Chapter 11
Cognitive Load Theory, Redundancy Effect and Language Learning

Carlos Machado and Pedro Luis Luchini

Abstract When learners read a text they turn to an array of cognitive procedures to process information, mainly retrieving and storing new input which is often associated and connected with previous knowledge. To be able to process this information, they need to deploy and make use of a number of reading strategies to make sense of what they read. This chapter aims to investigate the extent to which the so-called redundancy effect influences the L2 reading comprehension skills of two groups of young learners with different proficiency levels in a middle school in Argentina. Both groups completed a reading comprehension task. The first group was exposed to a single mode of instruction—reading—while the other was presented with a twofold format which combined reading with listening. Results showed that the group which worked with the single mode of instruction obtained better scores than the other group. Based on these findings, the extent to which language proficiency compensates for or reduces the redundancy effect is analysed. Finally, some pedagogical implications for the teaching of L2 reading comprehension are discussed.

Keywords Reading comprehension · Cognition · Redundancy effect
Instruction

Introduction

ESL (English as a second) and EFL (English as a foreign) language instructors know that reading comprehension is a very important predictor for successful language learning. The process of comprehension involves the construction of a mental representation of a text (Kintsch, 1998; Zwaan & Radvansky, 1998). In this chapter, we do not intend to provide a model of the entire reading process, starting off with the focusing of the eye on the printed page and ending with the encoding of

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information into long-term semantic memory or its subsequent retrieval for purposes of demonstrating comprehension. However, we mean to focus on one specific aspect of comprehension relevant to reading comprehension. This aspect is related to how the reader's schemata, or knowledge already stored in memory, operates in the process of interpreting new information and allowing it to enter and become part of the knowledge store. Indeed, it is the interaction of new information with old knowledge that we mean when we use the term 'comprehension'. To lay fair claim to have comprehended a text means to say that we have found a mental storage for the information in the text, or worded differently, that we have altered an existing mental storage to provide room in our minds for that new information (Anderson & Pearson, 1984). As was said earlier, several simultaneous operations are involved in the comprehension process; lexical processes are required to access word meanings, memory retrieval is required to elaborate on the text and thus form connections to prior knowledge, and inference processes are crucial when it comes to integrating a sentence with prior ones and background knowledge (Moss, Schunn, Schneider, McNamara, & VanLehn, 2011).

Most human cognitive activity is driven by the contents of a huge long-term memory that functions as an information store. Some activities such as perceiving and identifying input and determining familiar problem-solving situations depend greatly on the contents of such long-term memory. Information is obtained from the long-term stores of other people by emulating what they do, listening to what they say, or reading what they write. Working memory, on the other hand, processes new information, and only a few elements of novel information can be processed in working memory simultaneously, resulting in a limited-capacity working memory (Diao, Chandler, & Sweller, 2007).

Cognitive load theory (henceforth, CLT) is concerned with relationships between working and long-term memory and the effects of those relationships on learning and problem solving. CLT has been used to generate many instructional procedures (Sweller, 2004; Sweller, Ayres, & Kalyuga, 2011) and has analysed phenomena like the redundancy effect (henceforth, RE) (Sweller et al., 2011). This effect occurs when the same information is presented to learners in different forms simultaneously (for example: read and listen). The act of having to pay attention to and match up spoken and written text at once slows down comprehension and turns out to be counterproductive if learning English is the ultimate goal (Diao et al., 2007; Machado & Luchini, 2013; Luchini, 2015; Luchini, Ferreiro, & González, 2016; Sweller et al., 2011; Tuero & Luchini, 2012a, b).

Contrary to these research findings, it is often the case that many ESL/EFL instructors use an explicit dual mode of presenting a text to teach L2 reading comprehension. In many reading comprehension lessons, most of the work teachers do implicitly assumes that spoken and written text should be presented jointly when students are learning to read comprehensibly. In cases like this, multiple instructional resources are often encouraged in language teaching to provide learners with rich linguistic knowledge. The belief underlying this common teaching practice is that the more integrative the presentation modes are, the more beneficial for learning they will be. However, CLT suggests otherwise. Instructional design that

pushes learners to divide their attention between multiple sources of information is ineffective for learning to happen. It follows then that information should be presented to students in ways that do not impose on them a heavy extraneous cognitive load; for example, presenting reading alone (Diao et al., 2007; Sweller et al., 2011).

Along these lines, the purpose of this chapter is to investigate and compare the effect of simultaneous presentations (read and listen) and single presentations (read only) on reading comprehension in L2 with two groups of young learners with different English proficiency levels. In the light of the results obtained, the extent to which language proficiency compensates for the so-called RE will be analysed and some of its pedagogical implications will be discussed.

Extensive Review

In recent decades there has been growing interest in the field of reading comprehension in a second/foreign language. In this scenario, comprehension cannot be reduced to a mere process of accessing word meanings and combining them; it is an undeniably more active and complex process as there are a number of interactive variables involved in it. When learners tackle a comprehension task, they must resort to several cognitive procedures to select information from discourse clues, and connect it to their existing knowledge located in long-term memory (Gao, 2012).

As we have seen, comprehension is not a simple process of accessing word meanings and then combining them. It involves the construction of a mental representation of a text as a result of intricate cognitive processes (Kintsch, 1998; Zwaan & Radvansky, 1998). Given this complexity, reading comprehension becomes a very important predictor for successful language learning because it subsumes the mental processes of learning, memory and problem solving (Graves, Juel, & Graves, 1998). And this complexity becomes ever greater when students have to read in L2 because of the interactive nature of variables and factors involved. Although many studies have been conducted to examine and illustrate the L2 reading strategies used by different learners in diverse contexts (Hosenfeld, 1977; Block, 1986, 1992; Sarig, 1987; Barnett, 1988; Carrell, 1989; Pritchard, 1990; Anderson, 1991; Raymond, 1993; Liontas, 1999; Young & Oxford, 1997; Schueller, 1999; Brantmeier, 2000), there has been some disparity in the research methods utilized across them, a fact that has made it difficult to formulate generalizations. Given this situation, there are still a certain number of limitations in their instructional implications.

As a whole, learner strategies are the cognitive steps learners follow to process L2 input. In general terms, these cognitive procedures include retrieving and storing new input (Brown, 1994). More specifically, reading strategies are the comprehension processes that readers use in order to make sense of what they read. This process may entail skimming, scanning, guessing, recognizing cognates and word families, reading for meaning, predicting, activating general knowledge, making

inferences, following references, and separating main ideas from secondary ideas (Barnett, 1988).

As was mentioned above, a plethora of studies have been conducted to investigate the comprehension strategies that L2 readers use to process a text. Disregarding the variety of research method used in the process of collecting data, all researchers engaged in similar tasks. The research processes generally involved some type of mental process of learning, memory and problem solving, and the tasks used to elicit and examine strategy type and frequency of strategy use were mostly think-aloud verbal protocols, interviews, questionnaires, observations and written recalls. The reading passages used to collect data often varied in content or topic, difficulty level, and text type or genre. In all, the studies varied in both text type and test type. Given the wide range of variability of participants, tasks and reading materials employed in them, it has thus become difficult to compare their results and make some generalizations (Brantmeier, 2002). It is evident, therefore, that much important research remains to be done in this area. Subsequently, generalizations could be made based on the synthesis of research done at different levels of instruction. We could directly model and teach the strategies that good readers use to comprehend their L2 reading materials grounded in empirical research. We could also teach students how to be active L2 readers by providing them with effective instructional materials that facilitate learning by directing cognitive resources towards activities that are relevant to learning rather than toward preliminaries to learning. Ineffective instruction, however, takes place when learners are required to mentally divide their attention to mutually referring information such as reading and listening to the same text simultaneously. This split-source information often generates a heavy cognitive load, because material must be mentally integrated before learning can start to happen (Chandler & Sweller, 1991).

Cognitive load can be understood as the burden that a task imposes on an individual's working memory (Gao, 2012). Cognitive load may be classified into two different types: *intrinsic* and *extrinsic*. Chandler and Sweller (1991) first defined intrinsic cognitive load as the inherent difficulty of learning material. It is important to highlight that it cannot be altered by any instructional means other than changing the task or the levels of knowledge held by learners (Sweller, 1994). On the other hand, extrinsic cognitive load is defined as an unproductive burden imposed on the cognitive system which results from learners investing cognitive resources on activities which are irrelevant to learning. Unlike intrinsic cognitive load, the extraneous one typically results from an inappropriate mode of instruction and can therefore be altered and even reduced if a more effective instructional procedure is employed (Gao, 2012).

CLT (Sweller, 2003, 2004; Sweller et al., 2011) has contributed to shedding some light on some phenomena known as the RE. The RE occurs when one source of presentation is redundant and should be eliminated to free working memory for efficient learning. That is, the RE takes place when the same information is presented to learners in different forms, requiring them to mentally coordinate multiple forms. On some occasions, the learners may need to translate one form into the

other to check that the two forms contain the same information (Diao et al., 2007). Presenting information to learners using a dual format forces them to synchronize psychologically the multiple forms and inflicts an extraneous cognitive load on them that may obstruct learning (Chandler & Sweller, 1991; Sweller, 2005; Sweller & Chandler, 1994).

In the ESL/EFL class, this effect may take place when the same information is presented to learners simultaneously through different modes of instruction (e.g. spoken and written). Sweller (2004) states that learning is inhibited when a written and spoken text containing the same information is presented concurrently rather than in written or spoken form alone. When learners are presented with the same information in a dual mode, they are required to mentally bring together the multiple forms. This manifold operation generates, as was said earlier, an extraneous cognitive load that impedes learning (Chandler & Sweller, 1991; Sweller, 2005; Sweller & Chandler, 1994).

Background to the Study

When learning to read in a foreign language, it is a common practice among EFL teachers and instructors to use an explicit dual mode to present a text. Indeed, many textbooks include the phrase "listen and read" every time there is a text. In many cases, it seems to be the 'textbook advice' to expose students to the same information using a dual format. However, as stated before, the effects of this manifold operation do not seem to be conducive to learning. Many studies based on CLT suggest that multiple forms of presenting information turn out to be counterproductive for comprehension purposes. In fact, it has been demonstrated that simultaneous reading and listening is less effective than just reading (Luchini, 2015; Luchini, Ferreiro, & González, 2016).

In a study carried out with a group of 30 students preparing to take the TOEFL (Test of English as a Foreign Language) exam at a private middle school in Mar del Plata, Argentina, Machado (2014) showed that there were significant differences in gain scores in a reading comprehension task across the two presentation modes of instruction. Examination of text comprehension scores indicated that learners exposed to the reading-only mode (group A) obtained better results than those in group B, exposed to the redundant mode of instruction (read and listen). That is, the students who only read the text were able to retrieve more main ideas than the other group which read and listened to the same material at the same time. In a similar study conducted with EFL trainees on a teacher training programme at a university in Mar del Plata, Argentina, similar results were obtained. In this investigation, two groups of university students were exposed to two different reading treatments: read only, and read and listen, and the group exposed to the reading-only treatment outperformed the other one.

In another experimental study, and using the CLT as the theoretical framework, Luchini, Ferreiro, and González (2016) also analysed the extent to which the RE influenced the L2 reading comprehension skills of a group of young learners in a private school in Mar del Plata, Argentina. A group of 24 Spanish-L1 speakers participated in the study. They were divided into two groups, A and B, and both completed the same reading comprehension task separately, but each used a different mode of presentation. Group A was exposed to a single mode of instruction, reading, while group B was presented with a dual format which integrated reading with listening. Both groups had the same amount of time on task. Results revealed that group A (non-redundant group) outperformed group B (redundant group). Once more these findings were consistent with the ones deployed by other investigations in similar contexts.

On similar grounds, Luchini and Ferreiro (2014) carried out another study in which they explored the effect of the RE on the L2 reading comprehension skills of another group of young learners taking a low-intermediate course in English in a local middle school in Mar del Plata, Argentina. The students were divided into two groups: A & B. Group A was exposed to a single mode of instruction (reading) and group B was given a multiple-format presentation (reading + listening). Data were gathered using a text that was carefully chosen to meet the students' age and English language proficiency level. After completing the reading task, both groups filled out a questionnaire, and five students from each group were interviewed separately. Using a mixed research design, qualitative and quantitative information coming from different instruments of data collection was cross-checked. Findings showed that group A scored better results than group B. Therefore, anchored in the CLT and based on results from previous experimental research and our own professional experience, the present research study was designed to analyse the effect of simultaneous presentations (read and listen) and single presentations (read only) on reading comprehension with learners who have different proficiency levels: students preparing to take the PET (preliminary English test, Cambridge Certificate Exams) and the FCE (First Certificate in English exam, Cambridge Certificate Exams), both international examinations administered by the University of Cambridge.

Purpose

The purpose of this study is twofold. On the one hand, we aim to determine whether dual modes of presenting the same information generate an RE when reading in English. On the other hand, we set out to determine the extent to which language proficiency can reduce or compensate for the possible RE. Finally, based on these results some recommendations will be given for the teaching of reading comprehension in the foreign language class.

Research Question

In this study, we will explore and compare the effects of simultaneous presentations with those coming from single modes of instruction. To do this, we will have two groups of students (divided into two subgroups) complete the same reading comprehension task, working under the two different treatments. The research question that will guide this study is as follows:

- In the case of EFL reading comprehension, does language proficiency reduce or compensate for the extraneous cognitive load generated when dual modes of presentation are used in the reading class?

Methodology and Materials

Participants

Participants were two groups of students preparing to take PET and FCE exams. The total number of students from both groups was 50. The PET group included 24 students aged 14–15. In the FCE group, there were 26 participants, ranging in age from 16 to 18. Both groups were divided into two equal subgroups: PET, group A and B; FCE, group A and B. The students were randomly selected. Each group completed a task separately and at different times. Group A was exposed to a single mode of instruction (reading), while group B was asked to read and listen to the same scripted text simultaneously.

Procedure

Data were gathered employing a full text of about 500 words. This text was drawn from a students' course book used for preparation for the PET test (Baker, 2010). This passage was deliberately selected from this source to guarantee that its linguistic complexity and its length would not become an internal factor that would eventually threaten the validity of the study.

Three evaluators segmented the text into main and secondary ideas. Initially, two evaluators worked together to spot the main ideas. Then, a third intervened to cross-check their findings. Inter-marker rating and agreement was used. In cases of discrepancy between the raters, the three evaluators, working jointly, discussed them until they reached a common consensus. A total of nine main ideas were identified.

The text was broken into five different paragraphs, each similar in length (approximately 100 words). These paragraphs were shown to the learners on five

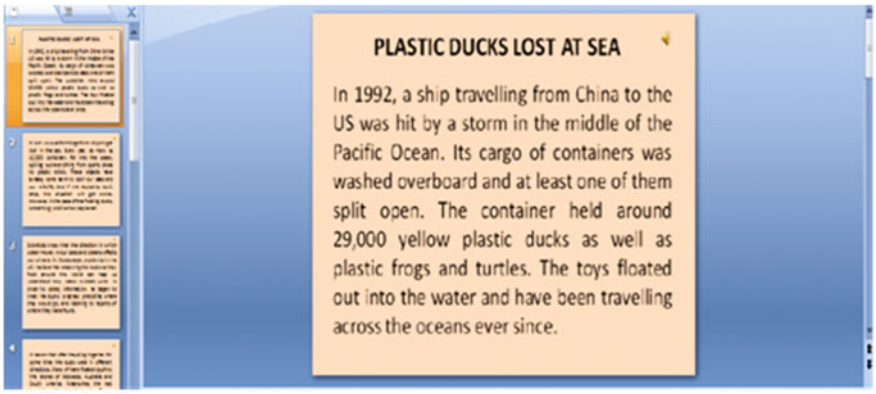

Fig. 11.1 First slide shown to both groups

successive PowerPoint slides. Each slide was held on display for about 30 s. Learners were not allowed to control the pacing of the slides. The time allotted for learners to read each slide was calculated taking into account a pilot experience carried out by their teacher, prior to data collection, in which the average time it took learners to read and understand excerpts of a similar linguistic complexity and length was measured.

Group A was asked to read the narration on slides, while group B was presented with the audio narration along with a synchronized redundant on-screen text. The slide presentation was shown to both groups individually in two consecutive turns. Right after the reading/listening tasks, the learners were asked to write a summary of what they had read, containing as much information as they could retrieve. They could choose to write their ideas in L1 or L2, to facilitate the expression of their ideas.

Figure 11.1 shows the first slide shown to the learners, containing the opening fragment.

Results

The ideas included in students' free recall procedures (A: read; B: read and listen) were then analysed following the set of nine main ideas selected by raters. These ideas were used as 'master ratings' to analyse the students' written texts and evaluate their productions.

In the PET group, the students exposed to the reading-only treatment (group A) identified 51 main ideas out of a total number of 108, whereas group B spotted a total number of 32 main ideas. In the FCE group the students exposed to the reading-only treatment identified 78 main ideas, whereas the learners presented with the dual mode of instruction spotted a total number of 54 main ideas. Table 11.1

Table 11.1 Students and main ideas retrieved

Group A: reading only		Group B: read and listen	
Participants	Main ideas	Participants	Main ideas
Student 1	6	Student 1	6
Student 2	2	Student 2	6
Student 3	6	Student 3	1
Student 4	4	Student 4	5
Student 5	4	Student 5	2
Student 6	4	Student 6	4
Student 7	3	Student 7	0
Student 8	7	Student 8	0
Student 9	6	Student 9	2
Student 10	5	Student 10	1
Student 11	2	Student 11	3
Student 12	2	Student 12	2
Total	51	Total	32

shows the number of students in each group and main ideas retrieved by each student in each group.

Examination of text comprehension scores indicated that those learners who were exposed to the reading-only treatment obtained better results than those exposed to the redundant mode of instruction. On applying the ratio suggested (9 main ideas, 12 and 13 students per group), the analysis of media indicates that, in both groups, the ones exposed to the reading-only treatment (subgroups A) were able to retrieve more main ideas than the students in subgroups B (exposed to a dual format) (see Table 11.1).

Although looking at media scores may show a difference, that information does not tell us if the difference is reliable. To check whether the average of the two means is reliably different from each other, we decided to run an unpaired *T*-test. The value for *p* (two tails) is 0.06. Because the *p* value is greater than 0.05, we can then say that the average of these two means is statistically significant (see Table 11.2).

Table 11.2 also reveals a difference between means when comparing scores between the FCE subgroups A and B. Results show that this difference favours considerably group A, which was exposed to the single mode of instruction. In much the same was as we did with the PET group, we also ran an unpaired *T*-test to verify the reliability of this difference (see Table 11.3).

The *T*-test showed that the *p* value is 2.53. Once more, as this value is much higher than 0.05, we may claim that the difference between the means for these subgroups is statistically significant.

Table 11.2 *T*-test for the PET group

	Group A	Group B
Media	4.25	2.66
Variance	3.11	4.6
Number of participants	12	12
Hypothetic diff. between means	0	
Degree of freedom	21	
Statistic 1	1.97	
$P(T \leq t)$ one tail	0.03	
Critical value of T (one tail)	1.72	
$P(T \leq t)$ two tails	**0.06**	
Critical value of T (two tails)	2.07	

Table 11.3 *T*-test for the FCE group

	Group A	Group B
Media	6	3.92
Variance	1.16	0.91
Number of participants	13	13
Hypothetic diff. between means	0	
Degree of freedom	24	
Statistic 1	5.19	
$P(T \leq t)$ one tail	1.26	
Critical value of T (one tail)	1.71	
$P(T \leq t)$ two tails	**2.53**	
Critical value of T (two tails)	2.06	

Conclusions

In our research question, we wondered whether English language proficiency could reduce or compensate for the extraneous cognitive load generated when dual modes of presentation were used in the reading comprehension class. The results of this experiment revealed that those learners who were exposed to the reading-only treatment obtained better results than those who read and listened to the same text at the same time. In both groups, a single mode of instruction decreased the RE and seemed to facilitate reading comprehension skills.

In the FCE group, where all students read a text which was not highly challenging for them as it was relatively below their proficiency level, the students from group A (read only) outperformed the students from group B (read and listen). Once again, it seems that an instructional design that integrates a dual mode of instruction imposes an extraneous cognitive load that manifestly obstructs reading comprehension, regardless of students' linguistic proficiency level.

This last claim may contradict some SLA (second language acquisition) theories which foster the use of multiple presentations. When, with the aim of fostering

overall comprehension, the same text is presented using two different modes of instruction, learners are pushed to activate two different channels simultaneously to process the same information and to build up referential network connections (Sweller, 2005).

Decoding an L2 text using one sole mode of instruction already implies a demanding cognitive load over working memory. It is very unlikely that L2 learners will have sufficient working memory capacity to be able to handle a dual mode of instruction that involves reading and listening simultaneously, as this implies competition between resources in working memory. As experts in the field of CLT have pointed out, when a text containing the same information is presented simultaneously in written and spoken form, students are immersed in a manifold operation which generates an extraneous cognitive load that hinders comprehension (Sweller et al., 2011; Sweller, 2005; Sweller & Chandler, 1994).

Some Pedagogical Implications

Although small-scale, the present study has some practical pedagogical implications. It suggests, first, that teachers and material designers should appraise their work in ways that reduce learners' extraneous or unnecessary cognitive load, so as to facilitate comprehension. Along these lines, a set of numerous steps could be taken in the foreign language reading comprehension class to foster learning. Teachers should reconsider the impact of the RE on the reading aloud of instructions.

A popular belief among language teachers points out that reading instructions aloud, along with their students, will facilitate reading comprehension. Another common practice that reinforces the RE consists in teachers reading out loud a passage along with their students who are later required to explain, in their own words, what they have understood. In some other cases, teachers often appoint one student to read aloud a text while the rest of the class does it silently. Once the reading stage is over, one of them is asked to reconstruct what they have understood. Certainly such practice is not conducive to learning (Luchini, 2015).

As shown in this and in previous studies, the RE affects EFL learners no matter what their command of the language may be. It is not a question of how each individual student tackles the reading task at hand, but rather of the extent to which a dual mode of instruction may thwart the reading comprehension process, imposing on students a heavy cognitive load.

We are confident that this study, along with some others in the area, will serve as a trigger to open new doors and raise ESL/EFL teachers' and researchers' motivation and interest to keep on investigating the impact that the RE has in their students' reading comprehension process.

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