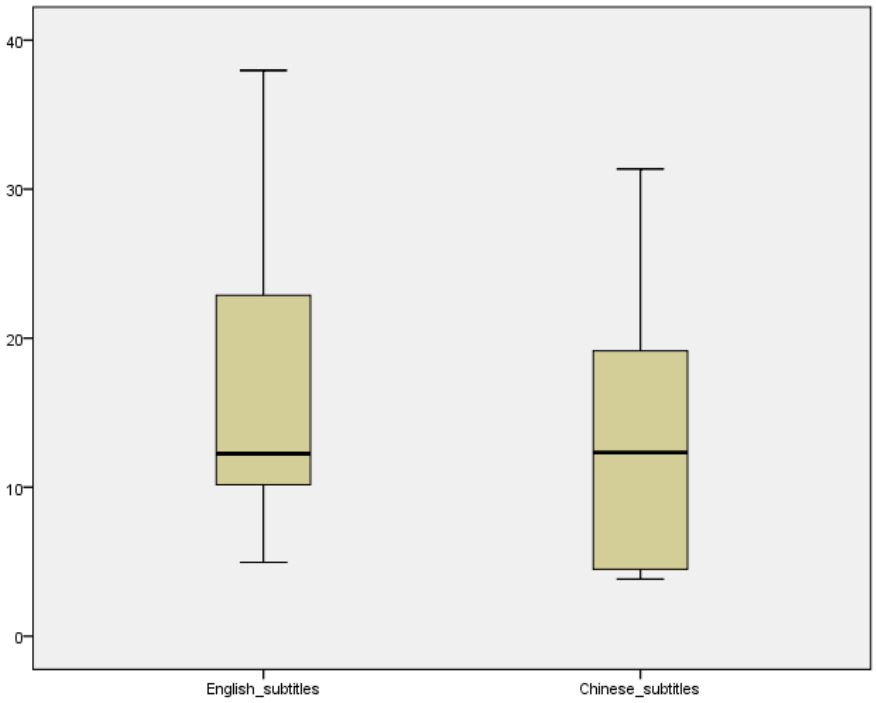

Figure 12. DT% in L1 and L2 subtitles in the bilingual condition. "English_subtitles" = absolute values of the difference in DT% between English subtitles and Chinese

subtitles in bilingual conditions with higher DT% in English subtitles. "Chinese_subtitles" = absolute values of the difference in DT% between English subtitles and Chinese subtitles in bilingual conditions with higher DT% in Chinese subtitles.

As can been seen from Figure 12 which compares DT% in subtitles between Chinese (L1) and English (L2) subtitles in the bilingual condition, the difference between the time spent on L1 and L2 subtitles is similar. It indicates that when viewers chose one language as a dominant resource, they spent a similar amount of time reading subtitles in another language.

It can be observed from Figure 13 that a majority of participants (62.5%) changed their preferences for the language of subtitles when they shifted from a monolingual to a bilingual condition, with seven participants changing their reliance on subtitles from English to Chinese and three from Chinese to English.

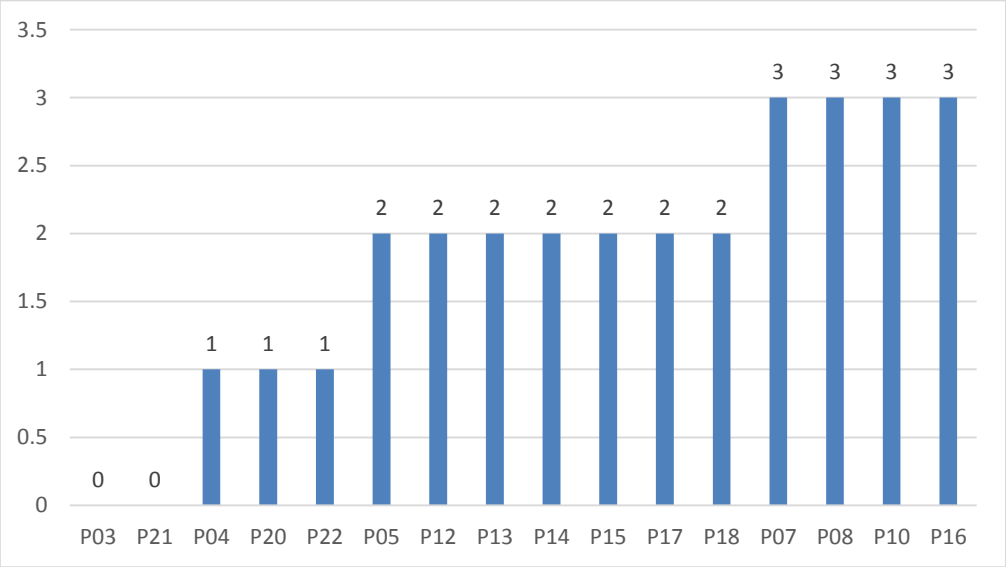

Figure 13. Comparison of DT% in L1 and L2 subtitles between monolingual and bilingual conditions. 0 = always higher DT% in Chinese subtitles. 1= higher DT% in L1 subtitles in the monolingual condition but higher DT% in L2 subtitles in the

bilingual condition. 2 = higher DT% in L2 subtitles in the monolingual condition but higher DT% in L1 subtitles in the bilingual condition. 3 = always higher DT% in L2 subtitles.

4.1.2 DT% on the visual image

The one-way repeated measures ANOVA found that DT% in the visual image was significantly different between subtitling conditions (F (3, 45) = 8.382, $p < 0.0005$). Post hoc analysis with a Bonferroni adjustment for multiple comparisons revealed that there was significant difference between NS and BS ($p = 0.028$), NS and CS ($p = 0.026$), and NS and ES ($p = 0.017$). However, no significant differences were found between subtitling conditions.

Table 4. Means of DT% on the Visual Image in Monolingual and Bilingual Conditions

Video condition	M (*SD*)	N
BS	64.48 (8,75)	16
CS	67.28 (9.61)	16
ES	64.58 (7.07)	16
NS	73.29 (13.45)	16

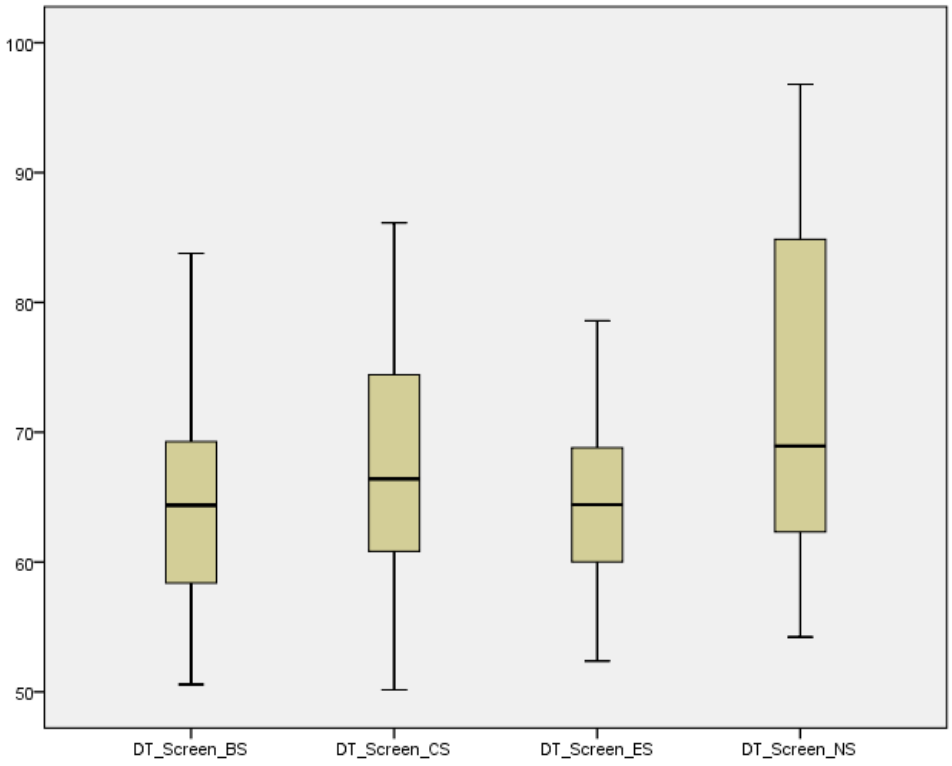

Figure 14. DT% on the visual image across four video conditions.

4.1.3 Difference in DT% between subtitles and the visual image

Paired samples t-tests found that there were significant differences in DT% between subtitles and image in three different subtitling conditions. DT% was significantly higher in image than in subtitles for all subtitled conditions: CS (t (16) = -13.354, p < 0.0005), ES (t (16) = -6.491, p < 0.0005) and BS (t (15) = -7.157, p < 0.005). While almost all participant spent more time on image than on subtitles regardless of the subtitling condition (see Figure 15), difference of DT% between subtitles and visual image in BS and ES were roughly the same while a more noticeable gap was observed in CS (see Figure 16).

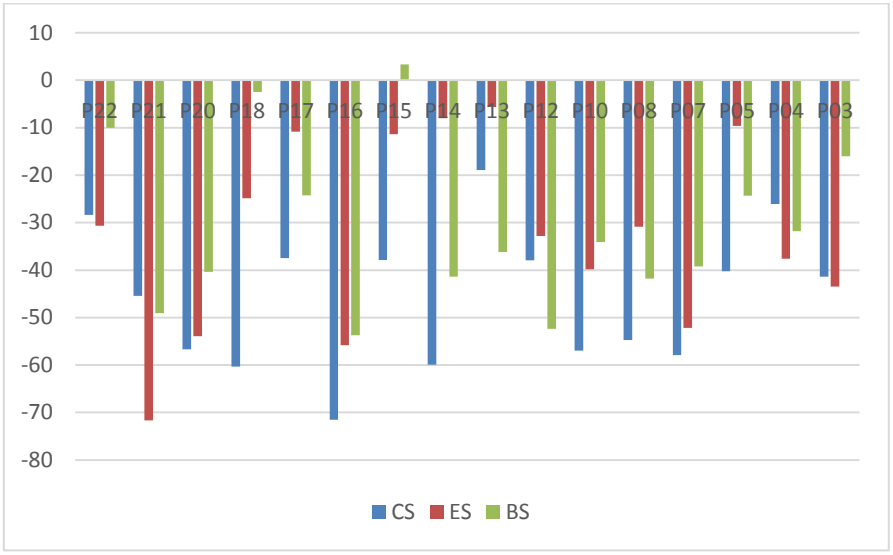

Figure 15. Difference of DT% between subtitles and visual image for all participants in different subtitled conditions. Positive results = a higher DT% in subtitles. Negative values = a higher DT% on the image.

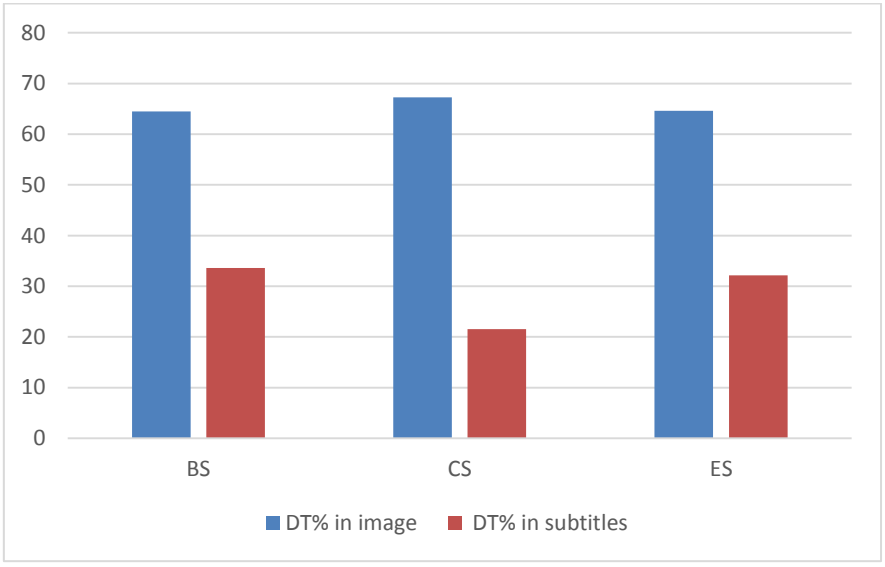

Figure 16. Comparison of DT% in image and subtitles in three subtitled conditions.

4.1.4 Mean Fixation Duration in the subtitled area

The one-way repeated ANOVA showed that mean fixation duration (MFD) was not significantly different between CS, ES, CS_B and ES_B (F (3, 45) = 1.289, p = 0.290).

Table 5. Mean Fixation Duration in Subtitles in Monolingual and Bilingual Conditions

Subtitled Condition	M (*SD*)	N
CS	159.21 (43.07)	16
ES	143.77 (27.13)	16
CS_B	150.42 (40.55)	16
ES_B	139.84 (51.17)	16

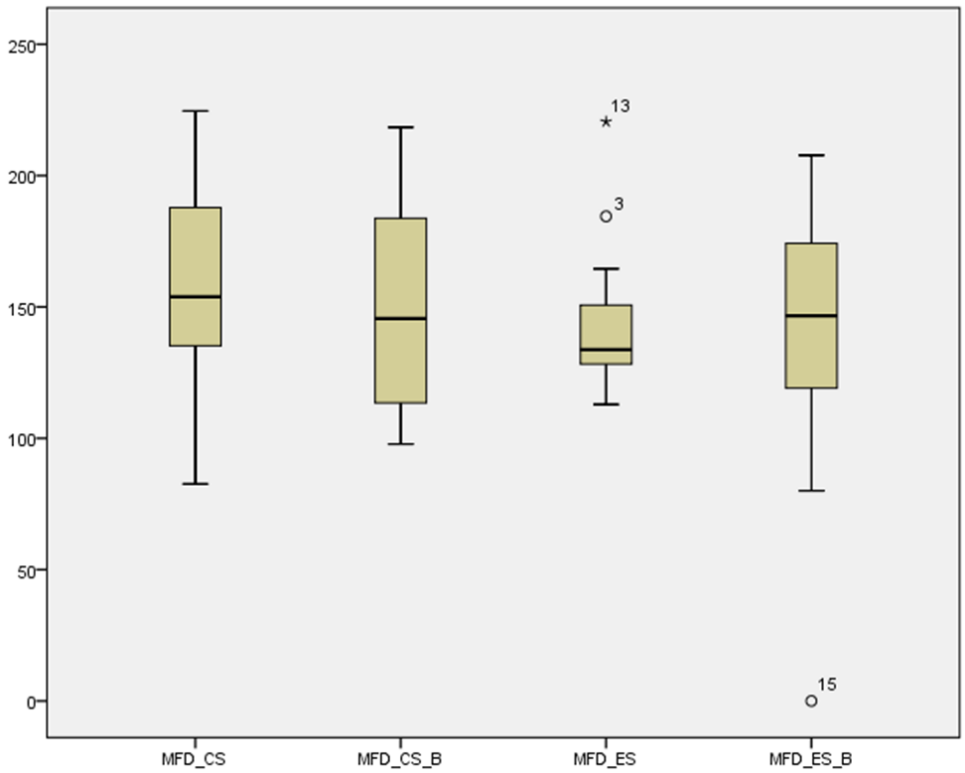

Figure 17. Mean Fixation Duration in subtitles in different subtitled conditions.

4.2 The Impact of Subtitle Mode on Cognitive Load

4.2.1 Intrinsic cognitive load (IL)

The one-way repeated measures ANOVA showed that there were significant differences in IL between subtitling conditions (F (3, 51) = 5.321, p = 0.003). Post hoc analysis with a Bonferroni adjustment for multiple comparisons revealed that there was significant difference between NS and ES (p = 0.035), NS and BS (p = 0.039). IL was highest in NS and lowest in BS (see Table 6).

4.2.2 Extraneous cognitive load (EL)

The one-way repeated measures ANOVA found significant differences in EL between different conditions (F (3, 51) = 5.103, p = 0.004). Post hoc analysis with a Bonferroni adjustment for multiple comparisons revealed that there were significant differences between NS and CS (p = 0.040), as well as NS and BS (p = 0.011). Similar to the trend in IL, EL was highest in NS and lowest in BS.

4.2.3 Germane cognitive load (GL*)

The one-way repeated ANOVA showed that there were significant differences between different conditions (F (2.198, 37.373) = 8.424, p = 0.001). Post hoc analysis with a

Bonferroni adjustment for multiple comparisons revealed that there was significant difference between NS and CS (p = 0.020), NS and ES (p = 0.017), and NS and BS (p = 0.009). GL* in the CS condition was the highest and lowest in the NS condition.

4.2.4 Mental effort in information acquisition (ME)

Results of the Friedman test showed that mental effort in the subtitled area was significantly different in different subtitling conditions ($\chi 2$ (3) = 9.245, p = 0.026). Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons. There was a marginally significant difference between NS and CS (p = 0.049).

Table 6. Means (*SD*) of Cognitive Load and Mental Effort in Different Conditions

Condition	IL	EL	GL*	ME
NS	18.78 (8.27)	14.56 (6.37)	15.44 (5.49)	5.44 (2.55)
CS	13.89 (7.40)	9.33 (5.74)	21.17 (4.34)	3.67 (1.94)
ES	12.06 (8.80)	9.56 (7.35)	19.89 (4.25)	4.61 (2.63)
BS	11.67 (7.90)	9.00 (6.25)	20.78 (3.89)	4.28 (2.87)

Note. N = 18.

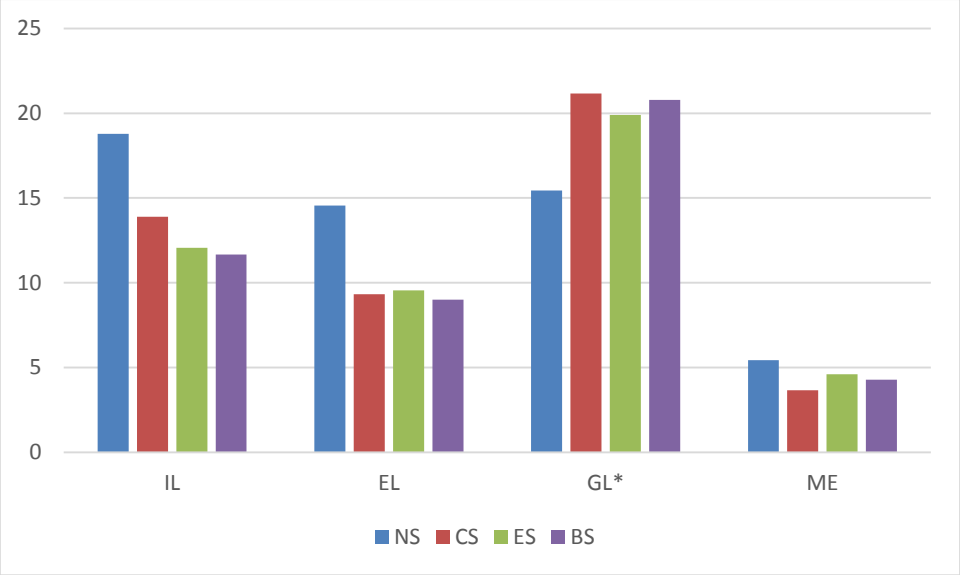

Figure 18. Average values of self-reported cognitive load and mental effort in four video conditions: NS, CS, ES and BS.

4.3 The Impact of Subtitle Mode on the Scores of Free Recall Test

The one-way repeated measures ANOVA revealed that there was no significant difference in the recall scores between different conditions (F (3, 42) = 1.447, p = 0.243), although the paired samples t-test results found that the difference between NS and BS was approaching significance (t (15) = -2.033, p = 0.06).

Table 7. Means of Recall Test Scores in Different Conditions

Video Condition	M (*SD*)	N
NS	8.45 (3.46)	15
CS	9.88 (5.44)	15
ES	9.82 (4.00)	15
BS	10.83 (5.93)	15

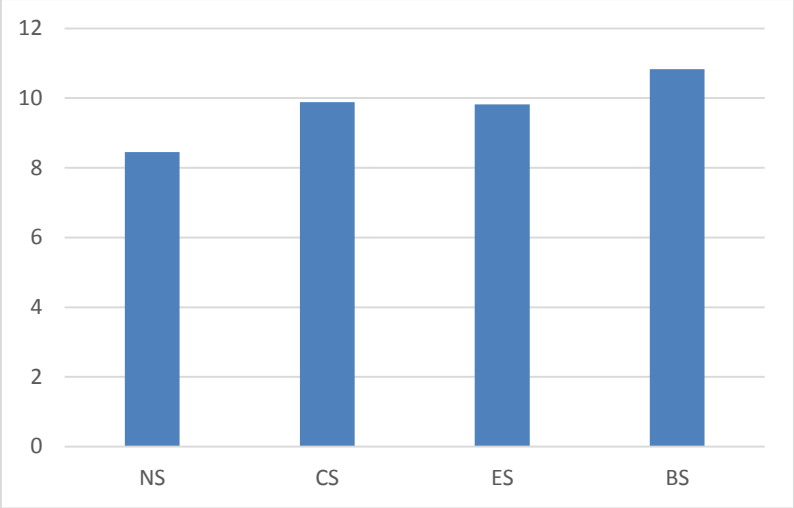

Figure 19. Means of recall scores in different conditions.

Chapter 5. Discussion

Drawing upon eye movement data and self-reported data, this study investigated Chinese L1 viewers' distribution of visual attention and cognitive load when watching English videos in different conditions: without subtitles, with English subtitles (L2 subtitles), with Chinese subtitles (L1 subtitles), and with bilingual subtitles (L1 + L2 subtitles). This study had two main objectives. The first objective was to compare the impact of bilingual subtitles to that of monolingual L1 and L2 subtitles in terms of viewers' visual attention to subtitles and image. The second objective was to determine whether bilingual subtitles will result in more cognitive gain by combining the benefits of intralingual and interlingual subtitles and thus facilitate comprehension or, alternatively, cause more cognitive load as a result of increased redundancy thus impairing comprehension.

5.1 The Impact of Subtitle Mode on Attention Allocation

An analysis of DT% in subtitles revealed a main effect of subtitle mode on viewers' visual attention to subtitles. Viewers spent more time looking at subtitles in the BS condition than in the CS condition, which is probably because bilingual subtitles contained two lines of subtitles whereas there were only one-line subtitles in the monolingual condition. However, this postulation is refuted by the lack of difference between the BS and ES conditions. This would suggest that it is not the number of subtitle lines but rather the addition of subtitles in a non-native language that results in

more attention to the subtitled area. This also provides some evidence for the statement made by Kruger and Steyn (2014) that "the number of lines do[es] not play as big a role in the processing of subtitles as previously thought" (p. 105). As L2 subtitles attracted a significantly higher amount of visual attention (nearly the same as the attention to the bilingual subtitles) than L1 subtitles, it seems that viewers are more compelled to divert their attentional resources from other visual elements (e.g., image) to L2 subtitles than to L1 subtitles.

An observation of the differences in the time spent on L1 and L2 subtitles between the bilingual and monolingual conditions revealed that viewers' visual attention to subtitles in different languages was not equally sensitive to competition. Viewers spent less time on L1 subtitles in the bilingual condition than in the L1 monolingual condition, but the difference did not reach significance. However, the case was different for L2 subtitles: viewers spent much less time looking at the L2 subtitles in the bilingual condition than in the L2 monolingual condition. In other words, the presence of both L1 and L2 in bilingual subtitles did not significantly alter the visual attention to L1 subtitles (they received the same amount of attention as in the monolingual condition), but it did result in a significant reduction of attention to L2 subtitles. This would suggest that viewers' visual attention to L2 subtitles is more sensitive to the increased visual competition in the bilingual condition.

When provided with both L1 and L2 subtitles in the bilingual condition, viewers did not allocate equal amount of visual attention to two different subtitles or completely ignored subtitles in one language due to their redundancy. Instead, they chose one language as a main source of visual-verbal information. It seems that viewers are able to adjust their viewing pattern and choose the less cognitively demanding way to

understand the video because paying equal attention to two subtitles would mean that viewers have to shift back and forth between two subtitles, which could consume extra cognitive resources and hinder information acquisition. It can also be explained by the early-selection theories of attention proposed by Broadbent (1958) and Treisman (1968) which posit that stimuli will be filtered at an early stage in order not to overload the limited processing capacity of the human cognitive system.

Moreover, the fact that viewers spent time reading subtitles in both languages in spite of their redundancy provides evidence for the automatic subtitle reading behavior hypothesis as proposed by d'Yewalle et al. (1991). The unequal amount of visual attention devoted to the L1 and L2 subtitles implies that the two different subtitles in the bilingual subtitling condition function differently, one is used as the major visual-verbal channel (dominant subtitles) and the other as complementary channel (complementary subtitles). The similar difference in the visual attention between dominant subtitles and complementary subtitles regardless of whether viewers chose L1 or L2 subtitles as dominant subtitles indicates that viewers may capitalize on the complementary subtitles for a similar purpose. As noted by Lavaur and Bairstow (2011), viewers may refer to the other language subtitles to compare and confirm the aural/visual input from time to time. However, such confirmation needs to be conducted effectively and quickly as a long translation process may cause the viewers to lag behind and lose the track (Saed et al., 2016), which could consequently deprive the viewer of the benefits of dual-channel presentation as suggested by the Dual Coding Theory (Paivio, 1986).

Furthermore, viewers' preference for the language of subtitles changed from monolingual conditions to the bilingual condition. Nearly half of viewers changed their

preferences from L2 subtitles to L1 subtitles when they shifted from monolingual to bilingual conditions, whereas only 18.75% of viewers changed from L1 to L2 subtitles. There are two possible explanations for that. One is that viewers may have more stable reliance on L1 subtitles than on L2 subtitles due to the language dominance of their native language (Heredia & Altarriba, 2001; Heredia, Olivares, & Cies, 2014). In face of time constraints, viewers are inclined to acquire information in their native language which is easier to process. A second possibility is that L2 subtitles render more redundancy than L1 subtitles when L2 audio information is available and therefore are less attended to by viewers. This would suggest that viewers may have the ability to filter more redundant information even though they are unable to completely avoid them in order to save cognitive resources for higher order processing and deeper elaboration of the messages (Liu, Lai, & Chuang, 2011; Reese, 1984).

It was found that viewers' visual attention to the dynamic image was not significantly affected by the subtitle mode. In all subtitled conditions, viewers spent an approximately similar amount of time on image, even though there were more sources of information in the bilingual condition competing for visual attention. It implies that viewers' reliance on image appears to be more stable than their reliance on subtitles. This is possibly because there is less redundancy between nonverbal information (image) and verbal information (narration/subtitles) than between visual-verbal information (subtitles) and audio-verbal information (narration), and therefore viewers would rather spend more time on the less redundant information (i.e., image) in order to maximize information acquisition. This again corroborates the view that viewers are able to filter out information that has a higher degree of redundancy.

In monolingual conditions where subtitles were presented in either viewers' native language (L1 subtitles) or second language (L2 subtitles), viewers spent significantly more time looking at L2 subtitles, which is in line with the results reported by Kruger et al. (2014).

As it was found in the studies of Guichon and McLornan (2008) and Tsai and Huang (2009) that the lexical interference between L1 subtitles and the L2 spoken dialogue impaired viewers' comprehension of lexical meanings, it could be possible that viewers skip more L1 subtitles in order to avoid lexical interference caused by the linguistic differences between the L1 subtitles and the L2 spoken dialogue. In this sense, viewers' processing of subtitles is based on a top-down processing strategy.

However, viewers' more visual attention to L2 subtitles could also be a result of bottom-up processing as research on language-mediated eye movements has revealed that the meaning of spoken language can impinge on the viewer's allocation of visual attention. It has been found that viewers are inclined to fixate on the visual objects that are most semantically relevant to the spoken words (see e.g., Cooper, 1974; Eichert, Peeters, & Hagoort, 2017; Mishra, Olivers, & Huettig, 2013; Salverda & Altmann, 2011). It is very likely that viewers spend more time looking at L2 subtitles because there exist stronger semantic relations between subtitles and the spoken dialogue that share the same language. If this is the case, viewers are expected to spend more time reading L1 subtitles if the spoken dialogue is in L1. To verify this postulation, further research is encouraged to explore the influence of spoken language on the visual processing of transient texts such as subtitles.

A comparison of the current study and previous relevant studies revealed that viewers' attention distribution to subtitles could be influenced by their knowledge of the

language in the soundtrack. As can be seen from Table 8, viewers who were able to understand the spoken dialogue spent less time reading subtitles than those who had no knowledge of the foreign language in the soundtrack regardless of the language of subtitles. It seems that when information is presented in two different channels, both aurally and visually, viewers tend to reduce their reliance on one single channel. This view partially corroborates the findings reported by Sohl (1989) that viewers tried to follow the speech when watching subtitled videos. An important implication of these findings is that redundancy between different channels could be beneficial to viewers as they are less likely to be cognitively overloaded by processing all information in one single channel. For instance, as demonstrated the study of Moreno and Mayer (2002b), students learned more effectively when the visual materials were accompanied by speech rather than by written text.

However, given that reading skills are more developed than listening skills (Garza, 1991) and that subtitles are more efficient than auditory information (Hinkin et al., 2014), it raises an interesting question as to why viewers still spare cognitive resources for processing the audio information when they are able to acquire sufficient information from the visual channel. One possible reason is that viewers split attention between the subtitles and the spoken dialogue (redundancy between different sensory channels) in order to relieve the stress on the visual processing memory and compensate for the information loss caused by the splitting of attention between subtitles and the image (redundancy within the same sensory channel). According to Dual Coding Theory, processing redundant information between different sensory channels, such as pictures and audio information, can produce enhancing effects by making the most use of two independent systems for processing visual and auditory information (Paivio,

1986b, 2007; Reese, 1984; Thompson & Paivio, 1994). Based on a premise that humans possess two independent processing systems, one is responsible for processing verbal information and one for nonverbal information, the Dual Coding Theory posits that retention of information can be strengthened when information is presented in two different sensory channels.

It could also be possible that the gap between reading and listening in dynamic contexts is so small for intermediate or advanced language learners that written verbal information is not superior to or even less efficient than auditory information. This may explain why subtitles are found to be beneficial for low proficiency viewers but distracting for advanced viewers as found in some studies (see, e.g., Lavaur & Bairstow, 2011).

Another explanation for viewers' tendency to process redundant audio information is that the integration of audio and visual verbal information could occur automatically as part of the multisensory processing of human cognition system (Ghazanfar & Schroeder, 2006; Quak, London, & Talsma, 2015). Further research is encouraged to determine whether making use of audio input is an automatic behavior like subtitle reading (d'Yewalle et al., 1991) and to what extent the presence of subtitles interferes with the processing of the spoken dialogue or vice versa.

Table 8. Comparison of Findings for the Overall Time Spent on Subtitles.

	Intralingual subtitling	Interlingual subtitling	Knowledge of the foreign language involved	Number of subtitle lines	Overall time spent on subtitles
Hefer (2013a) (p. 365)		French soundtrack with Sesotho subtitles (L1)	No (Sesotho L1 viewers without knowledge of French)	One-line	79%
				Two-line	86%
				Overall	83%
		French soundtrack with English subtitles (L2)	No (Sesotho L1 viewers without knowledge of French)	One-line	63%
				Two-line	76%
				Overall	74%
Kruger et al. (2014) (p. 7)	English soundtrack with English subtitles (L2)		Yes (Sesotho L1 viewers using English as a second language)	one-line and two-line	42.9%
		English soundtrack with Sesotho subtitles (L1)	Yes (Sesotho L1 viewers using English as a second language)	one-line and two-line	20.3%
Current study (2017)	English soundtrack with English subtitles (L2)			One-line	32.1%
		English soundtrack with Chinese subtitles (L1)	Yes (Chinese L1 viewers using English as a second language)	One-line	21.6%
	Bilingual subtitles		Yes (Chinese L1 viewers using English as a second language)	Two-line	33.6%

Note. Values were calculated as a percentage of dwell time of the visible time of subtitles.

5.2 The Impact of Subtitle Mode on Cognitive Load

5.2.1 Self-reported measures

Significant differences in three types of cognitive load were found between the NS and BS conditions, with BS reporting significantly lower scores in IL and EL and higher score in GL*, which suggests that adding bilingual subtitles makes the video easier to understand and allows for more cognitive resources for the learning process than not providing viewers any written text as linguistic support. It also supports the growing body of evidence that processing subtitles is cognitively effective and does not cause cognitive overload (Kruger et al., 2013; Lång, 2016; Perego et al., 2010).

In contrast to Diao and Sweller's findings in 2007, this study did not find an increase in extraneous cognitive load in the presence of redundancy between audio and visual information. It is worth noting, however, that their study compared text only to text with audio, whereas the present study does not have a text only condition.

As no significant differences were found in cognitive load or mental effort between the bilingual and monolingual conditions, there was no sufficient evidence for the arguments that bilingual subtitles give viewers a cognitive gain by combining the benefits of intralingual and interlingual subtitles or place more cognitive burdens on viewers as a result of containing more redundant information than monolingual subtitles.

5.2.2 Eye tracking measures

As no significant difference in mean fixation duration was found between L1 monolingual and L2 monolingual subtitles, or between L1 and L2 subtitles in the bilingual condition, it could be said that processing L1 and L2 subtitles is equally cognitively demanding regardless of whether the two subtitles are presented separately or simultaneously. This is probably because viewers chose one language of subtitles as a major channel for visual-verbal information in the bilingual condition – they were engaged in cognitive processing that was similar to the monolingual condition.

It is interesting to note that while viewers spent significantly less time looking at L2 subtitles in the bilingual condition than in the monolingual condition (refer to the results of DT% in subtitles), no difference was observed for the mean fixation duration in L2 subtitles between the two conditions. In other words, the reduction of time viewers spend looking at subtitles did not affect the depth of processing of subtitles. This further points to the necessity of making a distinction between attention allocation to and reading of subtitles (Kruger & Steyn, 2014).

It is also worth noting that mean fixation duration in L1 and L2 subtitles in both monolingual and bilingual conditions were shorter than that reported by Bisson et al. (2014) and d'Ydewalle and De Bruycker (2007) (see Table 9). A possible reason is that viewers in the study of Bisson et al. (2014) had no knowledge of the soundtrack, which means that they could only rely on subtitles for verbal information in the interlingual subtitling condition. It indicates that when viewers are able to acquire information from the spoken dialogue, they may experience less processing difficulties, even though the subtitles are in a different language from the spoken dialogue. This also partially

accounts for viewers' inclination to rely less on subtitles when the spoken dialogue is accessible to them as discussed before.

Table 9. Comparison of Mean Fixation Duration (MFD) in Subtitles between Different Studies

	L1 subtitles	L2 subtitles	Knowledge of the Soundtrack
Bisson et al., (2014) (p. 407)	240ms	227ms	No
d'Ydewalle & De Bruycker (2007) (p. 199)	178 ms (for adults) 248ms (for children)	N/A	No
Current study (2017)	159ms (in CS) 150ms (in BS)	143ms (in ES) 140 (in BS)	Yes

5.3 The Impact of Subtitle Mode on Content Comprehension

The free recall scores did not differ significantly across the four different conditions, which implies that viewers comprehend the video equally well regardless of the presence and linguistic formats of subtitles, although the lowest comprehension rate in the NS condition suggests that subtitles benefit comprehension, which is consistent with a number of studies (Chung, 1999; Hayati & Mohmedi, 2011; Hosogoshi, 2016; Markham et al., 2001; Wang, 2014). However, the lack of significance in the results makes it impossible to extrapolate.

Although bilingual subtitles do not seem to produce more cognitive benefits, the lack of significant difference in both subjective measures (self-reported questionnaire) and

performance measures between the bilingual and monolingual conditions at least dispels the concern that bilingual subtitles which generate more redundancy may cause cognitive overload and impede comprehension.

5.4 Audiovisual Redundancy in Subtitling Research

Different from some previous subtitling studies that used videos with an unknown language either in subtitles or in the soundtrack, this study provided viewers with access to both visual-verbal (subtitles in L1, L2 or L1 and L2) and audio-verbal (narration in L2) channels, which means that viewers are exposed to either two or three sources of redundant verbal information at a time. Moreover, this study presents an attempt to extend research on the redundancy effect from a L1 context to a L2 context. The four video conditions that were investigated in the current study represent different degrees of redundancy, with the NS condition containing the least amount of redundant information and the bilingual condition encompassing most redundancy. Although the CS and ES conditions consist of the same number of communication channels, they could generate different degrees of redundancy because the semantic relations between subtitles and the spoken dialogue differ when the two verbal channels are in the same language than in different languages.

This study therefore provides some interesting insights into the influence of redundancy on visual processing and cognitive load when watching subtitled videos. First, the absence of significant difference between the no subtitle condition and subtitled conditions suggests that the presence of subtitles as visual-verbal redundancy does not

give viewers a significant advantage in video comprehension. However, eye movement data revealed that viewers spent more than 20% of the time reading subtitles in monolingual conditions and more than 30% in the bilingual condition. Even though the two different subtitles in the bilingual condition were redundant to each other, viewers still spent time reading both subtitles. It appears that it is the presence rather than the usefulness of visual-verbal redundant information that plays a bigger role in attracting visual attention. This view is in line with previous studies which found that subtitle reading was an automatic behavior (Bisson et al., 2014; d'Yewalle et al., 1991).

The automatic reading behavior could be attributed to the fact that subtitles are a visual trigger for automatic or bottom-up visual attention. For instance, the dynamic nature of subtitles corresponds to viewers' inclination to be attracted to salient information, such as motion (Bisson et al., 2014). In addition, it has been found that people tend to read any available text as they believe that texts contain richer information (Cerf, Frady, & Koch, 2009; Ross & Kowler, 2013; Wang & Pomplun, 2012). Subtitles as written text therefore are likely to grasp visual attention even though they are redundant to information in other modalities from different sources.

If viewers cannot avoid redundant information, how they allocate their attentional and cognitive resources among multiple information sources effectively would be of great importance for comprehension due to the limited processing capacity of working memory. Consistent with the findings of the study by Liu et al. (2011), the current study found that viewers had the ability to filter out information with a higher degree of redundancy using selective attention according to their dynamic needs. A question that is worth further investigation is whether viewers' selective attention strategy is a function of their prior knowledge, motivation and learning practice. Research on

multisensory processing and integration would provide much insights in this regard (see, e.g., Koelewijn, Bronkhorst, & Theeuwes, 2010; Morís Fernández, Visser, Ventura-Campos, Ávila, & Soto-Faraco, 2015; Quak et al., 2015; Talsma, Senkowski, Soto-Faraco, & Woldorff, 2010; Van der Burg, Brederoo, Nieuwenstein, Theeuwes, & Olivers, 2010; Van der Burg, Talsma, Olivers, Hickey, & Theeuwes, 2011). This also points to the need for interdisciplinary collaboration in audiovisual research and highlights the potential benefits the subtitling research could gain from other disciplines such as cognitive psychology.

Interestingly, findings of the current study do not support previous claims that processing redundant information causes higher extraneous cognitive load. In contrast, the BS condition which presumably features more redundancy reported lower intrinsic and extraneous cognitive load than NS which contains the least amount of redundant information. There could be two reasons for that. First, the redundancy effect is originally based on native language contexts whereas the current study is based on a second language context. Presenting redundant information in viewers' native language may have a different impact on cognitive load than presenting redundant information in viewers' second language. This study could be replicated by including video conditions that contain L1 spoken dialogue with L1 and L2 monolingual subtitles to examine if there exists any difference in subtitle processing. Second, the video used in the current study is less image intensive than the animation used in other studies that explored the redundancy effect. As a result, viewers in the current study may have had more available cognitive resources for the processing of redundant verbal information.

In contrast to the redundancy effect which suggests that presenting the same information in multiple forms and modalities will result in a decrease in learning, the

current study does not provide evidence for the detrimental effect of redundant information. The comprehension performance between NS and BS is approaching significance in favour of the BS condition, but this would have to be investigated with a larger sample and possibly longitudinally before any conclusions can be made.

Findings of the current study suggest that the effects of redundancy may be less straightforward than previously assumed, especially in entertainment media. That is why previous research which focused on determining the impact of different sources of redundancy with a view to eliminating the redundant information that hinder comprehension often yields divergent findings. Redundancy is a dynamic and context dependent construct. Therefore, focus of future studies should be placed on exploring how the interaction between redundant information changes as a function of the complexity of the task, individual characteristics and presentation modes, among other factors.

Chapter 6. Conclusion

This chapter is composed of two sections. The first section (6.1) summarizes findings and contributions of the current study while the second section (6.2) discusses some limitations of this study and provides suggestions for future research.

6.1 Contribution

This study presents an empirical study as part of the growing body of research that explores the impact of subtitle mode on cognitive processing and video comprehension. In particular, it contributes to our understanding of the impact of bilingual subtitles on attention allocation and cognitive load, which has not been investigated before.

It was found that bilingual subtitles as a combination of intralingual and interlingual subtitles affected viewers' attention distribution to subtitles in a way different from intralingual and interlingual subtitles. Results showed that viewers' visual attention to L1 subtitles was more stable than to L2 subtitles and was less sensitive to the increased visual competition in the bilingual condition. This study also dismisses the concern that bilingual subtitles result in cognitive overload and impede comprehension as a result of increased redundancy.

Furthermore, this study enriches our understanding of the redundancy effect by exploring the processing of redundant information in a foreign language context. Results revealed that while viewers were inclined to attend to multiple available

redundant information, they appeared to have the ability to filter out some redundancy in order to save cognitive resources for deeper processing of essential information. Findings of the current study also indicate that the presence of redundant information does not necessarily result in an increase in cognitive load and less learning as suggested in previous research. The effects of redundant information on comprehension are, to some extent, dependent on viewers' ability to evaluate the momentary value of different layers of redundancy, and actively select and integrate different sources of redundancy based on their individual and dynamic needs to achieve their learning goal.

6.2 Limitations and Implications for Future Research

There are a number of necessary limitations that should be taken into account when replicating the current study in further research. First, given the time constraints of this project, the sample size in the current study is small, which does not provide sufficient statistical power to determine the impact of different subtitled modes on viewers' content comprehension. Although the sample size is in line with most other eye tracking studies, a larger sample size could produce more conclusive findings.

Second, as viewers were asked to complete the free recall test in their second language, their English writing skills may have interfered with their comprehension performance. Some participants reported that they understood the content but found it difficult to express it in English completely. A meta-analysis study conducted by Perez et al. (2013) found that the test type used to measure the effectiveness of subtitles had a significant impact on the effectiveness of subtitles for listening comprehension. The effectiveness

of subtitles on comprehension may be reduced when productive tests (e.g., recall protocol) interfere with other language skills, for example, writing skills. Some studies also found that asking participants to do the free recall test in their native and second languages produced contradicting results regarding the effects of same language subtitles on listening comprehension (Markham et al., 2001; Tsai & Huang, 2009). A combination of both receptive and productive tests is therefore advisable for further studies.

Third, any definite conclusions drawn from the data of the current study should be made with caution as samples were not completely homogeneous in terms of language proficiency. Although all participants that produced valid data for eye tracking and comprehension analysis have met the language entry requirements of postgraduate programs at Macquarie University in Australia, they may still possess different English language proficiency due to their previous educational background and their exposure to English language skill-related practice. For instance, students from the Translation and Interpreting studies program could have higher English language proficiency than students from the accounting program which involves a less intensive training of English language skills.

A further limitation is that this eye tracking study only made use of the established measures of dwell time and mean fixation duration. Future studies could consider more metrics such as regressions and saccades to provide a more comprehensive picture of viewers' visual processing of subtitled audiovisual content. It would also provide more insightful findings by investigating the extent to which L1 and L2 subtitles are processed in monolingual and bilingual conditions using the Reading Index for Dynamic Text (RIDT) developed by Kruger and Steyn (2014).

Finally, although this study provides some evidence in support of previous findings that viewers try to follow the spoken dialogue when processing subtitles and visual image, further research is needed to determine how viewers distribute cognitive resources between subtitles and the spoken dialogue.

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Appendix A. Biographical questionnaire

Thank you for participating in this experiment. This questionnaire is used to collect some background information of participants as part of this study. All information will be kept confidential and only be used for academic purposes.

1. Please fill in the following sections:

   Name: _____

   University ID: _____

   Age: _____

   Gender: _____

   Your home country: _____

   Your home Language: (e.g. Cantonese, Mandarin, etc.) _____

   Your current major: _____

2. Indicate how many months you have spent in an English-speaking country in the last 10 years. _____

3. Please provide your IELTS scores in the following components:
   Overall: _____
   Listening: _____
   Reading: _____
   Writing: _____
   Speaking: _____

4. How often do you watch English films in the following conditions (tick the box that is applicable):

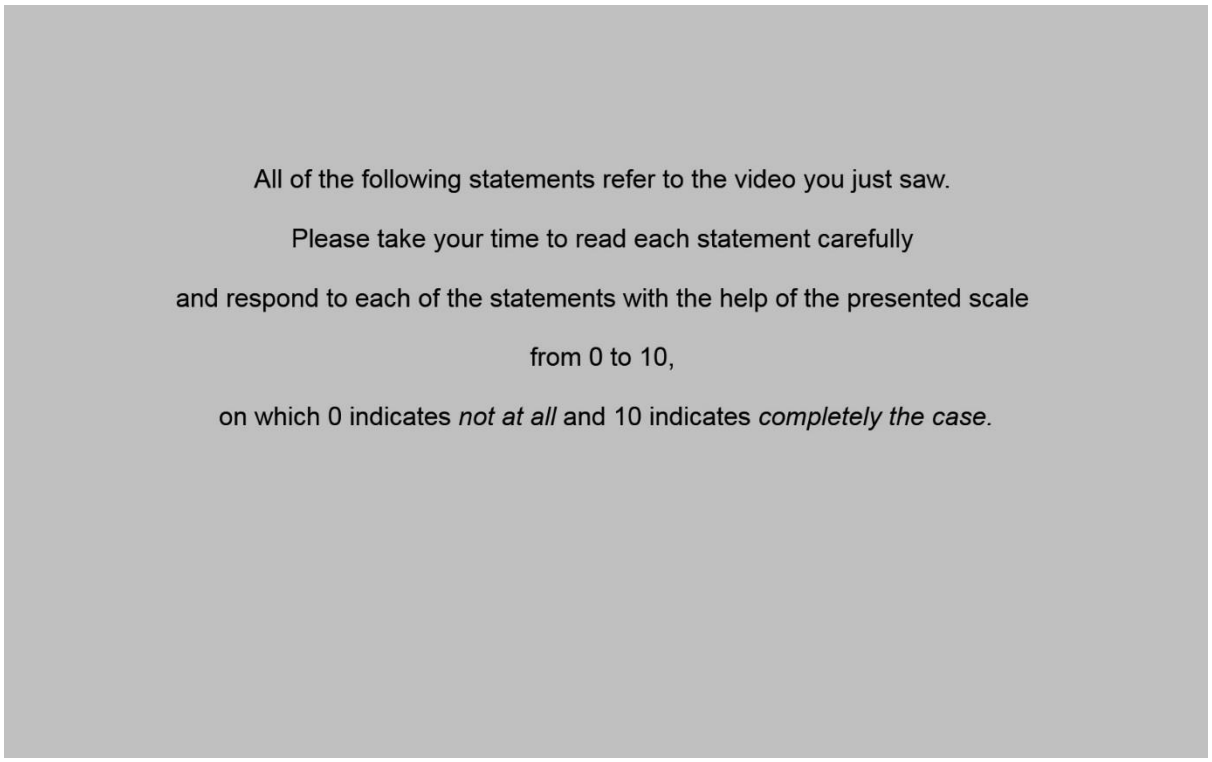
	1 (never)	2	3	4	5	6	7 (very often)
Without subtitles							

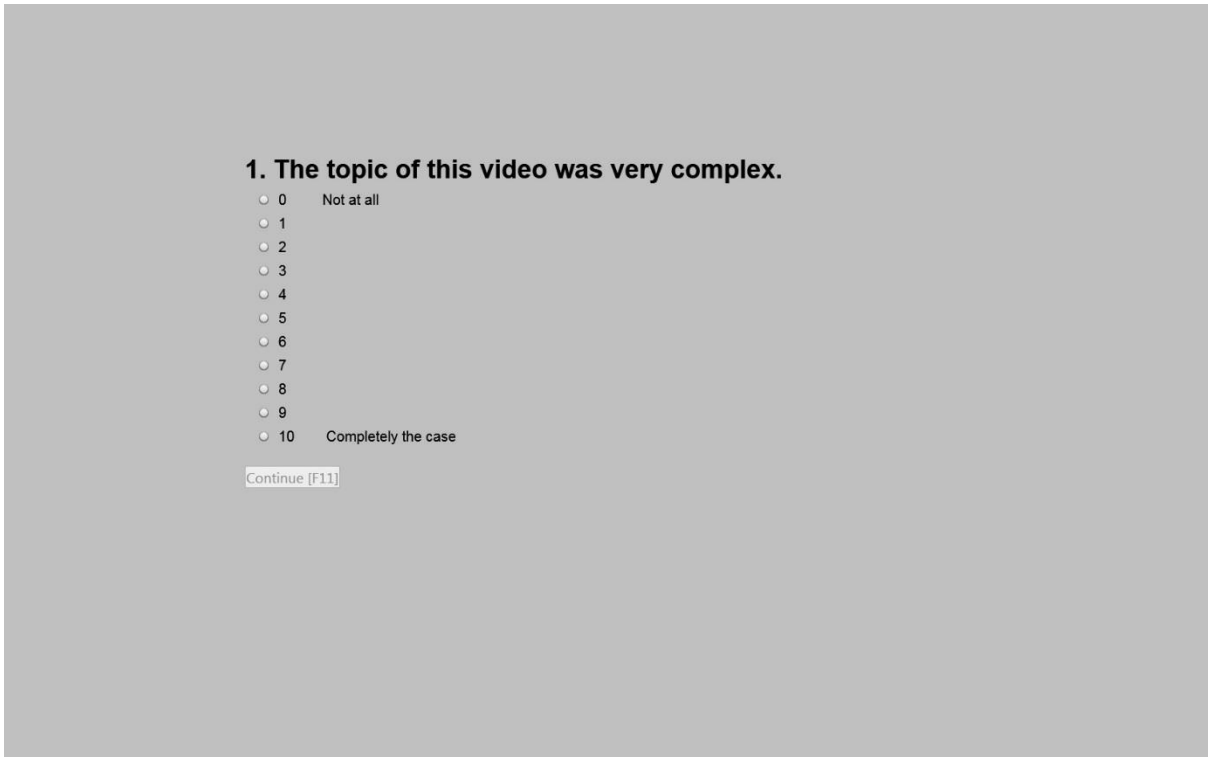
With English subtitles only							
With Chinese subtitles only							
With both English and Chinese subtitles							

5. How often do you watch BBC documentaries? (tick the box that is applicable):

1 (never)	2	3	4	5	6	7 (very often)

Appendix B. Cognitive Load Questionnaire





2. The information covered in this video was very complex.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

3. In this video, very complex terms were mentioned.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

4. I invested a very high mental effort in the complexity of this video.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

5. The presentation of information in this video was very unclear.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

6. The presentation of information in this video was full of unclear language.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

7. The presentation of information in this video was, in terms of acquiring knowledge, very ineffective.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

8. I invested very high mental effort in unclear and ineffective presentation of information in this video.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

9. This video really enhanced my understanding of the topic that was covered.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

10. This video really enhanced my understading of the information that was presented.

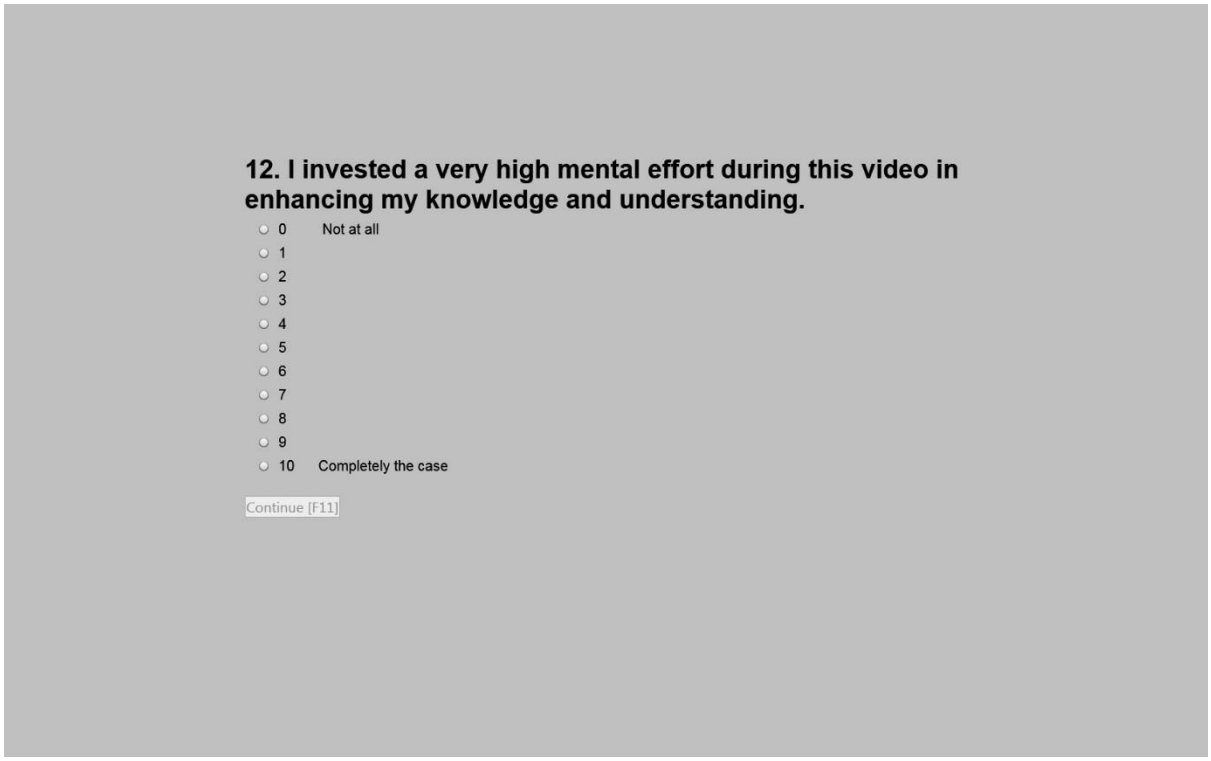
- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]

11. This video really enhanced my knowledge of the terms that were covered.

- 0 Not at all
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 Completely the case

Continue [F11]


12. I invested a very high mental effort during this video in enhancing my knowledge and understanding.
0 Not at all
1
2
3
4
5
6
7
8
9
10 Completely the case
Continue [F11]

Appendix C. Participant Information and Consent Form

Name of Project: **Subtitles in Native and Foreign Languages: The Impact of Bilingual Subtitles on Film Comprehension and Cognitive Load**

You are invited to participate in a study on the impact of bilingual subtitles on film comprehension and cognitive load. The purpose of this study is to investigate the effectiveness and mental effort of information acquisition in the presence of bilingual subtitles.

The study is being conducted to meet the requirements for the degree of Master of Research under the supervision of Associate Professor Jan-Louis Kruger (02 9850 1467 or janlouis.kruger@mq.edu.au) of the Department of Linguistics.

If you decide to participate, you will be asked to fill in a biographical questionnaire and then participate in an eye tracking experiment. You will be seated comfortably in a sound-proof, sufficiently illuminated room watching four videos. Only your eye movement data will be recorded by the eye tracking equipment. There will be no recording of your face or voice. All videos are in English with English subtitles only, Chinese subtitles only, bilingual subtitles in both Chinese and English or without subtitles. Each video lasts about 10 to 15 minutes. After watching one video, you will be given five minutes to fill in a self-reported questionnaire regarding your viewing experience. The whole experiment will take approximately one and a half hours to complete. Participation is on a voluntary basis and there will be no cost to you. You will receive 2 hours credit on your practicum unit (TRAN874) if you participate in the study.

Any information or personal details gathered in the course of the study are confidential, except as required by law. No individual will be identified in any publication of the results. The principle investigator and the co- investigator will be the only persons with access to the data, which will be kept secure. A summary of the results of the data can be made available to you on request via email to the investigator's address above.

Please note that your current lecturers will not be made aware of who has participated in the research. Furthermore, your participation in this study is entirely voluntary: you are not obliged to participate and even if you decide to participate, you are free to withdraw at any time without having to give a reason and without consequence.

I,_____ *(participant's name*) have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name:_____

(Block letters)

Participant's Signature: _____ Date:_____

Investigator's Name: _____JAN-LOUIS KRUGER

(Block letters)

Investigator's Signature: ___  _____

Date: _____

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics & Integrity (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

PARTICIPANT'S COPY

Appendix D. Research Ethics Approval Letter

Re: "Subtitles in Native and Foreign Languages: the Impact of Bilingual Subtitles on Film Comprehension and Cognitive Load" (5201700464)

Thank you very much for your response. Your response has addressed the issues raised by the Faculty of Human Sciences Human Research Ethics Sub-Committee and approval has been granted, effective 11th May 2017. This email constitutes ethical approval only.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

https://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research

The following personnel are authorised to conduct this research:

Associate Professor Jan-Louis Kruger
Dr Leidy Castro-Meneses
Miss Sixin Liao
Ms Andrea Shan Chan
Ms Sijia Chen

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 11th May 2018
Progress Report 2 Due: 11th May 2019
Progress Report 3 Due: 11th May 2020
Progress Report 4 Due: 11th May 2021
Final Report Due: 11th May 2022

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required tosubmit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/current_research_staff/human_research_

ethics/resources

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Sub-Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Sub-Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/current_research_staff/human_research_ethics/managing_approved_research_projects

5. Please notify the Sub-Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

http://www.mq.edu.au/policy

http://www.research.mq.edu.au/current_research_staff/human_research_ethics/managing_approved_research_projects

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of approval to an external organisation as evidence that you have approval, please do not hesitate to contact the Ethics Secretariat at the address below.

Please retain a copy of this email as this is your official notification of ethics approval.

Yours sincerely,

Dr Naomi Sweller

Chair
Faculty of Human Sciences
Human Research Ethics Sub-Committee