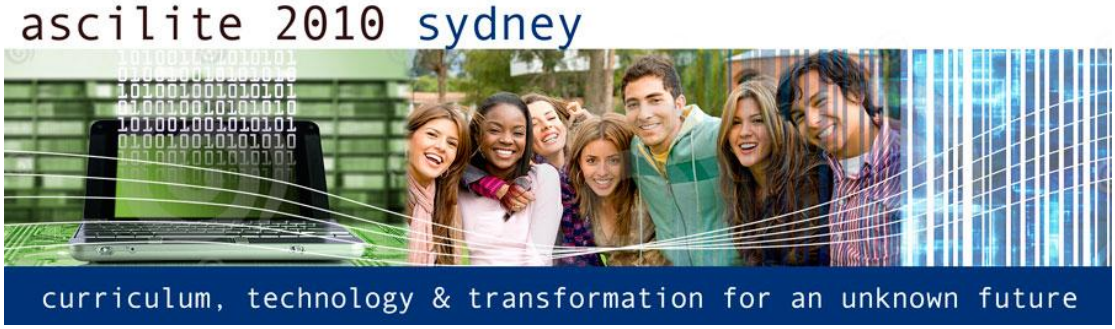

Redundancy effect in multimedia learning: A closer look

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The generally accepted assumption by most multimedia researchers is that learning is inhibited when on-screen text and narration containing the same information is presented simultaneously, rather than on-screen text or narration alone. This is known as the verbal redundancy effect. Are there situations where the reverse is true? This research was designed to investigate the reverse redundancy effect for non-native English speakers learning English reading comprehension, where two instructional modes were used - the redundant mode and the modality mode. In the redundant mode, static pictures and audio narration were presented with synchronized redundant on-screen text. In the modality mode, only static pictures and audio were presented. In both modes, learners were allowed to control the pacing of the lessons. Participants were 209 Yemeni learners in their first year of tertiary education. Examination of text comprehension scores indicated that those learners who were exposed to the redundancy mode performed significantly better than learners in the modality mode. They were also significantly more motivated than their counterparts in the modality mode. This finding has added an important modification to the redundancy effect. That is the *reverse redundancy effect* is true for multimedia learning of English as a foreign language for students where textual information was foreign to them. In such situations, the redundant *synchronized* on-screen text did not impede learning; rather it reduced the cognitive load and thereby enhanced learning.

Keywords: multimedia learning; redundancy principle; modality principle; cognitive load;

Introduction

Results of cognitive load theory related research indicated that pictures and narration that are presented simultaneously with redundant on-screen text increase cognitive load and can impede learning due to the competition of resources in the visual working memory (Moreno & Mayer, 1999; Mousavi et al., 1995; Tindall-Ford et al., 1997). This is known as the verbal redundancy effect. Hence, literature of multimedia learning suggests that the removal of redundant on-screen text rather than the inclusion of redundant material (Mayer, 2001). However, most of the empirical research to validate this principle was based mainly on the learning of scientific (Craig, Gholson, & Driscoll, 2002; Mayer, Heiser, & Lonn, 2001) and technical material (Kalyuga, Chandler, & Sweller, 2000, 2004), and learners were not given control over the pacing of the instruction. Very few studies were carried out to ascertain the truth of this effect in second language acquisition and where learners were given control over the pacing of the instruction. The purpose of this study was to ascertain whether simultaneous static pictures and narration that are presented simultaneously with redundant *synchronized* on-screen text will generate the redundancy effect, or otherwise, in foreign language reading comprehension instruction. In this learning situation, the main purpose of the learning environment is to enable learners to acquire language mastery rather than using the English language as a medium to learn other content material. The premise of the present study is that, whereas in the case of native English speakers, English was a vehicle for the organization and control of instructional materials and activities, simultaneous static pictures and narration with redundant on-screen text is frequently detrimental to learning. However,

this form of redundancy may have different effects when the goal is learning English as a foreign language rather than using the language to learn other content. Therefore, instead of increasing cognitive load due to redundancy, presenting information in both pictures and narration with redundant synchronized on-screen text may facilitate the learning of English when instruction is directed to learning the language itself (Dio & Sweller, 2007). Sweller's cognitive load theory and Keller's motivational model of instruction and performance were used to analyse the various cognitive and motivational consequences in order to provide hypotheses.

Theoretical framework of the study

The theoretical framework of the study is based on (a) the cognitive load theory by Sweller (1994, 1999), (b) the working memory model by Baddeley (Baddeley and Hitch, 1974; Baddeley 2000), and (c) the cognitive theory of multimedia learning by Mayer (2001).

Cognitive load theory (1999)

Cognitive load theory (CLT) was developed by Sweller and his colleagues (Clark, Nguyen, & Sweller, 2006; Sweller, 1994, 1999). This theory integrates knowledge of human cognitive architecture with the instructional implications of that architecture by addressing issues related the limitations of working memory and the construction of schema automation in the long-term memory. This theory posits that the working memory is limited both in capacity and duration and therefore during the design of instruction, care must be taken to ensure that the available cognitive resources of the learners are directed to the learning process itself, and not to irrelevant features of the instructional materials. The theory distinguishes among three types of cognitive load: *intrinsic load*, *extraneous* or *ineffective load*, and *germane* or *effective load*. *Intrinsic load is* caused by the inherent structure and complexity of the learning task, and it is the basic amount of processing required to understand the instructions. *Extraneous cognitive load* or *ineffective* load refers to poorly designed instructional variables that may make a hard task even harder. *Germane cognitive load, or effective load,* on the other hand, refers to instructional variables that facilitate learning. It actually increases the working memory resources available to perform the task at load. Thus within CLT, intrinsic, extraneous, and germane load are additive; when combined, they constitutes the overall construct of cognitive load. In multimedia learning, the necessary mental integration of information elements leads to a high cognitive load, so guidelines are required that keep the extraneous load as low as possible. CLT highlights several practices that can be applied to optimize learning. The most fundamental of these include methodologies for reducing the effects of the extraneous cognitive load of instructional materials to ensure optimal leaning. These effects include redundancy, modality and split attention.

Working memory model by Baddeley (2000)

The limited processing capacity assumption of the working memory in the CLT was further elaborated and articulated by Baddeley in the Working Memory model (2000). This assumption was pioneered by Baddeley (e.g. Baddeley, 1992; Baddeley & Hitch, 1974) who divided working memory into a visuo-spatial sketchpad for dealing with two or three dimensional diagrams, a phonological loop for dealing with verbal information and a central executive as a coordinating processor. The central executive is a controller that supervises and coordinates the subsidiary systems in working memory. It was characterized as "a limited capacity pool of general processing resources". The phonological loop has the function of processing speech or printed text, whereas the visuo-spatial sketchpad is responsible for setting up and manipulating mental images. The episodic buffer is assumed to be the place where information from the subsystems of working memory and that from long term memory is integrated.

Mayer's generative cognitive theory of multimedia learning (2001)

Taking cognizance of Sweller's *cognitive load theory* and Baddeley's *working memory model*, Mayer (2001) developed a prescriptive cognitive theory for multimedia learning. This theory focuses on the auditory/verbal channel and visual pictorial channel in the design of multimedia instruction. This model is based upon three primary assumptions (Mayer, 2001), namely: the dual channel assumption, the limited capacity assumption, and the active processing assumption. Further, this model is activated through five steps: (i) selecting relevant words for processing in verbal working memory, (ii) selecting relevant images for processing in visual working memory, (iii) organization of selected

words into a verbal mental model, (iv) organizing selected images into a visual mental model, and (v) integrating verbal and visual representations as well as prior knowledge.

One of the guidelines for multimedia learning is that when designing instructional multimedia messages, leave out any redundant information. This design principle is called the *redundancy effect* in cognitive load theory and the *coherence* or *redundancy principle* in Mayer's theory. The argument is that any redundant information in multimedia instructions will increase the extraneous cognitive load, because part of the learner's working memory capacity is used for the processing of unnecessary information that does not contribute to learning. Thus, for optimal multimedia learning, text accompanying a picture or animation should be presented as spoken text or narration, rather than on-screen text. This is called *the modality effect* (Sweller, 1999) or *modality principle* (Mayer, 2001.) Hence the cognitive load theory and Mayer's generative theory of multimedia learning take the processes in working memory as the starting-point for the development of instructional design guidelines. The three main guidelines for multimedia learning include: (a) removal of redundant information, (b) avoidance of split attention effect, and (c) usage of spoken text, not visual text. However, one limitation of the multimedia studies above is that only short multimedia instructions of just a few minutes long were utilized, and also on subjects from the exact sciences like geometry and electrical engineering. Also, the learning pace is not learner-controlled but system-controlled (Tabbers & Merriënboer, 2001). What influence does this have on the strength of the modality effect in multimedia learning for second language acquisition where learners are allowed to control the pace of instruction? Will the effect still be obtained if the subject matter is from another domain, where learners have to study the multimedia material for a longer period of time? Theoretically, the modality effect should also apply in these circumstances, but empirically, this has not been tested yet. With the conscious knowledge of this situation, this study attempted to take a closer look at the redundancy effect and the modality effect of multimedia learning.

What will happen if graphics and narration are presented together with redundant on-screen text? According to Clark and Mayer (2008) learners can learn better from graphics and narration than from graphics, narration, and on-screen text. This is based on the assumption that when graphics and words are both presented together in visual manner (i.e., as graphics and text), the pictorial channel become overloaded. However, is this principle true for EFL learning? Is there any caveat to this principle? Are there any situations in which e-learning courses would be improved by adding redundant on-screen text? This study seeks to provide answers to these questions. Clark and Mayer (2008) suggest three special situations in which they will *not* overload the learner's visual information processing system. These situations are:

(a) Kinds of learner: the learners must exert much greater cognitive effort to comprehend spoken text than printed text (for example, for learners who are not native speakers or who have specific learning disabilities, or when the verbal material is long and complex or contains unfamiliar key words). This caveat has a great relevance to the present study where the subjects consist of non-native speakers of English.

(b) Kinds of material: there is no pictorial presentation (for example, when the screen contains no animation, video, photos, graphics, illustrations, and so on); and

(c) Kinds of method: there is ample opportunity to process the pictorial presentation (for example, when the on-screen text and corresponding graphics are presented sequentially or when the pace of presentation is sufficiently slow). In this study, the conditions of situation (a) and situation (c) were fulfilled where the respondents are learners learning English as a foreign language (EFL), and they were allowed to control the pace of learning.

Research questions

Do the multimedia effects discovered in the instruction of scientific and technical explanations have the same effects when the focus of the instruction is teaching of English as a foreign language (EFL)? Therefore, the rationale of this study was to test the generalisability of the redundancy effect on EFL learners. With this in mind, the purpose of this study was to assess the effects of *redundancy* and modality on the participants' ability to understand, apply and analyse an English comprehension passage and also their perceived motivation towards the modes of instruction. Specifically, this study sought to answer the following questions:

1. What are the effects of multimedia presentation *redundancy* and *modality* on students' performance on learning EFL?
2. What are the effects of multimedia presentation *redundancy* and *modality* on students' perceived motivation towards the modes of instruction?
3. What are the effects of multimedia presentation *redundancy* and modality on students' performance for students of different learning preference styles?

Methodology

Background of study population and sample size

Yemen has a population of about 30 million according to May 2010 estimates, with 46% of the population being under 15 years old and 2.7% above 65 years. Yemenis are mainly of Arab origin. Arabic is the official language, and the use of English as a spoken language is not prevalent. The population of this study comprised of undergraduate learners who enrolled in the first year of community colleges in Yemen. There are five community colleges located at different Yemen's cities. One community college was selected randomly for this study. There were eight classes involved in this study. Four classes were assigned randomly to the group of redundancy mode and four classes were also assigned randomly to the group of modality mode. Initially, the sample size was 237 learners but 28 learners from the sample were omitted because of attrition. Thus, only the data of 209 learners were considered in the analyses. Each participant learner was provided with a multimedia computer with headphone. 98 learners with assigned to the redundancy mode while 111 learners were assigned to the modality mode.

Procedure of the study

This study employed a 2 x 2 quasi-experimental design with repeated measures. The independent variables were the two learning modes (redundancy mode and modality mode). The dependent variables were the gain scores (as measured by the post-test scores minus the pre-test scores) and the perceived motivation towards the instructional modes (as measured by the Keller's IMMS questionnaire). The moderator variables were the learning preferences styles with two levels (visual and verbal). The two groups were from intact classes in which equivalency could not be presumed. Thus, the learners' English Entry test was administered to the two groups and their scores were analyzed to examine whether the two groups are homogeneous in terms of English proficiency. The independent-groups *t*-test statistical technique was carried out to test if there was statistical difference among the learners of both modes. Analysis of results showed that there was statistically significant different terms of English language proficiency ($df = 207$, $t = 4.314$ $p = 0.000$). This means that the two modes were not homogeneous in term of English language proficiency. Therefore, analysis of covariance was used to reduce the effects of initial groups' differences.

Research instruments

There were instruments in this study, namely, (i) the English comprehension pre-test and post-test questions (comprising of 20 multiple questions from the domain of understand, apply and analyze an English comprehension passage), and (ii) the Instructional Material Motivation Scale (IMMS) to test the learners' perceived motivation towards the learning modes. The English comprehension questions were developed to determine the learners' understanding, application and analytical abilities of the English topics from a book published by Richards *et al.,* (1998). This book was designed for young adults and adults who learn English as a foreign language. Internal consistency of this test was established using the Cronbach's alpha procedure. Its Cronbach's alpha reliability coefficient was 0.81. The Instructional Material Motivation Scale (IMMS) was developed by Keller (1993) to measure the learners' motivation towards the modes of instruction. The IMMS questionnaire comprised of 36 Likert-type statements that are based on four components of ARCS motivation model: Attention, Relevance, Confidence, and Satisfaction. This instrument was translated into the Arabic language. The internal consistency of the Arabic version of the IMMS questionnaire was 0.93, as measured by Cronbach's alpha reliability coefficient. To maintain consistency in instructions and procedures, teacher assistants who participated in this study were given the same instructions prior to data collection of the experimental study as follows: (a) two weeks before the treatment, the learners were given the English comprehension pre-test; (b) just before the learning treatment the Index of Learning Styles survey (ILS) was given; and (c) immediately after the treatment, the learners were given the English comprehension post-test and the Keller's instructional material motivation Scale (IMMS). An

experimental protocol was provided to the teacher assistants and they were carefully briefed on how the experimental procedures.

The Redundant and Modality modes of presentation

Two presentation modes were developed using Authorware version 7, namely, redundancy mode, and modality mode. The learners are given control over the pacing of the instructions through learner-control buttons. The learners in all the two modes were exposed to the same instructional materials but in different modes of presentation. In the redundancy mode, static pictures and audio narration were presented concurrently with redundant on-screen text. The redundant on-screen text was carefully synchronized with the audio narration *karaoke* style. In the modality mode, static pictures and audio narration were presented without the redundant of textual information. Figure 1 depicts screen-shots of the redundancy presentation mode and the modality presentation mode.

Figure 1: Redundancy Mode (left) and Modality Mode (right)

The goal of this experiment was to investigate whether using the redundancy mode presentation really facilitates the learning of English as foreign language compared to the modality mode. The following null hypotheses were formulated and computed at the 0.05 level of significance.

Hypothesis 1: There is no significant difference in students' performance on learning EFL in the multimedia presentation *redundancy* and *modality* modes.

Hypothesis 2: There is no significant differences in students' perceived motivation as measured by Keller's Instructional Material Motivational Scale (IMMS) in the multimedia presentation *redundancy* and *modality* modes.

Hypothesis 3: There is no significant difference in students' performance for students of different learning preference styles (*visual* or *verbal*) in the multimedia presentation *redundancy* and *modality* modes.

Results

Results pertaining to Null-Hypothesis 1 (redundancy mode versus modality mode on gain scores)

The results of ANCOVA revealed that there was a significant adjusted mean difference between the two presentation modes on the gain scores. The mean gain test scores, the standard deviations, and the number of subjects of the two learning modes were given in Table 1. The redundancy mode had the large adjusted mean (adjusted mean = 6.468), compared with the modality mode (adjusted mean = 5.065). The F ratio of gain score (1, 206) = 20.918, $p < 0.05$. This means that the presentation mode

had a mean effect on gain scores. The descriptive and inferential analysis reveal that the learners who were exposed to the redundancy mode (mean gain score = 6.07, SD = 2.578, Adjusted mean= 6.468, p = 0.000) significantly outperformed the learners who were exposed to the modality mode with an adjusted mean difference of 1.403. Therefore hypothesis one was rejected.

Table 1: Means, standard deviations, adjusted means, adjusted mean difference and standard errors of gain scores by learning modes

Learning modes	Gain score				
	Mean gain score	SD	Adjusted Mean	Adj. Mean Difference	SE
Redundancy Mode, N = 98	6.07	2.578	6.468[a]	1.403[a]	0.219
Modality mode, N = 111	5.41	2.341	5.065[a]		0.205
Total, N = 209	5.72	2.471	5.766[a]		0.147

Note: [a] Evaluated at covariate appeared in the model: Entry-test = 67.34

Effect sizes of redundancy mode and modality mode were also studied because there were significant differences between the two modes. The results show that the effect size of redundancy mode towards modality mode was 0.5726, which in Cohen's (1988) terms would be considered as a medium effect size.

Results pertaining to Null-Hypothesis 2 (redundancy mode versus modality mode based on their perceived motivation)

Table 2 presents the results of Mann Whiten U test which revealed that there was a significant difference between the two presentation modes on the learners' perceived motivation (U = 2516.500, Z= -6.703, p = 0.000). This means that the presentation mode had a significant mean effect on perceived motivation. Learners in redundancy mode (Mean rank = 134.82, Sum ranks = 13212.50, p = 0.000) were significantly more motivated than their counterparts in the modality mode. Therefore, this null hypothesis was also rejected.

Table 2: Mann Whiten U test of IMMS score by presentation mode

Presentation mode	IMMS Score				
	Mean Rank	Sum of Ranks	MW-U	Z	Sig.
Main effect Presentation modes			**2516.50**	**-6.703**	**0.000**
Redundancy Mode, N = 98	134.82	13212.50			
Modality Mode, N = 111	78.67	8732.50			

Results pertaining to Null-Hypothesis 3 (redundancy mode versus modality mode based on their performance) for students of different learning preference styles (visual or verbal)

For the sake of clarification this hypothesis can be sub-divided into two parts:

$H_{3a:}$ There is no significant difference in gain score among the visual students of learning preferences style for both learning modes (redundancy mode and modality mode).

$H_{3b:}$ There is no significant difference in gain scores among the verbal students of learning preferences style for both learning modes (redundancy mode and modality mode).

Table 3 presents overall means, standard deviations, adjusted means, adjusted mean differences and standard errors of the dependent variable (gain score) for visual and verbal students of learning preferences style by the two learning modes (redundancy mode and modality mode). Values of standard deviations for visual students of the redundancy mode and modality mode were (SD = 2.486) and (SD = 2.352) respectively. A one-way analysis of covariance (ANCOVA), of the adjusted mean of the gain score between the visual students of the two learning modes was performed. The results of ANCOVA revealed that there was a significant adjusted mean difference between the visual students across the two learning modes on the gain scores. The F ratio of gain score (1, 109) was 13.988 ($p < 0.05$). This means that the learning mode had a mean effect on the visual students' gain score. This effect accounted for 11.4% of the variance of gain score ($\eta 2 = 0.114$). The visual students who were exposed to the redundancy mode (M = 6.33, SD = 2.486, Adjusted M = 6.690, p = 0.000) significantly outperformed the visual students in modality mode with an adjusted mean difference of 1.721. A one-way analysis of covariance (ANCOVA), of the adjusted mean of the gain score between the verbal students of the two learning modes was performed. The results of ANCOVA revealed that there was a significant adjusted mean difference between the verbal students across the two learning modes on the gain scores. The F ratio of gain score (1, 94) was 5.551 ($p < 0.05$). This means that the learning mode had a mean effect on the verbal students' gain score. This effect accounted for 6% of the variance of gain score ($\eta 2 = 0.056$). The verbal students who were exposed to the redundancy mode (M = 5.85, SD = 2.656, Adjusted M = 6.221, p = 0.021) significantly outperformed the verbal students in modality mode with an adjusted mean difference of 0.943.

Table 3: Means, standard deviations, adjusted means, adjusted mean difference and standard errors of gain score by learning mode for visual and verbal learners

Visual Learners					
Learning mode			**Gain score**		
	M	**SD**	**Adjusted M**	Adjusted Mean Difference	**SE**
Redundancy Mode, N = 45	6.33	2.486	6.690[a]	1.721[a]	0.348
Modality Mode, N = 67	5.21	2.352	4.969[a]		0.282
Total N = 112	5.66	2.459	5.830 [a]		0.218
Verbal Learners					
Learning mode			**Gain score**		
	M	**SD**	**Adjusted M**	Adjusted Mean Difference	**SE**
Redundancy Mode, N = 53	5.85	2.656	6.221[b]	0.943	0.265
Modality Mode, N = 44	5.73	2.316	5.279[b]		0.292
Total N = 97	5.79	2.496	5.750[b]		0.194

Note: [a] Evaluated at covariate appeared in the model: Entry-test = 66.65

Note: [b] Evaluated at covariate appeared in the model: Entry-test = 68.14

Discussion

Effects of the Redundancy Mode versus Modality Mode based on gain score

There were significant differences in gain scores across the two presentation modes. Additionally, the effect size in gain scores suggested that the redundancy mode had a more positive effect than the modality mode. These findings supported the assumption, for learner-paced learning, adding redundant on-screen synchronized text improved the learning. One possible explanation is that the learners in this study might have encountered difficulties in comprehending the audio narration as it was a foreign

language to them and the redundant *synchronized* on-screen text helped them in making sense of the narration and thus fulfilling the three conditions of active learning, that is, selecting, organizing and integration of knowledge (Clark & Mayer, 2008). Furthermore, these results were consistent with the findings of Mayer and Johnson, (2008); Ling and Yuen, (2008); Kaluga, (2009); and She, *et al.* (2009), who found positive effects of the redundancy principle on learning. The redundancy mode in this study was designed in such a way that it was learner-paced, and the on-screen text was carefully synchronized to the audio narration to *cue* the learner to the learning task. This redundant textual information was placed next to its relevant picture to provide spatial contiguity, and thus reducing the split-attention effect. Such a multimedia presentation was consistent with Mayer's contiguity principle which states that, "learners learn better when corresponding words and pictures are presented near each other on the screen" (Clark & Mayer, 2008). The results of this study was supported by Mayer and Johnson (2008) who state that redundant on screen-text could provide a positive effect on learning when it was "placed next to the portion of the graphic that it describes". They also suggested that the on screen-text should be short and the core action as described in the audio narration should be highlighted. The results of this study showed that preventing split attention was especially effective when two information elements like static pictures and synchronized onscreen-text picture were presented simultaneously. Under such conditions, the extraneous load caused by the visual search and the mental effort needed to integrate text and pictures could be minimised by placing the synchronized-text inside the picture next to the part it is referring to. Non-native learners of English have to exert greater cognitive effort to understand the narration, which leads to taking up their mental resources at the expense of the actual task of learning. Thus, the extraneous cognitive load may be imposed. This view was also articulated by Liu (2002) who says that non-English language learners encounter difficulties in comprehending the words' meanings in unfamiliar topics, vocabulary and accents. He extended these difficulties to include "even when they think they have identified the words, these words often do not fit the context" (Liu, 2002).

Learners in the redundancy mode were provided with the opportunity to reduce this extraneous cognitive load. The on-screen text helped the learners to identify the complex English words with no need to exert additional cognitive effort. On the other hand, learners who were exposed to the modality mode did not have this opportunity. As a result, they were compelled to exert additional cognitive effort that usually did not contribute to learning, which subsequently hindered language learning. According to cognitive load theory, to the extent that knowledge is unavailable, the 'randomness as genesis' principle will play a part in that search reducing the effectiveness of instruction. Random search will interfere with the functioning of the borrowing principle and it is the borrowing principle that is relied on when written or spoken instructional material is presented (Sweller, 1999).

Effects of the Redundancy Mode versus Modality Mode based on perceived motivation

Learners who were exposed to the redundancy mode had a significantly higher perceived motivation towards the instructional materials compared to learners in the modality mode. These particular findings can be attributed to several reasons. Firstly, the *synchronized* on-screen text provided the learners with cues to understand the English narration. Therefore, learners who perceived the redundant textual information might minimize their difficulties in comprehending the spoken words. This improved the learners' perceptions of enablers in which they feel that their effort would be facilitated rather than impeded (Lent, *et al.*, 2000). When learners perceive an enabler (*synchronized* on-screen text), they become satisfied and their motivation increases. Secondly, this could be attributed to the potential role of the on-screen text in capturing their attention. It was possible that the on-screen text served as a technique which can arouse and maintain the learner's attention. This view is consistent with Karoulis (2007) who states that attention is the first and single most important factor of the ARCS model. It is a key to gain and maintain the learner's motivation. Conversely, in the modality mode the instructional materials were presented in the form of static pictures and audio narration only. There was no redundant *synchronized* textual information that could be used as a technique to arouse learners' attention. Thus, it was possible that learners in the modality mode failed to pay attention which subsequently weakened their perceived motivation towards the instructional mode.

This finding is also supported by Astleitner and Koller (2006) who conducted an experimental study to test the effects of four types of multimedia-based instruction. These types were: multimedia-based instruction that had no ARCS strategies, multimedia-based instruction that had attention strategies, multimedia-based instruction that had relevance strategies, and last multimedia-based instruction that

had both attention and relevance strategies. The results indicated that attention strategies had a stronger effect on learners' motivation to learn. This finding is in line with findings by Toh (1998) who conducted a study on cognitive and motivational effects of two multimedia simulation presentation modes. These presentation modes were concurrent mode and consecutive mode. In the concurrent mode, animated graphics and *synchronized* redundant textual information were presented concurrently with redundant audio narration. In the consecutive mode, *synchronized* redundant textual information and audio narration were first presented followed by animated graphics. The study showed that learners who used the concurrent mode of multimedia simulation gained higher IMMS scores compared to those learners who used the consecutive mode.

Effects of the learning modes on IMMS scores based on learning preferences style

The study showed that students with different learning preference styles (visual or verbal) in redundancy mode had significantly higher perceived motivation towards the mode of instruction than students in the modality mode. Furthermore, in the redundancy mode, students had significant positive effects on perceived motivation of the students with a verbal learning preferences style. Students with this style were significantly more motivated in the redundancy mode than modality mode. These findings could be attributed to the assumption that students who have preferences for learning visually could be able to learn better by using the visual materials. Similarly, students who have preferences for learning verbally could be able to learn better by using the verbal materials. Thus, it was possible that visual students could be able to comprehend the narration through using the redundant textual information which was consistent with their learning preference. Conversely, in the modality mode visual students would try to understand the narration by using the verbal material (audio narration) which was not consistent with their learning preferences style. Thus, it was possible that visual students in the redundancy mode were more motivated than their counterparts in the modality mode because they studied using methods that matched their learning preferences style. This view was highlighted by Miller (2001), that adapting teaching methods to match the different learning preferences styles would contribute to improving the student's motivation and performance.

The findings could also be discussed within the context of the ARCS motivation model that was proposed by Keller (1987). The redundant on-screen text might cue the students' attention to the learning task. This redundant text served as a technique to capture and gain the students' attention to comprehend the English narration. Redundant on-screen text did enhance the motivation of the students in the first motivational factor ‘attention’ which consequently enhanced the student’s motivation on the other factors: relevance, confidence and satisfaction. This view was supported by studies done by Taran (2005); Astleitner and Koller (2006) that the attention strategy had positive effect on the students' motivation to learn.

Implications & conclusions

This study has theoretical and practical implications. On the theoretical side, firstly, this study concluded that the redundancy effect can be generalised to instructions as long as the instructions are system-paced based with the narration. But this effect cannot be ‘one size fits all’. It is neither feasible to all situations nor panacea for all instructional problems. As soon as learner-pacing is incorporated, the redundancy effect disappears. However, it must be emphasized that the redundant on-screen text must be carefully synchronized with the narration and presented in only small chunks to reduce cognitive load. Secondly, the often-stated explanation of the modality effect in terms of the modality-specific subsystems of working memory should be replaced by an explanation in terms of preventing split attention. On the practical side, the design guidelines for multimedia instructions should be:

1. remove redundant information
2. with system-paced instructions, use narration
3. with learner-paced instructions, use on-screen text; and
4. prevent visual search.

Together, these guidelines provide the nuances of cognitive load theory and suggest that when teaching novice second language learners to learn comprehension, particularly those who may still have difficulties with sound-symbol correspondences between the spoken and written language, the common procedure of presenting pictures and concurrent narration may not be optimal. If the aim of instruction is to teach novice learners to read, the modality mode with only pictures and narration could interfere

with, rather than facilitate, learning. On the other hand, this study showed that in terms of the redundancy effect, the presence of redundant information alone did not impair learning. Since the instruction was learner-paced, and the on-screen text was synchronized with that of the auditory text, it showed that the processing of s*ynchronized* on-screen text and auditory text did not interfere with each other but was harmonized or even enhanced.

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