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# Linking Multimedia Vocabulary CALL Research to SLA Cognitive Theories

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**Abstract** Researchers in the field of computer-assisted language learning (CALL) have been focusing on vocabulary - alongside grammar - more than other language areas and skills [22]. Vocabulary learning has attracted instructional designers and has led to the introduction of a wide range of technologies including courseware, dictionaries, online activities, corpora and concordancing, and computer-mediated communication technologies [38]. To investigate whether the design of these digital resources was theoretically grounded, this paper presents a review of experimental studies on vocabulary CALL for second language learners. In order to inform the future e-learning design, this review aims to explore the most striking SLA cognitive theories - if any - to which designers of multimedia vocabulary CALL drew their interventions. It has been found that most of the previous studies focused on employing multimedia technology on strengthening the link between the form of a word and its meaning with no emphasis on aspects of the word knowledge beyond that. Moreover, for the informants in this review, the design of the intentional language-focused vocabulary CALL software as well as the incidental meaning-focused ones has not been found to effectively operationalise SLA cognitive theories.

***Keywords:*** *multimedia, computer-assisted language learning, vocabulary acquisition, cognitive theory of learning*

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## 1. Introduction

In order to explain second language acquisition, it is important to know how it interacts with other cognitive processes. Cognitive theories of learning see second language acquisition as a cognitive skill that is acquired by the engagement of different cognitive systems like perception, memory and information processing. Just as when acquiring other skills, the learning process has to be designed to overcome the mental capacity limits that may hinder the performance [11].

A learner's internal cognitive tools collaborate with instructional technology in constructing his knowledge [17]. Thus to achieve better language learning outcomes, we should concern ourselves with developing technological tools which display activities that facilitate cognitive processes. In support of Clark and Mayer [7], I believe that new technologies have to be compatible with our cognitive learning process to support learning rather than hinder it. Instructional designers should not be overly concerned about advanced technology features to the extent that they ignore human mental abilities. The most crucial factor in designing an effective e-learning program is supporting human cognitive learning processes, rather than attempting to beat it [7].

The use of multimedia to enhance second language vocabulary learning has developed in recent decades. In fact, the term "multimedia" has very different meanings according to the context in which it is used. In a phone company, for instance, the consumer entertainment vendor might think of it as a cable-TV-like package provided over high-speed internet connection, or an interactive TV that shows thousands of digital channels. In a computer company, on the other hand, a laptop with an advanced sound capability and super multimedia-enabled microprocessors might come to the mind of a hardware vendor when he thinks of multimedia. In educational environments, instructional designers have a more application-oriented view of multimedia which involves applications that are designed using multiple modalities consisting of text, images, drawings, graphics, animation, video, and sound in various interactive ways. This is in contrast to the media that uses traditional printed materials and computer displays with only simple text-only contents. However, multimedia is not about mixing those materials simply together; rather, it places greater emphasis on integrating them with rich interactions amongst the materials, as well as such interactions between the materials and human beings [24].

## 2. Literature Review

Technologies have been employed to link the learner in the vocabulary CALL environments to dictionaries, using simple hyperlinks. This function is programmed in software such as WordChamp to present a standard definition, a pronunciation of the word, and its translation. Advanced features of more recent technologies, then, made it possible for the designers to expand the contents of the glosses by offering additional multimedia annotations such as pictures and videos to illustrate the word.

Discrete-point activities are also a type of technologies which has been used in the field of vocabulary CALL. One of the common examples of online activities is Hot Potatoes, a software that provides the learners with six vocabulary and grammar tutorial activities [22]. AntLap is another example of an online website that goes beyond simple activities and provides systematic recycling to enhance the vocabulary retrieval.

Computer-based lexical databases are also being developed derived on conceptual-semantic and lexical relations. WordNet, for example, is an online thesaurus that groups words together based on their meanings. The first version of WordNet was released in 1991 and at the end of 2007 the third update was made available. Words are mainly interlinked by means of semantic relations (such as IS-A-KIND-OF, IS-A-PART-OF, IS-AN-ANTONYM-OF and ENTAILS) which assembles WordNet into a huge network of linguistic nodes [26].

Another piece of technology that has been used to teach vocabulary is a concordance. A concordance consists of a list of contexts showing how the word is used, and can provide the learner with a vast amount of word knowledge. Reference [8]'s website (Lextutor) contains an online concordance that provides information of a word such as its collocates, grammatical pattern, related meanings and homonyms. In an experimental study, reference [8] found that learners who used the concordance scored higher in vocabulary quizzes than those who didn't.

Computer-mediated communication technologies enabled open learning that supports communicative learning. One striking example is the French Learner's Workbench, a hypermedia French language learning system [16]. The system integrated a collection of modules and packages. Among these packages is Dicologique, a dictionary that presents rich information for the study of French. It consists of 105,000 words and phrases and 20,000 notions which can enter into semantic relations. The learner can see the entry item in its position in the semantic field and infer its meaning [16].

Although a variety of technologies have been produced so far, research on the field of vocabulary CALL has been mostly restricted to limited comparisons of the effect of different annotations such as texts, pictures and videos. Researchers have started investigating the impact of these annotations in different gloss types for incidental vocabulary learning [1,2,3,4,5,6,18,19,21,33,39,40] and investigating the effects of multimedia in intentional communication of the meaning of lexical items via two modes: verbal and visual [9,12,20,35]. These studies moved away from comparing vocabulary CALL with non-CALL interventions. However, the majority of vocabulary CALL studies did not draw on SLA theory and only a limited amount of research used CALL environments that operationalise and test SLA theory [38].

Through a comprehensive examination and updating to systematic reviews of research on vocabulary CALL for primary and secondary ESL and EFL, reference [15] found that out of all the published research between 2004 and 2013, only six studies drew on SLA theory and current research at that time [15]. With regards to studies that focused on introducing vocabulary through different modalities as intentional language-focused learning, Handley found that only one study - that of reference [20] - related to SLA theory, in particular, Mayer's cognitive theory of multimedia learning [25].

Cognitive theory of multimedia learning is the theory that joins cognitive load theory [36] and dual coding theory [31]. These theories are the most striking SLA theories to which designers of vocabulary CALL have drawn to in their design of the instructional software used in their studies or even when they explain and discuss the results of their studies. Therefore, it is important to briefly revise these three theories before examining in depth examples of those few studies that were linked to them.

*Cognitive load theory:*

Based on this idea of limited capacity of both visual and auditory channels, reference [37] proposed the cognitive load theory, where he suggested that information which is presented via instructional design must be guided in a manner that does not impose a heavy load on working memory. Following the notion that working memory load should be decreased to encourage more schema construction, cognitive load theory has aimed at offering guidelines to insure the ease with which information is processed [36]. According to this theory, the load could be intrinsic (by the intrinsic nature of the material) or extraneous (by the manner of presenting the material), and is determined by the instructional design [36]. Sweller argued that since many instructional procedures and designs used were not designed with respect to working memory limitations, they are insufficient [36].

*Dual-coding theory:*

According to dual-coding theory, we use two main codes to represent information in our minds, pictorial and verbal [31]. Educational propositions of this theory are consistent with the historical trend of knowledge construction through pictures and imagery [32]. The dual coding effect on memory has been approved in several experiments [29,30]. In congruence with what Paivio posited in his theory, Nation [28] asserted that connecting the meaning of lexical items directly to real objects such as visual aids, is a strategy that is used widely by beginners. He also viewed it as a procedure that helped them to know the word and at the same time works as a cue for remembering it. These activities had a greater effect if complemented by, for instance, a verbal definition. Such situation would not only decrease the possibility of wrong guessing, but also result in 'dual encoding', i.e. visual and linguistic storing of information [28].

*Cognitive theory of Multimedia learning:*

The cognitive theory of multimedia learning combined the cognitive load theory and dual coding theory and maintains that three cognitive science principles form the basis of the theory: dual-channel assumption (pictorial and verbal processing of information); limited capacity assumption (both channels have limited span); and active processing assumption (coordinating sets of processes) [25]. That is, when a multimedia lesson is presented to a learner, he receives pictorial and verbal information into his cognitive system through both the visual and the auditory modalities. When the learner pays attention to the materials shown, they will enter his working memory for more processing. There, the learner mentally organises these materials into pictorial models or verbal models. Finally, these materials will be integrated with existing knowledge from the long-term memory. Engaging in such cognitive processes in multimedia environments would lead to effective learning [7].

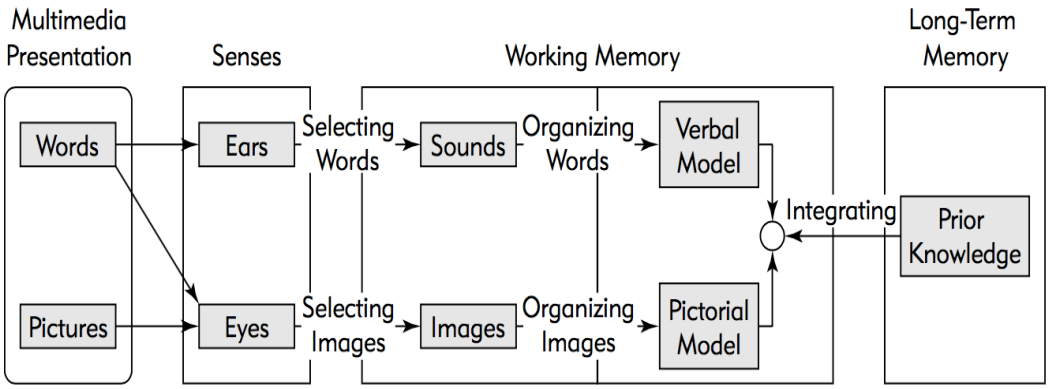


**Figure 1.** Mayer's [25] Cognitive Theory of Multimedia Learning

With respect to the contribution of CALL to vocabulary learning and teaching and specifically those who employ multimedia to communicate a word meaning via different modes whether intentionally or incidentally, the majority of previous studies are limited in terms of providing insight into our understanding of SLA and without relating their research to the SLA theories mentioned previously. This can be demonstrated in the discussions on the multimedia studies on language-focused vocabulary CALL that follows.

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## 2.1. Previous Multimedia Studies on Intentional Language-focused Vocabulary CALL

Intentional vocabulary learning refers to the deliberate acquisition of vocabulary when giving explicit attention to the lexical item for the purpose of learning it. Studies regarding such vocabulary CALL have been very few.

Reference [9] taught Russian vocabulary to 60 French learners in their first to sixth year at the University of Grenoble and found that the co-referencing of the different annotations of the word such as the sound, image and written form enhanced memorisation considerably. Learners who had zero knowledge about Russian were divided into four experimental groups (see Figure 2). Students in the first group (P1) were presented with (L2-L1) words. An illustrated image was added in the case of P2, while a pronounced example sentence and a written sentence were added in the case of P3 and P4 respectively. All the learners could hear the word in each of the experiment groups. Results showed that P3 and P4 were significantly better in word memorization than P1 and P2. The researchers explained these results by stating that the use of extra information given about a word by providing the learners with the spoken form (P3) and the use of the word (P4) reduced the cognitive load that was experienced in P2 as it split the learner's attention and destructed him or her by making extra semantic processing.

Reference [20] investigated the use of different multimedia components in teaching English vocabulary to Korean students. In a web-based program, the researchers compared between visual texts, spoken texts, and graphics in communicating the meaning of the target words. The study was designed to explore the effects of six methods of multimedia in a Web-based self-instructional software: visual text (Group A), visual text and added spoken text (Group B), visual text, and added graphics (Group C), visual text, added graphics, and added spoken text (Group D), reduced visual text and added spoken text (Group E), and reduced visual text, added graphics, and added spoken text (Group F). 172 14-year students participated in the study and completed a pre-test, a post-test, a retention test, as well as an attitude inventory. The results of the study revealed findings that were consistent with the multimedia principle of the cognitive theory of multimedia learning. That is, adding a picture to a textual item leads to more effective learning of a word. However, one distinct criticism of this study, was that the participants were not separated equally into the six groups (e.g. 43 students in group A and 22 students in group B) because of the lack of audio facilities associated with the computers in the classroom. Other limitations regarding the design of the software of this study are in common with the next study and will be discussed below.

Another example of studies that employed multimedia to represent the meaning of vocabulary as intentional language-focused learning programs is that of Reference [35]. In her Voka - a flash card multimedia software, the researcher used different multimedia combinations to teach learners of L2 German vocabulary. 72 participants were separated into five groups in which they either received a picture and a gloss of example sentence (PG), a definition and a gloss (DG), a picture and audio pronunciation (PA), a definition and audio (DA), or a picture, audio, gloss and definition (PAGD). In addition to the specific multimedia combination of each group, all participants received a translation and example sentence of the word. Results of the immediate post-test showed that learners in groups that provided pictorial annotations significantly outperformed learners in other groups. However, these differences were no longer apparent in the delayed post-test, which revealed an equal effect of all types of multimedia combinations. Although Rimrott's study drew on cognitive theory of multimedia learning as mentioned above, it failed to explain the decrease in the effect of pictorial representations used in Voka.

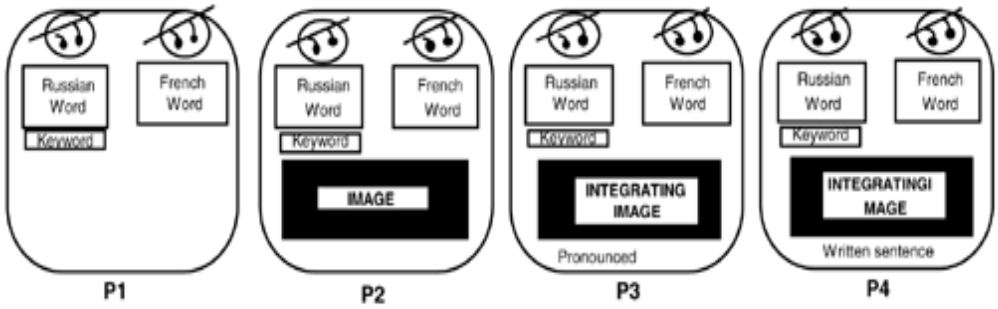


**Figure 2.** Material used in the experiment [9]

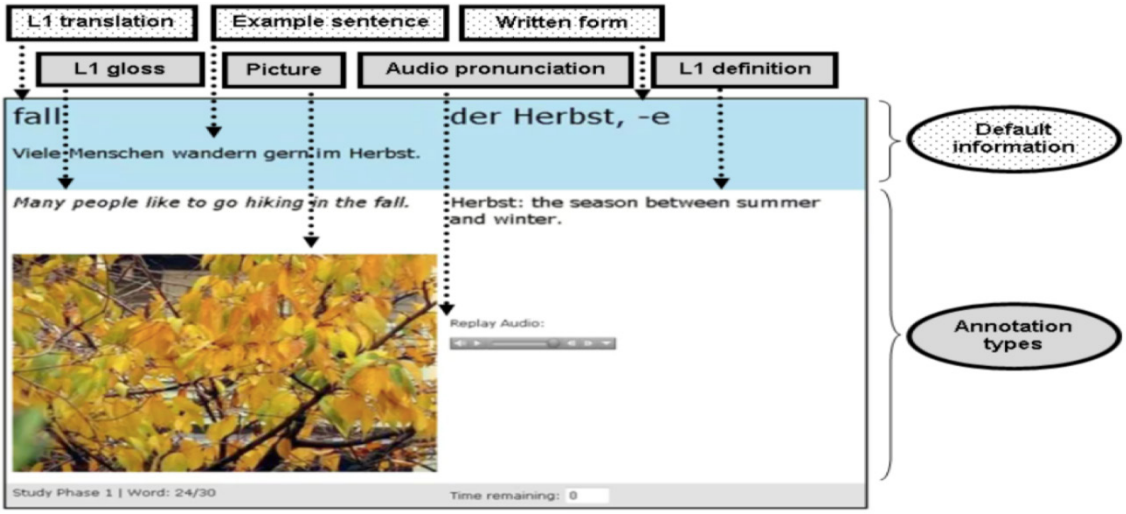


**Figure 3.** Labelled Voka flashcard of target word Herbst (fall) [35]

Figure 3 presents a screenshot of a flashcard in Voka that shows all types of annotations to the German word 'Herbst', which means 'fall'. One striking weakness of the software is that it fails to take the multimedia design principles into account. This appears clearly in the disruption of the elements on the screen as well as the random variations in the size and type of the font. Moreover, when much information presented randomly together in this way, there is a greater chance that it could cause cognitive overload to the user. Consequently, the learner could avoid reading much information presented in small-size texts by focussing attention at the large photo - an item which would more likely grasp his or her attention. This could explain the temporary effect of pictorial annotations found in this study.

The representation of all the information in the display, as the researcher explained, was to consider the interaction of form, meaning, and use aspects of word knowledge. Although this is a recommended procedure in teaching vocabulary and suggested by linguists, such as reference [27] it may have been improved by splitting the representation into different slides rather than challenging the learner's working memory when gathering all this information in one slide.

## 2.2. Previous Multimedia Studies on Incidental Meaning-focused input Vocabulary CALL

Incidental vocabulary learning is the non-deliberate learning of vocabulary that occurs when learners are performing another task such as communication, reading or listening. In such environments, a number of researchers examined vocabulary annotations as part of reading second language texts [2,3,6,33,34,39,40]. Other researchers [18,19] investigated the effect of different vocabulary annotations on vocabulary acquisition while listening to passages in the target language. One of the striking findings of these studies is that communicating the meaning of a word through verbal and pictorial annotations leads to better learning than presenting either one of the two annotations; findings that have often been related to Paivio's [31] dual-coding theory.

For instance, reference [6] conducted a study using *CyberBuch*, a hypermedia application for reading German texts, where they compared the effects of different annotations for acquiring words during reading. 160 university student participants were divided into three experimental groups. Learners in the first group received a definition of the word. In the second group, learners received a definition and a picture of the word. In the last group, learners received a definition and a short video. Results revealed that learners who were given a definition with a picture significantly outperformed the learners of the groups with video and definition or definition only.

In a computer reading environment, reference [41] confirmed the results of a non-CALL study conducted by reference [21] which showed significant differences of picture and text annotations and that this combination was better than the picture only or text only glosses. 151 ESL students read a text of 392 words and received 20 words glosses of text only, picture only, or text and picture

annotations. Results of the immediate and delayed vocabulary tests, which consisted of both production and recognition tasks, revealed that the performance was the best when learners receive a combination of picture and text glosses.

Reference [33] obtained results supporting the multiple annotation representation as they found significant effects of presenting multiple annotations on vocabulary acquisition. In their study of 103 participants, reading comprehension of passages was found to be improved if new vocabulary was annotated with both verbal input and images rather than with only one of them.

Similar results were found by reference [34]. English-speaking college students (152 participants) enrolled in a German reading course. Participants received no annotation, written annotations, pictorial annotation, or both when reading a story presented via a multimedia program. Learners in the multiple annotation group (written and pictorial) achieved higher scores than any of the other groups.

Reference [39] also explored the impacts of these type of vocabulary annotations on vocabulary learning during reading a passage. 83 EFL college students in Taiwan were presented with a passage about Thanksgiving in courseware with colour-coded novel words. When the learner clicks on a word, a pop-up window shows either text only, text and picture, or text and picture with aural annotation. Results of the study revealed that the presence of text along with the picture was the most effective.

In a within-subject design, reference [3] investigated the effects of different vocabulary annotations presented in a reading passage within a interactive multimedia program. ESL collage students at the university of Pittsburg (30 participants) were reading an English narrative text with annotations for target words through different modes: text, graphics, video and sound. In the immediate post-test, he found that the use of video clips was more effective in vocabulary learning than a still picture.

Reference [40] conducted a study in which 195 students from two universities in Japan participated in learning English vocabulary. The learners were presented with glosses of unfamiliar words while reading a passage within a multimedia learning environment. Different annotations were presented in each condition: a translation, a definition, a picture and a translation, or a picture and a definition. In the productive recall test, learners of the groups involving multiple annotations outperformed the others in the single annotation groups. However, there were no significant differences in the productive post-test between the learners' scores among all the groups.

Reference [19]'s study expanded upon research that looked into the effects of learners' cognitive abilities on L2 reading and listening abilities, including vocabulary acquisition in multimedia environments [6,33,34]. In particular, Jones investigated the effects of spatial and verbal abilities with vocabulary learning within a listening task. 171 French English-speaking students participated in the study and were categorised into either high spatial ability (87 students) or low spatial ability (84), and either high verbal ability (92), or low verbal ability (79) based on the score from the Kit of Factor- Referenced Cognitive Tests (Ekstrom, French & Harmon, 1976). Software developed using Adobe Premiere 4.2 (Adobe, 1994) and Authorware 4.0 (Macromedia, 1997) was used to present 27 key-words of different parts of speech during a listening task. The learners were then separated into four groups: In group 1, students could see the L2 key word and could only hear it if they clicked on the L2 key word (no annotations). Similarly, in group 2, students could see L1 translation, in addition to viewing its L2 written and spoken form (written annotations). In group 3, students could view a picture annotation (pictorial annotations). In group 4, students could see the target word, in addition to the ability to view any of all the previous annotations (pictorial and written annotations) (see Figure 4).


**Figure 4.** Screenshot of French Listening Comprehension Materials: Pictorial and Written Annotations Treatment [6].

**Table 1. Previous studies focused on employing multimedia technology on strengthening the link between the form of a word and its meaning**

| Study | Type of learning |
|---|---|
| Dubois and Vial (2000) | intentional language-focused vocabulary CALL |
| Kim and Gilman (2008) | intentional language-focused vocabulary CALL |
| Rimrott (2010) | intentional language-focused vocabulary CALL |
| Fagehi (2013) | intentional language-focused vocabulary CALL |
| Akbulut (2007) | incidental meaning-focused input vocabulary CALL |
| Al-Seghayer (2001) | incidental meaning-focused input vocabulary CALL |
| Chun & Plass (1996) | incidental meaning-focused input vocabulary CALL |
| Jones & Plass (2002) | incidental meaning-focused input vocabulary CALL |
| Jones (2009) | incidental meaning-focused input vocabulary CALL |
| Plass et al. (1998) | incidental meaning-focused input vocabulary CALL |
| Plass et al. (2003) | incidental meaning-focused input vocabulary CALL |
| Yeh and wang (2003) | incidental meaning-focused input vocabulary CALL |
| Yoshii & Flaitz (2002) | incidental meaning-focused input vocabulary CALL |
| Yoshii (2006) | incidental meaning-focused input vocabulary CALL |

Students had a pre-test, an immediate post-test, and a delayed post-test in vocabulary recognition and recall protocol comprehension. The vocabulary recognition immediate post-test results revealed significant effects in the case of pictorial annotations with no significant effects in the case of spatial abilities. With regards to the verbal abilities, high verbal ability learners within the second and third treatments outperformed low verbal ability learners within the immediate post-test when only pictorial or written annotations alone were presented. However, low verbal learners within the fourth treatment - where they could view all the annotations - outperformed high verbal ability learners. Among high verbal ability learners, group 1 learners who had no annotations performed significantly lower than learners of the other groups. Among low verbal ability learners, group 4 learners - who could view all the annotations - outperformed learners within the other treatments. A delayed vocabulary recognition test revealed the same results. The researcher concluded the study by relating its results to the cognitive theory of multimedia learning; however no clear or full explanation of why spatial abilities did not interact with multimedia annotations - as shown in the vocabulary recognition tests - was provided.

## 3. Conclusion

From the aforementioned discussion on the literature and through drawing on findings of the multimedia vocabulary CALL experimental studies mentioned, it can be concluded that the majority of the previous studies (see Table 1) focused on assessing the impact of technology on strengthening the connection between the form of a word and its meaning (mainly comparing between different verbal and pictorial annotations). Additionally, most of the intentional language-focused vocabulary learning interventions had not been employed to present and practice other aspects of word knowledge beyond form-meaning connections. Moreover, it can be concluded from this review that multimedia vocabulary CALL software has not been effectively employed in operationalising SLA cognitive theories. It is, therefore, recommended that future e-learning designs should be persuasively drawn to SLA research, to better achieve the aim of relating the effect of CALL research on vocabulary learning, and in turn, better inform SLA theories.

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