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Media presentation mode, English listening comprehension and cognitive load in ubiquitous learning environments: Modality effect or redundancy effect?

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Although ubiquitous learning enhances students' access to learning materials, it is crucial to find out which media presentation modes produce the best results for English listening comprehension. The present study examined the effect of media presentation mode (sound and text versus sound) on English listening comprehension and cognitive load. Participants were 162 students majoring in Applied Foreign Language at a university in Taiwan. The students were randomly assigned to either single mode (sound) or double mode (sound and text). The research questions are (a) whether students learning with double mode outperformed students learning with single mode in listening comprehension; and (b) whether students learning with double mode encountered less cognitive load than students learning with single mode. If the answers to these questions are affirmative, then the modality effect occurs and the redundancy effect does not occur. The results demonstrated that (a) text significantly enhanced English listening comprehension and lowered cognitive load; (b) students with higher English listening comprehension experienced lower cognitive load, and vice versa; (c) text added no benefit to schema construction in long term memory; and (d) complex media presentations were not necessarily helpful to learning. Results (a) and (b) confirmed that the modality effect occurred, and the redundancy effect did not occur in the present study.

Introduction

Background

Listening comprehension is difficult for foreign language learners because it is a continuous process that requires learners to understand messages while listening to them and sometimes can lead to a heavy cognitive load. In order to minimise listening barriers, various media presentation modes and ubiquitous learning activities should be implemented for teaching and learning because they are convenient and can enhance students' learning motivation and learning performance (Liu & Chu, 2010). "Ubiquitous learning" involves a context-aware environment that users engage in with some mobile devices (Chang, Sheu & Chan, 2003; Li, Zheng, Ogata & Yano, 2005; Tan, Liu & Chang, 2007). Yang (2006) established a context-aware learning system with the support of multimedia for ubiquitous learning, so students were able to get the information they needed anytime and anywhere. Hence, students learning in an authentic situation may have better English listening comprehension due to an enhanced sensory stimulation.

The impacts of different media presentation modes on learning remain inconclusive. According to the working memory model proposed by Baddeley (2000), working memory can simultaneously receive information from different channels, such as auditory and visual. Thus, when the efficiency of the working memory is improved, learning performance will also be enhanced. However, Kalyuga, Chandler and Sweller (2000) suggested that some multimedia learning software can lead to cognitive overload, which affects learning performance negatively. Sweller (2005) also argued that unnecessary or repeated multimedia messages can result in a redundancy effect, which negatively affects learning performance.

Multimedia helps learners learn, but different media presentation modes affect learners' cognitive load differently (Moreno, 2002; Mayer & Moreno, 2003; Plass, Chun, Mayer & Leutner, 2003). Sweller (2007) mentioned that the purpose of instructional design is to assist learners to store information in long term memory. This implies that the way teaching materials presented to learners is a key element in instructional design. Attention to cognitive load is a critical concern for instructional designers when designing multimedia teaching materials, because unnecessary multimedia messages may worsen learning performance by increasing working memory load and interrupting information processing (Sweller, 2007).

Multimedia instructional systems have been widely applied in teaching and learning, but the media presentation mode that is best for English listening comprehension remains uncertain, and whether unnecessary information led to cognitive overload for learners also remains inconclusive. According to the studies done by Jones and Plass (2002) and Diao, Chandler and Sweller (2007), students learning with double mode (sound and text) outperformed students learning with single mode (sound) and had lower cognitive load. Studies related to foreign language learning and cognitive load are mostly about digital learning environments. Hence, the present study examined the effect of media presentation mode on listening comprehension in a ubiquitous learning environment to see if there were any differences from the studies on digital learning environments. Which media presentation mode can efficiently help learners store information in long term memory is another issue to be further examined.

Research purpose and questions

The present study aimed to examine the effect of media presentation mode (single mode: sound; double mode: sound and text) on English listening comprehension and cognitive load in a ubiquitous learning environment. The research questions include:

1. Are there any significant differences in English listening comprehension between two media presentation modes?
2. Are there any significant differences in cognitive load between two media presentation modes?
3. Are there any significant correlations between English listening comprehension and cognitive load?
4. Are there any significant differences in extended English listening comprehension between two media presentation modes?
5. Are there any significant differences in extended cognitive load between two media presentation modes?
6. Are there any significant correlations between extended English listening comprehension and extended cognitive load?

Literature review

Listening in foreign language learning

Although listening has played a crucial role in foreign language learning, it has often been neglected by instructors (Osada, 2004). Nevertheless, listening examination has been included in most English proficiency examinations, such as TOFEL, TOEIC and GEPT, which implies the importance of listening. Listening comprehension is a difficult task for foreign language learners to master due to the interference of first language and the limitation of listening time (Teng, 2006). Thus, instructors must design teaching materials and learning activities appropriately for learners to learn efficiently. Teaching materials can be delivered through the support of multimedia, with the intention that sound can be presented to learners with text, image or video (Tabbers, Martens & Van Merriënboer, 2004). Therefore, learners can learn not only by single mode (sound) but also other modes with the support of multimedia, which will stregthen their learning motivation.

Ubiquitous learning

Elements of ubiquitous learning
Ubiquitous learning refers to a context-aware learning environment that learners engage in with a mobile device and the Internet (Chang, Sheu & Chan, 2003; Li, Zheng, Ogata & Yano, 2005; Tan, Liu & Chang, 2007). Chang (2003) mentioned three main fundamental elements for ubiquitous learning, including (a) a mobile device, such as a PDA (personal digital assistant), web pad or tablet PC, which is small, light, portable and customised with a wireless facility; (b) communication facility, such as mobility server and Global Positioning System (GPS), which enables learners to obtain materials and communicate with one another; and (c) learning activity, which should be implemented appropriately in the instruction and makes learning become meaningful.

Ubiquitous learning and foreign language learning in listening
Ubiquitous learning enables learners to learn in their daily life and helps them to overcome limitations of time and space. Learners who study a foreign language with mobile devices will be able to experience learning from an authentic situation and have their learning performance enhanced (Nash, 2007), as multiple sense stimuli may be more helpful to learners in absorbing knowledge. So far, ubiquitous learning has been implemented in many types of learning, such as museum tours, natural science learning and language learning, etc (Chen & Chung, 2008; Chiou, Tseng, Hwang & Heller, 2010; Tan et al., 2007). Well-designed ubiquitous learning can enhance English learners' motivation and learning performance (Chen & Chung, 2008; Liu & Chu, 2010). Since learners have different educational backgrounds and learning preferences, it is better for learners to learn at their own pace and obtain information they need at any time (Yang & Lin, 2010).

Cognitive load theory

Sources of cognitive load
Cognitive load is a load upon working memory produced when a particular task is processed by one's cognitive system (Sweller et al., 1998). Sweller et al. (1998) proposed four basic hypotheses toward cognitive architecture based on the cognitive load theory, including: (a) capacity of working memory is limited; (b) capacity of long term

memory is unlimited; (c) knowledge is stored as schema in long term memory; and (d) automation is an important process for schema construction. A well-designed media presentation mode will help learners build up schema for storing the obtained information in the long term memory. Moreover, a learning activity with an appropriate media presentation mode can also facilitate schema automation and construction, so learners' cognitive load can be lowered and learning performance can be enhanced.

There are three types of cognitive load (Pawley, Ayres, Cooper & Sweller, 2005; Paas, Renkl & Sweller, 2003), which are:

1. *Intrinsic cognitive load*
   The higher the correlation between the nature of the material being learned and the expertise of the learners, the lower the load in working memory because learners will be able to retrieve relevant information from long term memory. On the other hand, the lower the correlation between the nature of the material being learned and the expertise of the learners, the higher the load in working memory because there is no related schema in long term memory and learners are required to process more in working memory. Therefore, intrinsic cognitive load cannot be lowered easily by instructional design.

2. *Extraneous cognitive load*
   Extraneous cognitive load can be affected by presentation modes of teaching materials. Thus, extraneous cognitive load can be lowered by instructional design, which is also a point for the present study.

3. *Germane cognitive load*
   Germane cognitive load can be affected by instructional design and is thought of as a facilitator of learning performance, not an interrupter. Instructors can facilitate learners' learning motivation by learning activities, which make learners become more concentrated on learning and help them to construct schema.

Since it has been difficult to lower one's intrinsic cognitive load by instructional design and the impact of germane cognitive load will be small (because learners were participating in the same learning activity), only *extraneous cognitive load* has been examined in the present study.

Modality effect and redundancy effect
Modality effect is defined as an effect in which learners perform well when they receive information from various channels, such as visual and auditory (Sweller, 2005). A number of researchers have confirmed the modality effect (Debuse, Hede & Lawley, 2009; Diao et al., 2007; Jones & Plass, 2002; Low & Sweller, 2005; Moreno & Mayer, 2002; Plass et al., 2003; Tabbers, Martens & Van Merriënboer, 2004). On the other hand, a redundancy effect happens when too much useless information is added to learners' working memory, which leads to high extraneous cognitive load. Again, numerous researchers have confirmed the modality effect (Debuse, Hede & Lawley, 2009; Jamet & Bohec, 2007; Kalyuga, Chandler & Sweller, 2000; Mayer, Heiser & Lonn, 2001; Mayer & Moreno, 2003; Moreno & Mayer, 2002; Sakar & Ercetin, 2005). Consequently, the media presentation modes in the present study were designed based on the ideas of the modality effect and the redundancy effect. The teaching materials for the single mode group and the double mode group were the same. The only difference between both

groups was that participants in the single mode group learned with sound only and the double mode group learned with sound and text.

Cognitive load and listening in foreign language learning
From the perspective of the modality effect, double mode, including visual and auditory, will be expected to enhance learning performance. A study done by Markham (1999) revealed that foreign language learners who learned with double mode had better listening comprehension. However, from the perspective of the redundancy effect, double mode will not be beneficial to learning. Research by Diao et al. (2007) demonstrated that text was not helpful to listening comprehension. Hence, the results from different studies on listening in a foreign language have been inconsistent.

A study on French learning, with university students as participants, by Jones and Plass (2002) supported the proposition that simultaneous visual and auditory presentations can cause the modality effect, which lowers extraneous cognitive load and enhances learning performance. Another study about English learning, also with university students as participants, by Daio et al. (2007) revealed that double modes, such as sound and complete paragraph, and sound and caption, were better for enhancing listening comprehension and lowering cognitive load than sound-only presentation mode. Both studies showed that double mode tends to cause a modality effect.

However, double mode will also cause a redundancy effect. Diao and Sweller (2007) conducted a study with university students which demonstrated that text-only presentation mode was better than synchronised sound and text presentation mode, for both performance and cognitive load. This result supported the proposition that the redundancy effect occurs when sound is presented simultaneously with text, which is not beneficial to learning. However, this study did not take learners' prior knowledge into account. A Chinese learning study, with high school students as participants, done by Chung (2008) revealed that students with high prior knowledge performed better in memory tests and encountered low cognitive load when visual and auditory were presented simultaneously, which led to the modality effect. On the other hand, learners with low prior knowledge performed better in memory tests and encountered lower cognitive load when visual was presented only, which caused the redundancy effect. This study also revealed that learners' prior knowledge could be a main factor that caused the modality effect and the redundancy effect.

In sum, the studies mentioned above all showed that learners who encountered high cognitive load attained a lower learning performance. Therefore, decreasing extraneous cognitive load for learners is an important goal for instructional designers (Sweller et al., 1998). Learners' proficiency in English listening was considered as an extraneous variable in the present study, as since differences in proficiencies could affect the findings.

Research method

Participants

Participants were 162 university students in Taiwan, aged from 18 to 23, majoring in Applied Foreign Language with the same instructor. These participants were assigned randomly to the single mode (82 students) or double mode (80 students) group. The

participants had similar academic proficiency because all students had been assigned to the university based on their scores obtained from the Joint College Entrance Examination. Before the experiment started, all the participants had been familiarised with the PDA (Hewlett Packard *iPAQ 112 Classic*, 3.5 inch screen).

The ubiquitous learning activity in the present study was held at the Taipei Zoo. The Taipei Zoo is one of the main Natural Science Education centres in Taiwan, where people can acquire knowledge about animals and nature. Since the topic of the learning activity was related to animals, it was more appropriate for learners to learn in the zoo. Learning in the zoo enabled learners to experience an experiential learning. With the support of PDA, teaching efficiency and learning motivation are enhanced, which can be a contribution to education. The possible career opportunities for students majoring in Applied Foreign Language are tour guides, who can speak more than one second language, and foreign language teachers. So, the experiment in the present study provided an opportunity for the participants to visit a potential future workplace.

Research design

The independent variable in the present study was media presentation mode, being single mode (sound only) and double mode (sound and text). The dependent variables were learners' English listening comprehension and cognitive load. There were two tests in the present study. The first test, for examining the participants' listening comprehension, was given immediately after concluding the ubiquitous learning activity. The second test was given to the participants one week after the learning activity was over, to assess their extended listening comprehension. The covariate variable was English listening proficiency, measured by the *General English Proficiency Test* (GEPT).

As shown in Table 1, participants in both groups took the GEPT as the pretest. In the ubiquitous learning activity, participants in the single mode group learned with sound-only materials whilst the double mode group learned with sound and text materials. In the extended learning activity, both groups learned with sound-only extended materials. After the learning activity, both groups took English listening tests and cognitive load questionnaires as the post-test.

Table 1: Research design (ubiquitous learning)

Group	N	Pretest	Experiment	Post-test
Single	82	General English Proficiency Test (GEPT)	Sound only English listening material	English listening test Cognitive load
Double	80		Concurrently sound and text English listening material	

Table 2: Research design (extended listening)

Group	N	Pretest	Experiment	Post-test
Single	82	General English Proficiency Test (GEPT)	Sound only English listening material	English listening test Cognitive load
Double	80			

After the data collection, two-way multivariate analysis of covariance (MANCOVA) was conducted to examine the differences between the posttest scores obtained by the two groups, and the covariate variable was based on the score of the pretest. To examine the relationships between listening comprehension and cognitive load, a Pearson correlation was performed. The research framework is shown in Figure 1.

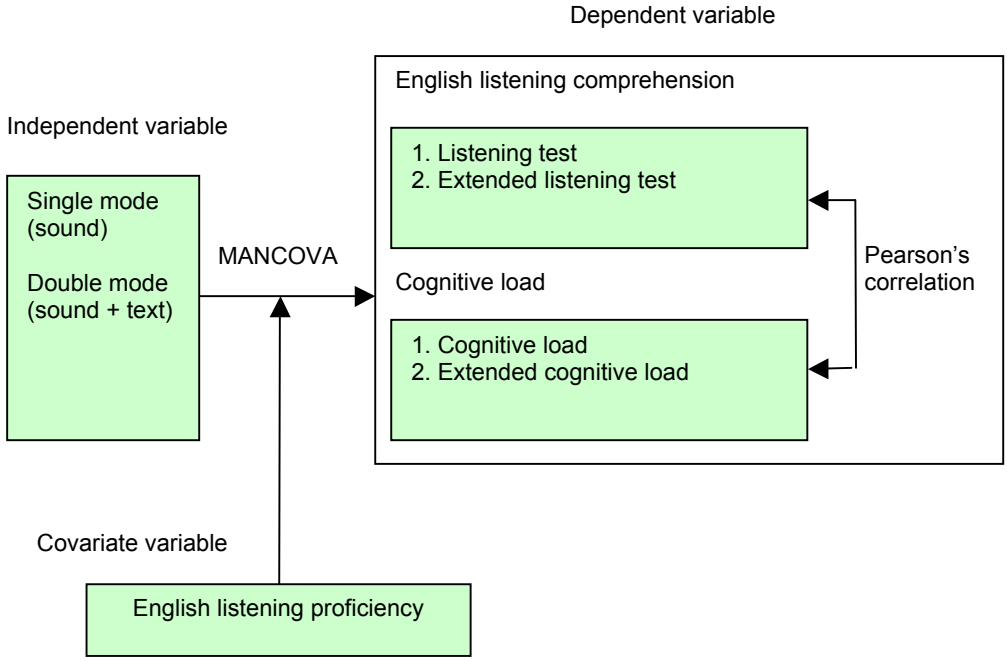

Figure 1: Research framework

Procedure

There were four stages in the experiment including pretest (first week), training (second week), intervention and post-test (third week), and extended learning and extended post-test (fourth week), as shown in Table 3 and Figure 2.

Instrument

English listening proficiency test
The General English Proficiency Test (GEPT) was utilised in the present study to determine students' proficiency in English listening, as the GEPT is a graduation requirement for the students majoring in Applied Foreign Language. There were 20 multiple choice questions given by sound speech in the test. Each question was worth five points, and the total possible score for the test was 100.

Table 3: Experimental procedure

Stage	Description
Pretest (First week)	The pretest was administrated during the class (1.5 hours): 1. The instruction for the test was given by the instructor (0.5 hour). 2. Students took listening test from GEPT (1 hour).
Training (Second week)	The training was provided during the class (3 hours): 1. Introduction to ubiquitous learning, PDA (HP *iPAQ 112 Classic*, 3.5 inch screen) and GPS, including practical experience on using PDA and GPS. 2. Instructor provided key words that would be included in the material.
Intervention and post-test (Third week)	Ubiquitous learning and test in the zoo (4 hours): 1. Students were randomly assigned into two groups with either single or double mode material. 2. Students had their PDA connected with GPS. 3. The system asked students to enter their student ID. 4. Exploration of animals would be displayed on the screen. Students could see the map of Africa area in the zoo and their current location. Each animal was marked on the map and students could decide the listening order by their preferences. The system guided students to the target by GPS. 5. When students arrived in the observed area, the system would display its material automatically by GPS and ask students if they wanted to start the listening or not. 6. Students were presented to English listening material by clicking on the button "Play". 7. After the speech sound played, students needed to click on the button "Next Page" for the test page. 8. After taking the test, students would then continue to the next animal with the steps mentioned above. 9. Students were required to fill in the cognitive load rating scale.
Extended learning and extended post-test (Fourth week)	Extended listening and test during the class (2 hours) 1. Students participating in the extended listening activity (1 hour). 2. Students participating in the extended listening test (0.5 hour). 3. Students were required to fill in the cognitive load rating scale (0.5 hour).

English listening material and test

1. *The ubiquitous learning activity and test*

   A total of four animals, including elephant, lion, monkey and giraffe, were chosen from the Africa area in the Taipei Zoo. Each animal was described by a passage, so there were a total of four passages in the test. The English listening training system was developed by the research team in the present study. The content of the teaching material and the test were adapted from the website of National Geographic (http://animals.nationalgeographic.com/animals/) and San Diego Zoo (http://www.sandiegozoo.org/animalbytes/), as shown in Figures 3 and 4. The spoken time for each passage, with length from 180 to 220 words, was about three minutes. There were five multiple-choice questions for each passage, which required students to answer (without time restriction) after listening to each passage. There were 20 questions in the test and one point for each question.

   a. Item analysis

   Criterion of internal consistency was adopted by using *t*-test to compare the differences between high scores (top 27%) and low scores (last 27%), and a Pearson correlation was performed to examine the relationship between each question and the test, as shown in Appendix 1. The analysis revealed a significant result on critical ratio and item-total correlation. Six out of 20 questions were deleted from the test, so that item internal consistency could be acceptable.

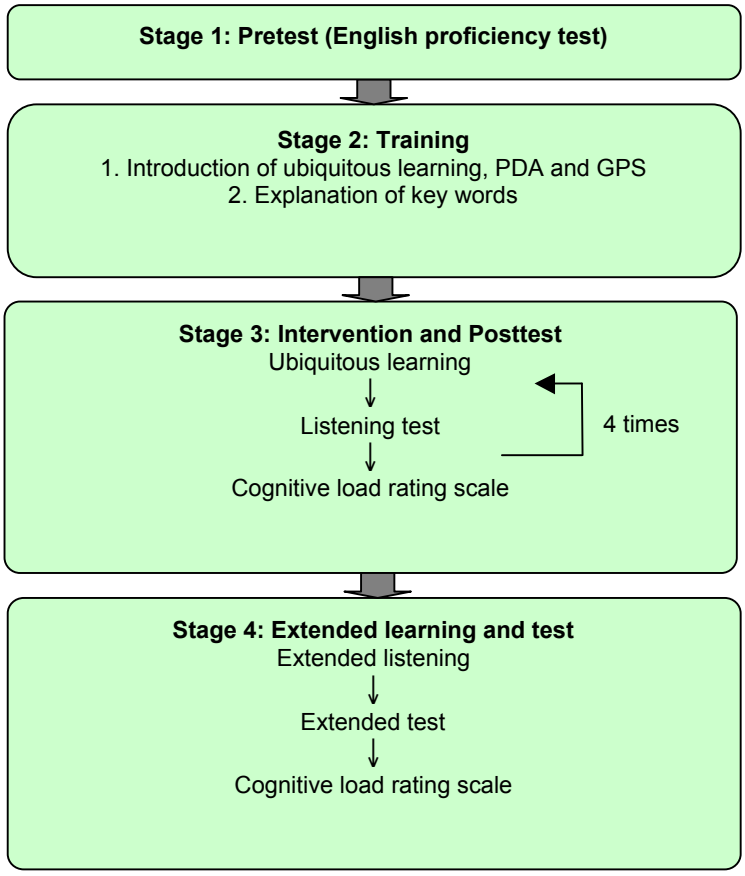

Figure 2: Research procedure

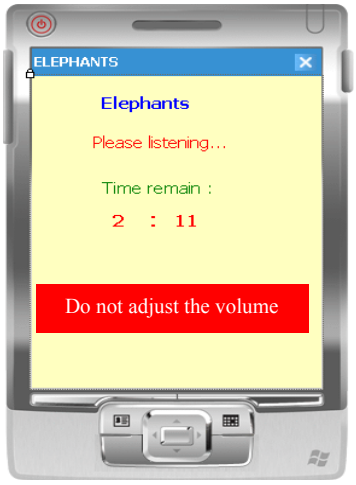

Figure 3: PDA screen of single mode

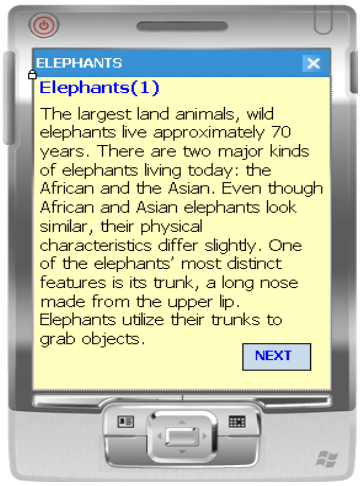

Figure 4: PDA screen of double mode

b. Difficulty and discrimination analysis
The calculating formula for difficulty index was $(P_H+P_L)/2$ and discrimination was P_H-P_L. P_H represented students in the top 27%, whereas P_L represented students in the last 27%. The overall difficulty index for the test was 0.523 and the overall discrimination index was 0.327, which were acceptable, as provided by Appendix 1.

2. *The extended learning activity and extended test*
The extended listening test is not the same as the first test mentioned above. But, the vocabularies for the extended material and extended test were chosen from the first test. The purpose of the extended learning material was simply to remind the students of the vocabularies in the first test. The extended test was to examine learners' schema construction in long term memory, so the extended test was administrated only through speech sound. There was one passage, with length of 220 words, followed by five multiple choice questions in the test. The total score for the extended test was five points.

a. Item analysis
The method for the item analysis was same as the test mentioned above, as shown in Appendix 2, and no question was deleted.

b. Difficulty and discrimination analysis
The overall difficulty index for the extended test was 0.418 and the overall discrimination index was 0.519, which were acceptable, as shown in Appendix 2.

3. *Cognitive load rating scale*
The cognitive load rating scale by Yeung et al. (2000) was adopted in the present study, as shown in Table 4. The rating scale included four aspects, which were difficulty, incompetence, negative affect and lack of effort. The reliability for each aspect was ranged from 0.78 to 0.93, which was acceptable. The factor loadings for all the items were greater than 0.5 and the four factors accounted for more than 50% of total explained variance. Therefore, the validity of the rating scale was satisfied. The participants were required to rate themselves on a 5-point Likert-type scale with response options from 1 (strongly agree) to 5 (strongly disagree).

The cognitive load formula proposed by Yeung et al. (2000) is as follows, the higher the score, the higher the estimated cognitive load.

Cognitive load = D*I/A + D*I/E

D = Difficulty**; I =** Incompetence**; A =** Negative affect; **E** = Lack of effort

a. Item analysis
The criterion of internal consistency was adopted by using a *t*-test to compare the differences between high scores (top 27%) and low scores (last 27%), and a Pearson correlation was performed to examine the relationship between each question and the test. The analysis revealed a significant result on critical ratio and item-total correlation. The item internal consistency of the test was acceptable without deleting any item, as shown in Appendix 3.

Table 4: Cognitive load rating scale

Aspects	Description	Item
Difficulty	Self-perceived difficulty toward the task. The higher the score, the more difficult the task.	01. I think the material is very easy.*
		02. I think the material is too difficult.
		03. I did not face any difficulty when I took the test.*
		04. I faced difficulty when I took the test.
Incompetence	Self-perceived incompetence toward the task. The higher the score, the higher the level of incompetence.	05. I do not perform well in the lesson.
		06. I think I get correct for each question.*
		07. I think I perform well in the lesson.*
		08. I do not answer questions incorrectly.*
Negative affect	Attitude toward the task. The higher the score, the higher the motivation.	09. I like the material.*
		10. I am interested in the material.*
		11. I hate to do such kind of test again.
		12. I think it is fine for me to do such kind of test again.*
Lack of effort	Lack of effort toward the task. The higher the score, the less the effort.	13. I worked hard for the test.*
		14. I concentrated on the lesson.*
		15. I did my best with the test.*
		16. I worked hard for the lesson.*

* Negative items

b. Analysis of validity

As shown in Table 5, Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) were performed at first. The results showed that Bartlett's test of sphericity was significant and KMO was greater than 0.5, meaning that the correlation matrix was not an identity matrix and the factor model was appropriate for proceeding a factor analysis. A principal components analysis with orthogonal rotation was conducted for the factor analysis. The factor loadings for each item were greater than 0.5 and the validity coefficient was greater than 0.1, therefore all items did not have to be deleted, as shown in Appendix 5. The eigenvalue of each aspect was greater than 1, so four aspects could be established. The total explained variance was greater than 50%, implying that the construct validity of the rating scale was good enough.

Table 5: Factor analysis for the cognitive load rating scale

Aspect	Bartlett's test of sphericity		KMO	Total variance explained
	Chi-square	P		
Difficulty	121.036	0.000	0.748	57.343%
Incompetence	129.890	0.000	0.693	56.175%
Negative affect	205.013	0.000	0.793	67.066%
Lack of effort	193.779	0.000	0.785	65.040%
Overall	902.031	0.000	0.806	65.813%

c. Analysis of reliability

As shown in Table 6, the reliability coefficient of the measures of cognitive load was .814, as measured by Cronbach's α, which was acceptable.

Table 6: Reliability for the cognitive load rating scale

Aspect	Cronbach's α
Difficulty	0.751
Incompetence	0.733
Negative affect	0.829
Lack of effort	0.819
Overall	0.814

Result and discussion

Data processing

A total of 137 valid samples were collected. Among these 137 valid samples, 66 samples were in the single mode group and 71 samples were in the double mode group.

Effect of media presentation mode on English listening comprehension and cognitive load (Research questions 1 and 2)

Test of homogeneity
As shown in Table 7, Box's test of equality of covariance matrices (F = 5.327, p = .155) and Levene's test of equality of covariance (listening comprehension: F = .348, p = .556; cognitive load: F = .041, p = .840) were insignificant, meaning that the variance of listening comprehension and cognitive load was equal across groups and the homogeneity assumption was sustained. Furthermore, Wilk's λ (F = 0.985, p = .364) and regression slope (listening comprehension: F = 1.675, p = .198; cognitive load: F = .048, p = .828) appeared insignificant, suggesting that the homogeneity assumption was sustained and the covariance (pretest) had the same degree of impact to the participants. Therefore, a two-way MANCOVA could be performed.

Table 7: Test of homogeneity for English listening comprehension and cognitive load

Dependent variable	Box's *M*		Levene's test		Wilk's λ		Regression slope	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.
English listening comprehension	5.327	0.155	0.348	0.556	0.985	0.364	1.675	0.198
Cognitive load			0.041	0.840			0.048	0.828

Two-way multivariate analysis of covariance (MANCOVA)
As shown in Table 8, for English listening comprehension, learners in the double mode group outperformed learners in the single mode group. For cognitive load, learners receiving single mode encountered a higher level than learners receiving double mode. As shown in Table 9, Wilk's *lambda* showed a significant result, indicating that learners in both groups had significant differences in at least one dependent variable (English listening comprehension or cognitive load). The analysis of two-way MANCOVA, with covariance of English listening proficiency, showed that there was a significant difference in listening comprehension ($p < .05$) between the two groups, indicating that learners in the double mode group outperformed learners in the single mode group.

There was a significant difference in cognitive load ($p < .05$) between the two groups, revealing that the single mode group had higher cognitive load than the double mode group. Both groups had significant differences in listening comprehension and cognitive load, but the estimated effect size for listening comprehension (η^2 = 0.117) was greater than cognitive load (η^2 = 0.033). This implied that media presentation mode had more impact on listening comprehension than on cognitive load, and both groups had more differences in listening comprehension than in cognitive load.

Table 8: Descriptive statistics for listening comprehension and cognitive load

Aspect	Single mode		Double mode	
	Mean	Std deviation	Mean	Std deviation
English listening comprehension	6.667	1.916	8.099	2.262
Cognitive load	51.617	20.458	44.621	19.907

Table 9: Two-way MANCOVA summary of listening comprehension and cognitive load

Wilk's λ (sig.)	Source	Aspect	Type III sum of squares	df	Mean square	*F*	Sig.	*eta*-squared
0.877 (0.000)	Covariance	Listening comprehension	66.780	1	66.780	16.878*	0.000	0.112
		Cognitive load	6183.521	1	6183.521	16.993*	0.000	0.113
	Between group	Listening comprehension	70.070	1	70.070	17.709*	0.000	0.117
		Cognitive load	1671.568	1	1671.568	4.594*	0.034	0.033
	Within group	Listening comprehension	530.197	134	3.957			
		Cognitive load	48760.674	134	363.886			
	Total	Listening comprehension	8187.000	137				
		Cognitive load	372151.143	137				

*$p < 0.05$

Discussions

In the ubiquitous learning environment, learners in the single mode group encountered higher extraneous cognitive load due to the lack of text support. On the other hand, learners in the double mode group had lower extraneous cognitive load because they received support from text. Some learners learning with double mode needed only to overcome intrinsic cognitive load from the material itself. Hence, learners learning with double mode outperformed learners learning with single mode. For the double mode, the modality effect occurred, but the redundancy effect did not. These results confirmed some findings on cognitive load (Diao, et al., 2007; Jones & Plass, 2002). A study by Chung (2008) revealed that learners with high English proficiency had lower cognitive load when they learned with double mode. So, the result in the present study that learners who learned with double mode had lower cognitive load could be explained by their sufficient English proficiency. Based on the result of the present study, text enhanced students' listening comprehension and lowered their cognitive load. At the same time, the result also confirmed the viewpoint by Baddeley (2000) that information could be received from both visual and auditory channels for increasing the capacity of the working memory and helping students learn, which referred to the modality effect from the cognitive load theory (Sweller, 2005).

The correlation between English listening comprehension and cognitive load (Research question 3)

A Pearson correlation was performed in the present study to examine if there was a correlation between English listening comprehension and cognitive load. As shown in Table 10, English listening comprehension and cognitive load had a significant negative correlation ($r = -0.393$; $p < 0.001$)

Table 10: Correlations between English listening comprehension and cognitive load

Aspect	English listening comprehension	Cognitive load
English listening comprehension	1.000	
Cognitive load	-0.393***	1.000

***$p < 0.001$

In ubiquitous learning environment, learners who performed well in English listening comprehension encounterd lower cognitive load, and vice versa. This result supported the cognitive load theory and confirmed most findings on cognitive load (Chung, 2008; Diao et al., 2007; Diao & Sweller, 2007; Jones & Plass, 2002) that learners having low cognitive load performed well.

Effect of media presentation mode on extended English listening comprehension and extended cognitive load (Research questions 4 and 5)

Test of homogeneity

As shown in Table 11, Box's test of equality of covariance matrices (F = .276, p = .965) and Levene's test of equality of covariance (extended listening comprehension: F = .691, p = .407; extended cognitive load: F = .067, p = .796) were insignificant, meaning that the variance of extended listening comprehension and extended cognitive load was equal across groups and the homogeneity assumption was sustained. Furthermore, Wilk's λ (F = 0.997, p = .847) and regression slope (extended listening comprehension: F = .333, p = .565; extended cognitive load: F = .001, p = .974) appeared insignificant, suggesting that the homogeneity assumption was sustained and the covariance (pretest) had the same degree of impact on the participants. Therefore, two-way MANCOVA could be performed.

Table 11: Test of homogeneity for extended English listening comprehension and extended cognitive load

Dependent variable	Box's M		Levene's test		Wilk's λ		Regression slope	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Extended English listening comprehension	0.276	0.965	0.691	0.407	0.997	0.847	0.333	0.565
Extended cognitive load			0.067	0.796			0.001	0.974

Two-way multivariate analysis of covariance (MANCOVA)

As shown in Table 12, for extended English listening comprehension, learners in the double mode group slightly outperformed learners in the single mode group. For extended cognitive load, learners receiving single mode attained a higher level than learners receiving double mode. As shown in Table 13, Wilk's λ showed an insignificant result, indicating that learners in both groups did not have a significant difference in both dependent variables (extended English listening comprehension and extended cognitive load). The analysis of two-way MANCOVA, with covariance of English listening proficiency, showed that there was no significant difference in extended listening comprehension (p = .340) and extended cognitive load (p = .497) between the two groups.

Table 12: Descriptive statistics for extended listening comprehension and extended cognitive load

Aspect	Single mode		Double mode	
	Mean	Std dev	Mean	Std dev
Extended English listening comprehension	2.02	1.196	2.20	1.179
Extended cognitive load	48.426	19.480	46.224	19.122

Table 13: Two-way MANCOVA summary on extended listening comprehension and extended cognitive load

Wilk's λ (sig.)	Source	Aspect	Type III Sum of squares	df	Mean square	*F*	Sig.	*eta*-squared
0.991 (0.545)	Covariance	Extended listening comprehension	25.421	1	25.421	20.670*	0.000	0.134
		Extended cognitive load	2957.325	1	2957.325	8.377*	0.004	0.590
	Between group	Extended listening comprehension	1.128	1	1.128	0.918	0.340	0.007
		Extended cognitive load	163.680	1	163.680	0.464	0.497	0.003
	Within group	Extended listening comprehension	164.803	134	1.230			
		Extended cognitive load	47303.815	134	353.014			
	Total	Extended listening comprehension	801.000	137				
		Extended cognitive load	356800.660	137				

*$p < 0.05$

Discussion

According to the results in the present study, learners receiving single mode had no significant difference with learners receiving double mode, in extended English listening comprehension and extended cognitive load. The reason for this was that learners learning with double mode during the ubiquitous learning were used to learning with the support of text, so when there was no support from text in the extended learning and test, learners would have higher extraneous cognitive load and lower listening comprehension scores. Thus, combining with the result of the last section, text caused the modality effect and lowered students' extraneous cognitive load temporarily. However, text did not efficiently assist students to store knowledge in long term memory. This result confirmed a study on an extended test by Diao et. al (2007). Another reason for explaining this result is that the extended learning happened seven days after the ubiquitous learning activity, which implied that students without immediate review would have difficulty in building up schema in long term memory. Therefore, instructors should provide review sessions to learners in listening training, in order to help them build up schema.

The correlation between extended English listening comprehension and extended cognitive load (Research question 6)

Pearson correlations were performed to examine whether there was a correlation between extended English listening comprehension and extended cognitive load. As

shown in Table 14, extended English listening comprehension and extended cognitive load had a significant negative correlation (r = -0.214; $p < 0.05$).

Table 14: Correlations between English listening comprehension and cognitive load

Aspect	Extended English listening comprehension	Extended cognitive load
Extended English listening comprehension	1.000	
Extended cognitive load	-0.214*	1.000

*$p < 0.05$

In the extended test, learners who performed well in English listening comprehension experienced lower cognitive load, and vice versa. This result was identical to the correlation between English listening comprehension and cognitive load.

Discussion concerning all research questions

Cognitive load and extended cognitive load

In the ubiquitous learning environment, learners learning with double mode outperformed in the English listening test and had significantly lower cognitive load than learners learning with single mode. Learners learning with single mode obtained slightly lower extended test scores and had higher extended cognitive load than learners learning with double mode, but the result was insignificant. Taking a closer look at the correlation between their cognitive load and extended cognitive load, as shown in Tables 15 and 16, although the correlation was not statistically significant, the level of cognitive load for learners who learned by single mode was tending lower from the ubiquitous learning to the extended learning, whereas the level of cognitive load for learners who learned by double mode was tending higher from the ubiquitous learning to the extended learning

Table 15: Paired t-test of cognitive load and extended cognitive load for single mode

Aspect	N	Mean	Std dev	t	Sig.
Cognitive load	66	51.617	20.458	1.409	0.164
Extended cognitive load	66	48.426	19.480		

Table 16: Paired t-test of cognitive load and extended cognitive load for double mode

Aspect	N	Mean	Std dev	t	Sig.
Cognitive load	71	44.621	19.907	-0.731	0.467
Extended cognitive load	71	46.224	19.122		

Discussion

The above findings could be explained by the fact that learners receiving single mode during the ubiquitous learning or the extended learning were used to learning by sound-only presentation mode. Some students in the single mode group had already built up schema for English listening in their long term memory, so they had low extraneous cognitive load. On the other hand, for learners receiving double mode in the ubiquitous learning, they became uncomfortable during the extended learning due to the lack of text support. Since learners receiving double mode did not build up schema for English listening in long term memory, they required more time and space to process information in working memory, which led to higher extraneous cognitive load. Based on the results in the present study, text enhanced English listening

comprehension and lowered extraneous cognitive load, but was unhelpful to schema construction in long term memory, which confirmed the findings of Diao et al. (2007).

Conclusions and implications

For English listening comprehension, regardless of English listening proficiency, learners learning with double mode significantly outperformed learners learning with single mode. For cognitive load, learners learning with double mode had significantly lower cognitive load than learners learning with single mode, implying that text did not make the cognitive load become higher. In other words, the lack of text support led to higher cognitive load and was not beneficial for English listening. This finding revealed that text can facilitate learners in listening comprehension and lower their cognitive load efficiently. For the double mode, the modality effect was caused, but redundancy effect was not, which confirmed the study results on cognitive load (Debuse, Hede & Lawley, 2009; Diao et al., 2007; Jones & Plass, 2002; Low & Sweller, 2005; Moreno & Mayer, 2002; Plass et al., 2003; Tabbers, Martens & Van Merriënboer, 2004).

In both ubiquitous learning and extended learning, learners' English listening comprehension and cognitive load had a significantly negative correlation. This phenomenon is similar to the cognitive load theory that learners' cognitive load influences their learning performance. The finding confirmed the most related studies (Chung, 2008; Diao et al., 2007; Diao & Sweller, 2007; Jones & Plass, 2002).

Regarding the findings for research questions 1, 2, 4 and 5, in the ubiquitous learning environment, learners in the double mode group obtained higher grades on listening comprehension test and had lower cognitive load than learners in the single mode group. However, in the extended learning, there was no significant difference between groups in English listening comprehension and cognitive load. This finding implied that text could only temporarily enhance learners' English listening comprehension, lower learners' cognitive load and cause the modality effect, but could not efficiently help learners store knowledge in long term memory. This result was identical to the findings by Diao et al. (2007). Furthermore, extended cognitive load tended to be low for learners in the single mode group, but high for learners in the double mode group. This event revealed that learners who learned with double mode tended to have a hard time in accommodating themselves to the learning environment with single mode (auditory only). Therefore, text is not an efficient support for listening training.

According to the present study findings, text could temporarily enhance learning performance and lower cognitive load, but it could not efficiently help learners store knowledge in long term memory. This result showed that text is not essential to listening. Materials with an abundance of media presentations will not definitely enhance learning performance, so it is important to utilise media appropriately and take subject matter, learners' proficiency and learners' educational background into account. Providing students an appropriate media presentation mode for learning will reduce unnecessary cognitive load and efficiently help students build up schema.

Although text significantly enhances English listening comprehension, learning without reviews is more difficult for learners to build up schema in long term memory. So, instructors who teach English listening are encouraged to provide teaching materials with double mode (simultaneous sound and text) for facilitating learners'

listening comprehension. After the listening class is over, instructors should provide review materials with single mode (sound only) for assisting students to build up schema.

English listening comprehension and cognitive load showed a significant negative correlation. Based on some relevant studies (Pawley et al., 2005; Paas et al., 2003), extraneous cognitive load can be lowered by appropriate instructional designs and learning activities. So, instructors should pay much attention to the impact of cognitive load because learners without unnecessary information in the working memory learn more efficiently.

The comparisons among single mode, double mode and triple mode, such as sound, text and image, with different learning environments, including traditional learning and multimedia digital learning, could be included in future studies. Also, the presentation modes of text can be further categorised into synchronisation and non-synchronisation to examine the effect of text presentation mode on learning performance and cognitive load. For cognitive load, extraneous cognitive load can be lowered by instructional design choices, so it is appropriate to be a dependent variable in the experiment. Therefore, the present study focused only on examining the effect of two different presentation modes on extraneous cognitive load. Intrinsic cognitive load and germane cognitive load could be considered as the other dependent variables in future studies.

Learners' prior knowledge or proficiency would be an important factor for determining an appropriate media presentation mode for learners (Chung, 2008). English proficiency was a covariance in the present study. Prior knowledge or learners' characteristics, such as learning styles and media preference, could be other independent variables in a future study. Furthermore, the interaction between learners' prior knowledge and media presentation mode and its effects on learning performance and cognitive load with two-way ANOVA are suggested for future research.

The ubiquitous learning activity in the present study was held outdoors, so for some students, listening comprehension would be influenced negatively by the crowd, weather or other external factors. Researchers could include holding outdoor learning activities on campus in the future research. If researchers conduct the learning activity in a public place, selection of a quiet day may be best, to minimise unexpected interruptions.

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Appendix 1: Item analysis for the listening test

Item	CR	Item-total correlation	Difficulty	Discrimination	Delete/Retain
1	5.186***	0.415**	0.662	0.465	Retain
2	4.317***	0.331**	0.811	0.336	Retain
3	3.784***	0.309**	0.194	0.292	Retain
4	2.956**	0.356**	0.509	0.303	Retain
5	4.241***	0.344**	0.517	0.413	Retain
6	3.186**	0.293**	0.779	0.272	Retain
7	1.538	0.173*	0.389	0.158	Delete
8	2.582*	0.195*	0.442	0.264	Retain
9	0.196	0.114	0.416	0.021	Delete
10	1.969	0.241**	0.579	0.205	Delete
11	3.654***	0.321**	0.586	0.361	Retain
12	2.934**	0.275**	0.218	0.245	Retain
13	1.693	0.182*	0.243	0.152	Delete
14	5.646***	0.463**	0.694	0.384	Retain
15	3.549**	0.287**	0.306	0.325	Retain
16	2.802**	0.241**	0.746	0.253	Retain
17	1.755	0.181*	0.299	0.169	Delete
18	4.779***	0.374**	0.414	0.448	Retain
19	1.178	0.133	0.244	0.108	Delete
20	2.116*	0.228**	0.443	0.220	Retain
Average			0.523	0.327	

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Appendix 2: Item analysis for the extended listening test

Item	CR	Item-total correlation	Difficulty	Discrimination	Delete/Retain
1	3.545**	0.349**	0.478	0.351	Retain
2	5.894***	0.535**	0.246	0.446	Retain
3	7.150***	0.522**	0.383	0.580	Retain
4	7.150***	0.498**	0.383	0.580	Retain
5	8.021***	0.542**	0.599	0.639	Retain
Average			0.418	0.519	

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Appendix 3: Item analysis for cognitive load rating scale

Item	CR	Item-total correlation	Delete/Retain
1	-2.986**	-0.371**	Retain
2	4.914***	0.477**	Retain
3	-3.719***	-0.370**	Retain
4	6.944***	0.494**	Retain
5	7.924***	0.548**	Retain
6	-2.710**	-0.304**	Retain
7	5.634***	0.454**	Retain
8	-4.887***	-0.407**	Retain
9	4.617***	0.293**	Retain
10	-2.970**	-0.354**	Retain
11	-2.826**	-0.267**	Retain
12	8.680***	0.551**	Retain
13	-5.413***	-0.483**	Retain

14	-2.404*	-0.323**	Retain
15	7.559***	0.584**	Retain
16	3.000**	0.291**	Retain

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Appendix 4: Factor analysis for cognitive load rating scale

Aspect	Original item	Current item	Eigenvalue	Total % of variance cumulative	Factor loading	Validity coefficient
Difficulty	1	15	2.294	57.343%	0.760	0.597
	2	2			0.764	0.551
	3	5			0.618	0.671
	4	12			0.629	0.616
Incompetence	5	4	2.247	56.175%	0.834	0.722
	6	7			0.780	0.776
	7	9			0.492	0.567
	8	16			0.824	0.699
Negative affect	9	3	2.683	67.066%	0.810	0.684
	10	1			0.793	0.672
	11	10			0.800	0.657
	12	6			0.796	0.663
Lack of effort	13	11	2.602	65.040%	0.804	0.703
	14	13			0.826	0.763
	15	14			0.648	0.519
	16	8			0.792	0.670
Overall			3.741	65.813%		

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