Subtitles in News Explainer Videos and the Impact on Information Retention

Hassaan Shazuli

National Innovation Centre - National Institute of Business Management,No. 24, Edmonton Road, Colombo 00500, Sri Lanka.

ABSTRACT

The redundancy principle of the Cognitive Theory of Multimedia Learning states that the use of subtitles in videos affects the storage of information in a person's memory. Previous studies that tested this assumption were based on videos, tutorials, and presentations in academic settings. There is a gap in literature on whether this theory applies to news explainer videos which break down complex news topics for audiences. This study addressed this gap by showing a news explainer video with and without subtitles to two groups of participants, and by testing how much information they could recall in the short and long terms. The findings show that the use of subtitles has a minor negative impact on information retention in the long-term and not in the short-term. Another key finding is that the negative impact prevails even if subtitles are used in a non-native language or if people have high levels of prior knowledge about a topic. The results suggest it is better to avoid using subtitles in news explainer videos regardless of the characteristics of the audience to which the videos are shown.

Keywords: Cognitive Theory of Multimedia Learning, Delayed Recall, Immediate Recall, Information Retention, News Explainer Videos, Subtitles.

1. Introduction

Explanatory journalism is important for people to understand news easily. According to Dan & Rauter (2021), explanatory journalism answers 'how' and 'why' questions and offers context to a certain topic, and is different to conventional journalism which answers 'who/what/when/where' questions. News explainer videos contain a mix of multimedia elements such as video, audio, text, and graphics. These elements must be integrated and used mindfully in a way that facilitates information retention (Vijayalakshmi & Reddy, 2020; Abdul Samat & Abdul Aziz, 2020).

The Cognitive Theory of Multimedia Learning, first formulated by Mayer et al. (1996) based on Sweller (1988)'s Cognitive Load Theory, focuses on how multimedia elements such as text, audio, and visuals can be used to enhance learning. Both theories are built on the premise that the working memory of a person which is responsible for processing and storing information, has limited capacity and that it must be used as effectively as possible. The Cognitive Theory of Multimedia Learning's redundancy principle states that using subtitles in videos affects the retention of information in a person's mind (Mayer et al., 2001). But the use of subtitles can be observed in several news explainer videos available online. This is an attempt to examine whether the redundancy principle is applicable for news explainer videos.

2. Literature Review

2.1. The Cognitive Theory of Multimedia Learning

Fig. 1: Cognitive Theory of Multimedia Learning (Mayer et al., 2001:190)
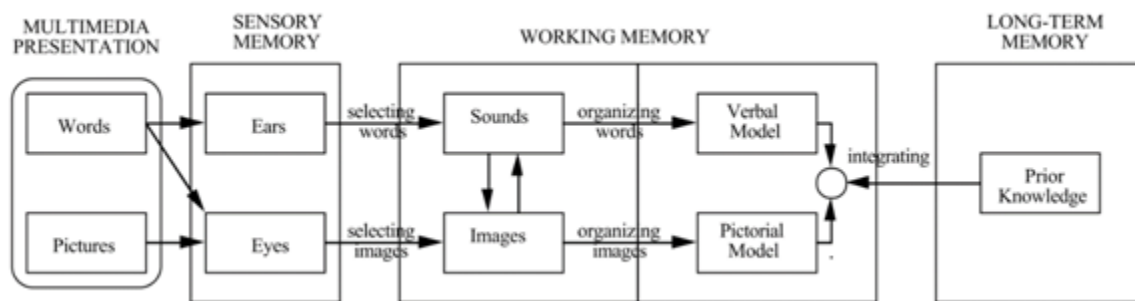
The Cognitive Theory of Multimedia Learning of Mayer et al. (1996) is based on cognitive science principles which state that the mind has two separate channels to process auditory and visual material, and that each channel has limited processing capacity (Baddeley, 1986; Paivio, 1979; Chandler & Sweller, 1991). Mayer (2024) has said printed words and visuals (which include photos, videos, graphics, and animation) first enter the sensory memory through the visual channel, while spoken words, sounds and music enter through the auditory channel. Selected visual and auditory material is sent to the working memory for processing and then stored in the long-term memory.

When the working memory receives more information that it can process, it results in cognitive overload, and that it can be avoided by using 15 principles (Mayer, 2021). They are the coherence principle, signalling principle, redundancy principle, spatial contiguity principle, temporal contiguity principle, segmentation principle, pre-training principle, modality principle, personalization principle, voice principle, image principle, embodiment principle, immersive principle, and the generative activity principle.

The redundancy principle developed by Mayer et al. (2001) states subtitles are redundant as they match the information conveyed through narration, and that people learn better from narration and visuals, than a mix of visuals, narration and on-screen text. This principle is not applicable if words are placed as guiding text next to a graphic, and is only valid if on-screen text replicates the narration word-for-word and is placed at the bottom of the screen (Mayer et al., 2001; Mayer & Johnson, 2008). This means that subtitles which reproduce the narration in a video and appear at the bottom of the screen, are the only form of on-screen text which is discouraged as they create unnecessary cognitive processing demands and affects the ability to remember information.

The theoretical explanation is that the working memory has to process subtitles, which is unnecessary, since it has to process the narration as well which contains the same meaning. The idea is that the limited capacity in the working memory can be used to process incoming visuals more effectively, rather than having to use it to process on-screen text as well. This is because the failure to process information properly will have a negative impact on the storage of information in the memory.

2.2. Immediate and Delayed Information Recall

Immediate and delayed information recall are two important parameters that can be used to test information retention. According to the American Psychological Association, 'immediate recall' refers to a test which evaluates the ability to recall information immediately after a stimulus (in this case a video) is presented to a person. The term 'delayed recall' refers to the ability to recollect information at a later date. While scientific literature does not outline a specific time period at which a delayed recall test should be conducted, many researchers have conducted a delayed recall test after one week to measure information retention in the long-term (Alviarez-Schulze et al., 2022; Lindbergh et al., 2020, Saloner et al., 2017). Most studies have used immediate recall tests to derive results relating to the impact of subtitles on information retention (Adegoke, 2017; Chu, 2006; Craig et al., 2002; Craig et al., 2004; Debuse et al., 2009; Jadin et al., 2009; Khan & Masood, 2012; Mayer et al., 2001; Moreno & Mayer, 2002; Munassar et al., 2010; Wang & Evans, 2021). There is a need to conduct delayed recall tests after at least a week to measure the impact of subtitles on information retention in the long-term.

Pioneering research on the redundancy principle by Mayer et al. (2001) had determined that the use of subtitles in videos affects information retention. In the second experiment of their study which was conducted using an animation describing the formation of lightning, those who watched the animation with narration and subtitles had performed poorly when recalling information compared to those who watched the video without subtitles. That is because the working memory had to process both written text and narration which conveyed the same

meaning, rather than using its limited capacity to process visuals and either narration or subtitles. However, the researchers had acknowledged that this result is unlikely to be the same if the study is conducted among people with hearing impairments or high levels of prior knowledge. The conclusion that subtitles are a deterrent to information retention had, however, been derived only through an immediate recall test after showing the video.

Tarchi et al. (2021) had addressed this gap in his study which evaluated the impact of subtitles on information retention through immediate and delayed recalled tests conducted six weeks apart. In this study, undergraduate students had been shown content on the science-related topic of stem cells, as a subtitled video, a video without subtitles, or as a piece containing on-screen text and graphics. There was no significant difference between those who watched the subtitled video and those who watched it without subtitles, in terms of how much information they could recollect in each of the immediate and delayed tests. The participants had been granted control over the video, meaning they could pause, play or watch the video as many times as they wanted.

Mayer & Johnson (2008) have said that using on-screen text as key words beside a graphic will not affect information retention even if there is audio narration. They had derived this conclusion based on a study in which two presentations; one on lightning formation, and the other on how a car's braking system works, had been shown to two groups of undergraduates. While presentations with short text placed next to the graphic had been shown to one group of students, the other group had been shown the presentations without any on-screen text. From a theoretical viewpoint, the research found that short text can guide 'essential processing' (forming a mental picture of the information) while long text can lead to 'extraneous processing' (the use of cognitive capacity to process the design of the material). Research conducted by Munassar et al. (2010) found that this assumption is valid even in the case of short subtitles when they are placed next to the image. In this study, the researchers had used a multimedia presentation aimed at building the English language skill of Yemeni speakers. Their findings were that students who watched the presentation with on-screen text performed well in an immediate recall test of English words compared to those who watched the presentation without on-screen text. In this case, the inclusion of redundant but short subtitles had a positive effect, potentially because they were used in a non-native language of the speakers.

Moreno & Mayer (2002) had found that the use of subtitles which duplicate the narration does not have a negative impact when it is used after an animation which conveys the key message. In the second experiment conducted as part of their study, participants who had watched the animation first and then the redundant text, had been able to recall more information compared to those who watched the animation, narration, and text simultaneously. But these findings are disproven by Chu (2006) who had conducted a study by showing a presentation on the computer-based instructional topic called 'data flow' to undergraduate students with no prior knowledge of

the subject. This research found that participants who watched the animation first and then the presentation with subtitles had been able to recall less information compared to those who watched the presentation which used animation, narration, and subtitles simultaneously.

2.3. Subtitles in Non-Native Languages

Diao & Sweller (2007) have suggested that the use of subtitles simultaneously with narration is redundant even when they are presented to non-native speakers. Their research, which was conducted on a group of students learning English as a foreign language, found that presenting written and spoken text simultaneously to convey the same information affects the learning process. They found that students who were shown a presentation containing only written text performed well in translation scores, mental load ratings, and free recall performance, compared to students who watched the presentation with narration and subtitles.

But these findings are not supported in research carried out by Wang & Tagrant (2019) which used students in China who had been studying English for seven years as their sample. In the first test of their study, the participants had been divided into three groups: one group had been shown a presentation containing only narration, the second group had been shown a presentation with single-sentence subtitles, and the third group was given a full script of the narration while listening. Their research found that comprehension levels were high among students who received some form of written text (i.e. the full script or subtitles) when watching the video, compared to those who watched the video only with narration. This research led to the assumption that written text must be used in a way that it matches the learner's proficiency level, and the failure to do that will result in low-proficiency learners not being able to gain advantage of the text that is used to supplement the narration.

Contrary to the findings of Diao & Sweller (2007) and Wang & Tagrant (2019), research conducted by Wang & Evans (2021) found that there was no significant difference among non-native speakers who watched a video with or without subtitles, in terms of how much information they could remember. This research is important in the context of their participant sample, as 82 percent of participants were non-native English speakers who had average proficiency in English. In their findings, the researchers said that the use of written and spoken English text for non-native English speakers may not be redundant as it does for native English speakers. However, a better study is required to test the impact of using subtitles on information retention through delayed recall tests as well among a sample of non-native English speakers, which is a secondary objective in the current research.

2.4. Pre-existing Knowledge as a Moderating Factor

Pre-existing knowledge is an important factor that needs to be taken into account when evaluating redundancy in the context of news explainer videos. Existing empirical literature has shown that prior knowledge about a certain topic is a moderating factor that can alter the impact of redundancy on information retention. However, there is a gap in literature in examining whether pre-existing knowledge can act as a moderating factor when redundancy is caused specifically by subtitles which duplicate the narration.

The 'Expertise Reversal Effect' developed by Kalyuga et al., (2003) states that the effectiveness of video-designing techniques aimed at cutting down on redundancy and reducing the load on working memory depends on the pre-existing knowledge of a person. This means that although some techniques may be highly effective for people with less knowledge, they can have negative effects among people who have a high amount of prior knowledge. For example, their research states that highly guided techniques such as providing step-by-step instructions may work well for novice learners, and affect people with high levels of prior knowledge, as it interferes with their ability to engage in high-level cognitive processes such as problem solving or integrating new information with their existing knowledge. However, this study focuses on the redundant scenarios that occur when using instructional text for academic learning and auditory explanation for diagrams, and does not draw reference to the use of subtitles when it is used redundantly with narration in a video.

Kalyuga et al. (2003)'s assumption is supported by Trypke et al. (2023) who have said that redundancy has a negative impact among participants with prior knowledge. Their study has suggested that a mix of visuals, audio narration, and subtitles should be used only when they are essential for understanding and when the visualisation is highly complex. However, more research is required to identify the parameters that can determine instances where subtitles are essential or not, and to distinguish visualisations that are highly complex from those which are not. Their review of 66 existing studies on redundancy does not focus on evaluating the moderating effect of pre-existing knowledge in situations where redundancy is caused due to overlapping narration and subtitles.

3. Research Methodology

3.1. Introduction

A quantitative approach was identified as the most appropriate method in the context of this research. Data was collected from the participants using a questionnaire prepared on Google Forms and shared via WhatsApp. A news explainer video titled 'What is Climate Change?' (Al Jazeera English, 2019) with a run time of 7 minutes and 7 seconds, produced by the Al Jazeera Media Network as part of its 'Start Here' news explainer series was chosen for this research.

3.2. Data Collection

A total of 60 participants had been chosen for this study by convenient sampling from the personal and professional network of the researcher. News journalists or media professionals employed at newsrooms were excluded from the sample, as the research deals with a news-related domain. The participants were between the ages of 20 and 40 who are considered 'young adults' (Montgomery & Arnett, 2015). Participants who spoke English as either their first or second language were allowed to participate in the study, as an attempt was made to examine whether subtitles in a non-native language moderate the impact on information retention. Similarly, participants with both high and low levels of prior knowledge on the topic were allowed to participate in the study since pre-existing knowledge was studied as a moderating effect.

The 60 participants in this research were randomly assigned into two groups of 30 members each. While the original video without subtitles was downloaded from Al Jazeera English's YouTube channel and shown to one group, the other group was shown the same video with subtitles added using CapCut software. Both videos were uploaded to a private YouTube channel of the researcher and embedded in the Google Form, to ensure that the viewing platform remained as a control variable. Participants had been granted full control over the content, allowing them to pause, rewind, replay or fast-forward the video. But they were instructed not to watch the video when answering the questionnaire. Participants in both groups were allowed to watch the video and answer the questionnaire in an uncontrolled environment. The decision to conduct this study in an uncontrolled environment was backed by the rationale that people watch news explainer videos in uncontrolled environments, and that it was important to perform the research in a similar setting.

Immediate and delayed recall tests were held one week apart to test the impact of subtitles on information retention. The questionnaire for the immediate recall test consisted of two parts. The first part comprised of screening questions and five single-choice questions to test prior knowledge of the topic. This was done to derive a more accurate understanding of their prior knowledge rather than asking them to perform a self-rating. After the video was shown, the participants were given five single-choice questions based on the video. For the delayed recall test conducted a week later, the questionnaire contained five MCQ questions based on the information presented in the video. At the time of conducting the immediate recall test, the participants were not informed that they would have to take another test in a week. This was done to avoid any attempt that could have been made by the respondents to purposefully remember the information for the second test.

The respondents were asked to mark their proficiency in English in the screening section of the questionnaire. Those who stated that English is their mother tongue were considered as native speakers, while those who stated they are proficient in English although it is not their mother tongue / they are learning English and understand most conversations / they have limited English proficiency were considered as non-native speakers.

Five single-choice questions were used for the pre-test that was conducted to measure high vs low pre-existing knowledge. Participants were awarded 1 point for a correct answer and 0 points for an incorrect answer based on the dichotomous scoring guide recommended by Kanzow et al. (2023). Previous studies have found that participants without any prior knowledge can score 20 percent by making guesses (in this case one out of five questions) when attempting single-choice questions (Schmidt, 2022, cited in Kanzow et al., 2023). By taking that into account, this research set the expected real knowledge value at 60 percent, meaning that those who answer more than three questions accurately will be considered as those with high levels of prior knowledge. The same dichotomous scoring guide will be used to evaluate the immediate and delayed recall tests.

3.3. Data Analysis Method

Data analysis for this research was conducted using the central tendency method, which identifies a single value to represent a data set and offers an accurate representation of the data (Manikandan, 2011). For the immediate and delayed recall tests, the mean value of the results in both groups were calculated and compared against each other. The presence of moderating factors (i.e. prior knowledge and English proficiency) was analysed in the subtitled and non-subtitled contexts. An analysis was done separately for the immediate and delayed tests.

4. Results and Discussion

4.1. Description of the Participants

- Both groups had 11 participants each with low prior knowledge on the topic of climate change.

- Both groups had 19 participants each with high prior knowledge on the topic of climate change.

- There were 2 native English speakers in Group 1, and 4 native English speakers in Group 2.

- There were 28 non-native English speakers in Group 1 and 26 non-native English speakers in Group 2. All of them spoke Sinhala or Tamil as their native language.

Table 1: Description of participants

Group 1 – Video without subtitles		
	High Prior Knowledge	Low Prior Knowledge
Native English Speakers	1	1
Non-Native English Speakers	18	10
Group 2 – Video with subtitles		
	High Prior Knowledge	Low Prior Knowledge
Native English Speakers	3	1
Non-Native English Speakers	16	10

4.2. Results

This study was conducted to examine whether Mayer et al. (2001)'s redundancy principle of the Cognitive Theory of Multimedia Learning is applicable in the case of news explainer videos. Based on prior literature, this study was guided by the hypothesis that the use of subtitles will negatively impact information retention, unless the subtitles are in a native language or if the participant has high levels of prior knowledge about a certain topic.

Hypothesis 1: The redundancy principle of the Cognitive Theory of Multimedia Learning is applicable in the context of news explainer videos

Mayer et al. (2001) has said that the use of subtitles at the bottom of the screen to duplicate the narration affects the processing and retention of information in the memory. This assumption, called the redundancy principle, is strongly supported in research conducted by Craig et al. (2002), Moreno & Mayer (2002), and Chu (2006). These studies had used an immediate recall test to arrive at the conclusion that subtitles affect information retention. However, in the current study, the results of the immediate recall test did not strongly support the hypothesis that the use of subtitles negatively impacts information retention. In the immediate recall test, the mean score of Group 1 (without subtitles) was 3.46 while the mean score of Group 2 (with subtitles) was 3.66.

This is likely because the characteristics of the sample population used for this research may have played a role in producing results that did not strongly support the redundancy principle in the immediate recall test. The sample population in the current research was dominated by participants who did not speak English as their native language (90 percent) and also by participants with high prior knowledge about the topic (63.3 percent). This was different to the characteristics of the sample populations used in the studies of Mayer et al. (2001), Craig et al. (2002), Moreno & Mayer (2002), and Chu (2006). Their studies had been carried out using

subtitles that were in the native language of the participants, and by excluding participants with high-prior knowledge from their experiments. Mayer at al. (2001) had said it is unlikely that results supporting the redundancy principle could be obtained when a study is conducted among participants with high prior knowledge or hearing impairments.

Fig. 2: Mean scores of both groups in the immediate and delayed recall tests
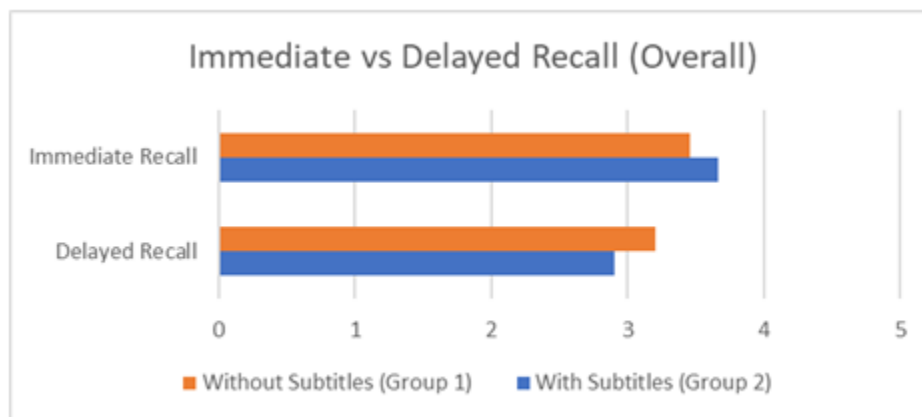
The results of the immediate recall test are an indication that the use of subtitles in a non-native language and the presence of high prior knowledge about a topic can reduce the negative impact slightly on information retention. However, this moderating effect can be observed only in the short-term.

The results of the delayed recall test in the current research support the hypothesis and the redundancy principle of Mayer et al. (2001). The overall mean score of the performances of Group 1 (without subtitles) was 3.2 while the mean score of Group 2 (with subtitles) was 2.9 in the delayed recall test which was conducted one week after showing the video. This shows that the role of moderating factors is not applicable in the long-term, and that the use of subtitles has a negative impact on information retention in the long-term regardless of the characteristics of the sample population.

In both the immediate and delayed recall tests, it is worth noting that there was no significant statistical difference in the performances between the two groups.

Hypothesis 2: There will be no negative impact on information retention when subtitles are used in a non-native language and/or if the participants have high prior knowledge in the topic

The immediate recall test conducted as part of the current study has found that the presence of either one or both moderating factors, namely the use of subtitles in a non-native language and

the existence of high prior knowledge, slightly reduces the negative impact on information retention.

Non-native English speakers, regardless of their level of prior knowledge on the topic of the video, had scored more after watching the video with subtitles compared to those who watched it without subtitles. The mean scores were 3.46 for Group 1 (without subtitles) and 3.57 for Group 2 (with subtitles). Similarly, participants with high prior knowledge, regardless of whether English was their native language or not, had been able to recall more information after watching the video with subtitles compared to those who watched it without subtitles. The mean scores were 3.63 for Group 1 (without subtitles) and 4.26 for Group 2 (with subtitles). Among participants in which both moderating factors were present (they had high prior knowledge and spoke English as their non-native language), those who watched the video with subtitles could recall more information than those who watched it without subtitles. The mean scores were 3.68 for Group 1 (without subtitles) and 4.22 for Group 2 (with subtitles). It must be noted that the difference in the performances in the immediate recall test were not statistically significant.
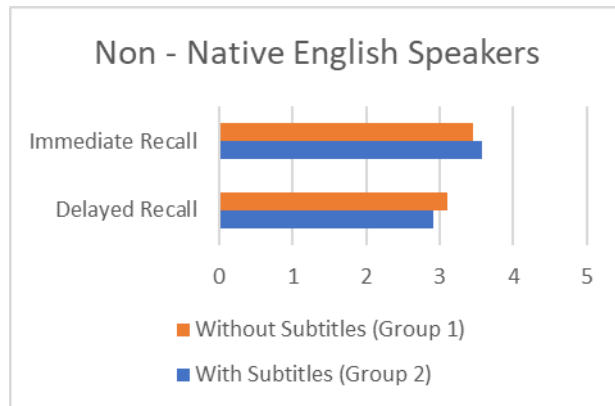

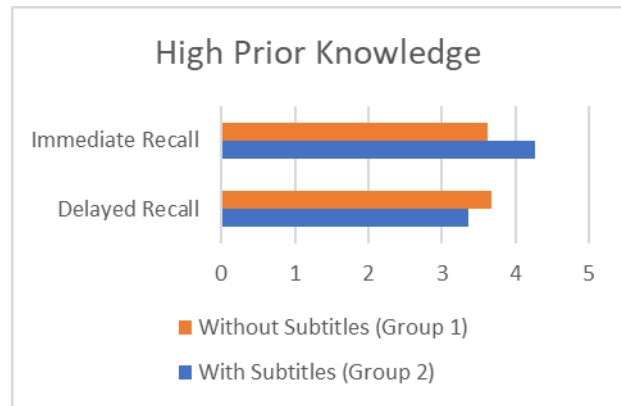Fig. 3: Mean scores of non-native English speakers

Fig. 4: Mean scores of participants with high-prior knowledge

The role played by moderating factors in reducing the negative impact of subtitles on information retention was only seen in the short term, as reflected in results of the immediate recall test. These results support the findings of previous research conducted by Debuse et al. (2009), Jadin et al. (2009), and Khan & Masood (2012) had found that people who watched videos with subtitles performed well in immediate recall tests in situations where they had high levels of pre-existing knowledge or when the subtitles had been used in a non-native language. According to a study conducted by Tarchi et al. (2020) using a video produced in English for people who spoke Italian as their native language, participants who watched the video with subtitles had performed well in the immediate recall test compared to those who watched the

video without subtitles. However, in the delayed recall test conducted six weeks apart, those who watched the video without subtitles had performed better. Similar results were found in the current research as well.

Fig. 5: Mean scores of non-native English speakers with high-prior knowledge
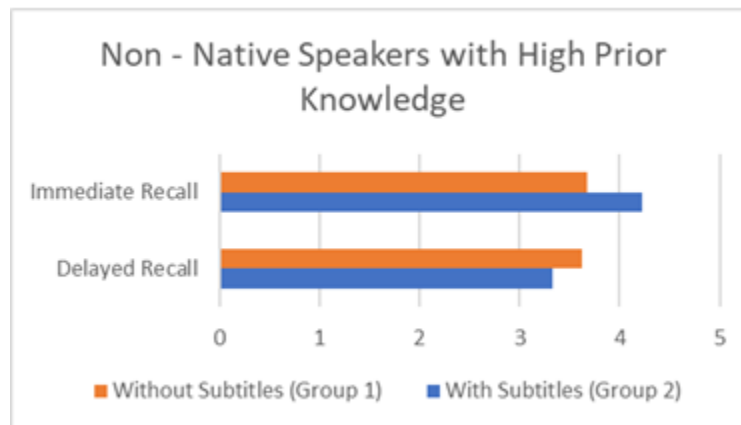
In the delayed recall test, the presence of either one or both moderating factors, namely the use of subtitles in a native language and the existence of high prior knowledge, did not play any role in reducing the impact on information retention.

Non-native English speakers, regardless of their levels of prior knowledge, who watched the video without subtitles were able to recall more information compared to those who watched the video without subtitles in the delayed recall test. The mean scores were 3.11 for Group 1 (without subtitles) and 2.92 for Group 2 (with subtitles). Those with high prior knowledge, regardless of their English proficiency levels, who watched the video without subtitles were also able to recall more information a week later, compared to those who watched it with subtitles. The mean scores were 3.63 for Group 1 (without subtitles) and 4.26 for Group 2 (without subtitles). Even among participants among whom both moderating factors were present, those who watched the video without subtitles could recall more information than those who watched the video with subtitles. The mean scores were 3.68 for Group 1 (without subtitles) and 4.22 for Group 2 (with subtitles). However, the lack of a major statistical difference can be observed in the performances of both groups.

The results of this research are useful for media outlets and journalists to design news explainer videos in a way that helps people develop a clear understanding of news topics, especially those which are complex in nature. Helping audiences understand news clearly is one of the crucial factors that can contribute towards building a well-informed society. This would eventually assist

people in making the right decisions at crucial junctures such as elections in democracies. Therefore, the findings of this research play an important role in facilitating this entire process.

5. Conclusion

This research has found that the use of subtitles has a minor impact on information retention in the long-term, as measured through the delayed recall test. However, subtitles seem to have played a minor supporting role in remembering information in the short term, as reflected in the results of the immediate recall test. This study was guided by the hypothesis that the use of subtitles will have an impact on information retention when they are used in news explainer videos. This hypothesis was proven to be true only in the delayed recall test and not in the immediate recall test. Another key hypothesis of this research was that the presence of moderating factors such as the use of subtitles in a non-native language or the presence of high prior knowledge about a topic can minimise the negative impact of subtitles on information retention. This research found that the effect of moderating factors lasts only in the short term and not in the long term.

Previous studies conducted to test the redundancy principle of the Cognitive Theory of Multimedia Learning have been carried out based on academic videos, tutorials and presentations. Therefore, the results of this study have addressed a crucial gap in empirical literature on whether the redundancy principle is applicable in the case of news explainer videos as well. This result indicates that the use of subtitles does have a minor impact on information retention in the long-term even if they are used in a non-native language or even if the participants have prior knowledge about the topic. Although there is no significant statistical difference in the performances between those who watched the video with subtitles and those who watched it without subtitles, the results reflect that there is a certain amount of impact on information retention.

Since not all news explainer videos are designed in English, future research can be used to test whether the impact is different when the videos or subtitles are used in other languages. Further research can also be carried out to derive a strong conclusion of whether the redundancy principle is applicable if subtitles are used in the native language of the person watching the video. An interesting area of research would be to test the effects of using subtitles in a native language while the narration is in a non-native language.

It is also noteworthy that news explainer videos are not published with the aim of targeting an online audience between 20 and 40 years alone. The impact of subtitles on information retention may vary based on various age categories based on their capacity to store details in their memory. Testing the impact of subtitles across various age categories will also help in deriving

more useful results with regard to the redundancy principle of the Cognitive Theory of Multimedia Learning.

Regardless of these limitations, this research has addressed a crucial gap in literature concerning the applicability of subtitles in news explainer videos. The findings of this research would be useful when designing news explainer videos while ensuring that people remember the information presented to them.

References

1. Dan, V. and Rauter, D. (2021) 'Explanatory reporting in video format: Contrasting perceptions to those of conventional news', Journalism Practice, 17(5), pp. 1046–1067. doi:10.1080/17512786.2021.1966644.

2. Vijayalakshmi, A. and Reddy, P.J.K. (2020) 'Role of Multimedia on Motivation and Knowledge Retention', The International Journal of Analytical and Experimental Modal Analysis, 12(4), pp. 1500–1509.

3. Abdul Samat, M.S. bin and Abdul Aziz, A. (2020) 'The effectiveness of multimedia learning in enhancing reading comprehension among indigenous pupils', Arab World English Journal, 11(2), pp. 290–302. doi:10.24093/awej/vol11no2.20.

4. Mayer, R.E. et al. (1996) 'When less is more: Meaningful learning from visual and verbal summaries of science textbook lessons.', Journal of Educational Psychology, 88(1), pp. 64–73. doi:10.1037/0022-0663.88.1.64.

5. Sweller, J. (1988) 'Cognitive load during problem solving: Effects on learning', Cognitive Science, 12(2), pp. 257–285. doi:10.1016/0364-0213(88)90023-7.

6. Mayer, R.E., Heiser, J. and Lonn, S. (2001) 'Cognitive constraints on multimedia learning: When presenting more material results in less understanding.', Journal of Educational Psychology, 93(1), pp. 187–198. doi:10.1037//0022-0663.93.1.187.

7. Baddeley, A.D. (1986) Working memory. Oxford Oxfordshire, NY: Clarendon Press, Oxford University Press.

8. Paivio, A. (1979) Imagery and verbal processes. Hillsdale (N.J.): Lawrence Erlbaum Associates.

9. Chandler, P. and Sweller, J. (1991) 'Cognitive load theory and the format of instruction', Cognition and Instruction, 8(4), pp. 293–332. doi:10.1207/s1532690xci0804_2.

10. Mayer, R.E. (2021) Multimedia learning. 3rd edn. Cambridge: Cambridge University Press.

11. Mayer, R.E. and Johnson, C.I. (2008) 'Revising the redundancy principle in multimedia learning.', Journal of Educational Psychology, 100(2), pp. 380–386. doi:10.1037/0022-0663.100.2.380.

12. Alviarez-Schulze, V. et al. (2022) 'Validation and normative data of the Spanish version of the Rey auditory verbal learning test and associated long-term forgetting measures in middle-aged adults', Frontiers in Aging Neuroscience, 14. doi:10.3389/fnagi.2022.809019.

13. Lindbergh, C.A. et al. (2020) 'Worth the wait: Delayed recall after 1 week predicts cognitive and medial temporal lobe trajectories in older adults', Journal of the International Neuropsychological Society, 27(4), pp. 382–388. doi:10.1017/s1355617720001009.

14. Saloner, R. et al. (2017) 'Performance on a 1-week delayed recall task is associated with medial temporal lobe structures in neurologically normal older adults', The Clinical Neuropsychologist, 32(3), pp. 456–467. doi:10.1080/13854046.2017.1370134.

15. Adegoke, B.A. (2017) 'Integrating animations, narratives and textual information for improving physics learning', Electronic Journal of Research in Education Psychology, 8(21). doi:10.25115/ejrep.v8i21.1391.

16. Chu, S.L. (2006) Investigating the effectiveness of redundant text and animation in Multimedia Learning Environments, Investigating the effectiveness of redundant text and animation in multimedia learning environments. dissertation. University of Central Florida.

17. Craig, S.D., Gholson, B. and Driscoll, D.M. (2002) 'Animated pedagogical agents in multimedia educational environments: Effects of agent properties, picture features and redundancy.', Journal of Educational Psychology, 94(2), pp. 428–434. doi:10.1037/0022-0663.94.2.428.

18. Craig, S., Driscoll, D.M. and Gholson, B. (2004) 'Constructing Knowledge from Dialog in an Intelligent Tutoring System: Interactive Learning, Vicarious Learning, and Pedagogical Agents', Journal of Educational Multimedia and Hypermedia, 13(2), pp. 163–183.

19. Craig, S.D., Gholson, B. and Driscoll, D.M. (2002) 'Animated pedagogical agents in multimedia educational environments: Effects of agent properties, picture features and redundancy.', Journal of Educational Psychology, 94(2), pp. 428–434. doi:10.1037/0022-0663.94.2.428.

20. Craig, S., Driscoll, D.M. and Gholson, B. (2004) 'Constructing Knowledge from Dialog in an Intelligent Tutoring System: Interactive Learning, Vicarious Learning, and Pedagogical Agents', Journal of Educational Multimedia and Hypermedia, 13(2), pp. 163–183.

21. Jadin, T., Gruber, A. and Batinic, B. (2009) 'Learning with E-lectures: The Meaning of Learning Strategies', Educational Technology & Society, 12(3), pp. 282–288.

22. Khan, F.M. and Masood, M. (2012) 'Effectiveness of visual animation-narration presentation on Student's achievement in the learning of Meiosis', Procedia - Social and Behavioral Sciences, 46, pp. 5666–5671. doi:10.1016/j.sbspro.2012.06.493.

23. Moreno, R. and Mayer, R.E. (2002) 'Verbal redundancy in Multimedia learning: When reading helps listening.', Journal of Educational Psychology, 94(1), pp. 156–163. doi:10.1037/0022-0663.94.1.156.

24. Munassar, W.A.S., Yahaya, W.A.J.W. and Chong, T.S. (2010) 'When is the Redundancy Principle Effective in the Multimedia Learning of a Foreign Language?', Journal of Institutional Research South East, 8(2), pp. 16–31.

25. Wang, Y. and Evans, C. (2021) 'Are Captions in Video Tutorials a Bad Idea?', in 4th International Conference on Research in Education, pp. 46–54. Available at: https://discovery.ucl.ac.uk/id/eprint/10134849/6/ICRE%20Published%20version%2053-4143.pdf (Accessed: 2024).

26. Tarchi, C., Zaccoletti, S. and Mason, L. (2021) 'Learning from text, video, or subtitles: A comparative analysis', Computers & Education, 160, p. 104034. doi:10.1016/j.compedu.2020.104034.

27. Diao, Y. and Sweller, J. (2007) 'Redundancy in foreign language reading comprehension instruction: Concurrent written and spoken presentations', Learning and Instruction, 17(1), pp. 78–88. doi:10.1016/j.learninstruc.2006.11.007.

28. Wang, X. and Tragant, E. (2019) 'The effect of written text on comprehension of spoken English as a foreign language: A replication study', International Review of Applied Linguistics in Language Teaching, 60(3), pp. 625–645. doi:10.1515/iral-2018-0350.

29. Kalyuga, S. et al. (2003) 'The expertise reversal effect', Educational Psychologist, pp. 155–170. doi:10.1007/978-1-4419-8126-4_12.

30. Trypke, M., Stebner, F. and Wirth, J. (2023) 'Two types of redundancy in Multimedia learning: A literature review', Frontiers in Psychology, 14. doi:10.3389/fpsyg.2023.1148035.

31. Al Jazeera English (2019) What is climate change? | Start Here, YouTube. Available at: https://www.youtube.com/watch?v=dcBXmj1nMTQ (Accessed: 03 August 2024).