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A TEMPLATE TO GENERATE HYPERTEXT AND HYPERMEDIA READING MATERIALS: ITS DESIGN AND ASSOCIATED RESEARCH FINDINGS

Robert Ariew
University of Arizona

Abstract

This article describes the design and use of a software template to generate hypermedia texts for use by foreign and second language students. The original purpose of the template was to generate teaching materials and to provide an easy way to display target or native language annotations of all kinds, including text, graphics, audio recordings and video as needed to illustrate the meaning of the text. Subsequently, the template was used to conduct research into reading behavior, reading comprehension and vocabulary retention.

Why one should develop a template for reading? How does one rationalize its use with students? In what way does it help students? These questions are discussed in the following sections. Issues dealing with models of reading comprehension are also discussed, as are the Mental Effort Hypothesis and Dual Coding Theory. Also addressed is how have reading templates of this kind been used to conduct research involving hypermedia? What are the findings of this research? A short literature review is presented. The template and studies that have made use of it along with research findings of these studies are discussed.

Background

Models of Reading

Interpreting a text, according to current models of reading, involves both bottom-up and top-down reading processes. Reading proceeds efficiently when the reader successfully coordinates these processes (Kintsch & Van Dijk, 1978; Rumelhart, 1977). Bottom-up skills involve knowledge of the language to interpret lexical and syntactic structures. They involve decoding the written symbols, starting with smaller segments, syllables and words, and proceeding to larger units, clauses, sentences, and paragraphs. Top-down processes, on the other hand, refer to how readers use their own experience and background knowledge to understand the text. For example, top-down processes involve using previous knowledge, making predictions, interpreting assumptions, and drawing inferences. Those readers simultaneously employing both processes are said to be efficient readers with good reading skills.

Bernhardt (1991), in an interactive model of L2 reading, posits that five factors have a facilitating effect on L2 reading comprehension. These are fluent word recognition, familiar text structure, appropriately used background knowledge, and knowledge of syntactic and

phonographemic features. In addition, metacognitive reading strategies are important to Bernhardt's model, and are considered an individual learner characteristic.

A certain amount of language proficiency is necessary to read effectively and to employ background knowledge and reading strategies (Devine, 1988). Those readers with limited language proficiency may resort to using poor reading strategies and become text-bound readers who mainly decode text (Clarke, 1988). On the other hand, these same readers may become knowledge-bound readers (Carell, 1988), who over-rely on background knowledge to compensate for their lack of language proficiency.

The Mental Effort Hypothesis

In the area of vocabulary learning, the debate centers around the issue of incidental vocabulary learning versus explicit learning. There are, of course, adherents to both sides of the debate. Incidental learning proponents maintain that learners are able to acquire vocabulary through exposure to words in meaningful contexts, such as in extensive reading situations. Incidental vocabulary acquisition is said to happen without a conscious effort, as a consequence of accomplishing a tangential task such as reading for pleasure (Laufer & Hulstijn, 2001). However, incidental learning is slow because students typically do not pay attention to unfamiliar words, do not notice them, may regard the new words as unimportant, may not be exposed to enough repetitions of the new words to learn them, or may not retain the meaning of the word in any case (Hulstijn, Hollander, & Greidanus, 1996; Rott, Williams, & Cameron, 2002). It has been proposed that if more processing cost is involved, as when readers make a concerted effort to be exposed to words, vocabulary retention is better (Laufer & Hulstijn, 2001; Rott, Williams, & Cameron, 2002). The Mental Effort Hypothesis proposes that new information goes into long-term memory depending on the amount of processing required when the word was encountered. If there is minimal effort and minimal processing, then the word is more likely not to be stored in long-term memory and is also likely not to be acquired.

It is thought that the use of hypertext and hypermedia glosses, by providing information about words and expressions and by requiring some effort on the part of the reader, may promote incidental vocabulary learning. The hypermedia glosses thus play a multiple role. They provide assistance with understanding the text through enhancement, ask for effort in selecting the information, and allow the reader to notice the information provided. Otherwise, the reader may ignore the new words or make incorrect inferences about their meaning.

Dual Coding Theory and Multimedia Learning Theory

Among the theoretical frameworks from the area of multimedia, Paivio's (1990) Dual Coding Theory and Mayer's (2001) Generative Theory of multimedia learning provide rationales about how learning from multiple symbol systems occurs, also known as "multimodal learning" (Mayer, 2001, p. 41). Mayer suggests that verbal and visual information are accessed separately for verbal and visual representations in short-term memory. The two representations, the verbally-based model and visually-based model, are reorganized into a coherent whole in working memory. When verbal and visual input are provided such as through a multimedia presentation, the learner selects relevant information, words, and images, and organizes them separately into verbal and pictorial models. Then, connections are established between the two models to form a coherent mental structure. The words in the verbal model provide discrete

information, linearly, while pictures in the other model provide holistic and nonlinear information. These two models are qualitatively different and complement each other. When the two models are integrated into the familiar knowledge structures already in memory, learning takes place. Connections between the corresponding portions of the verbal and visual models are established with the help of the learner's prior knowledge. Mayer contends that learning in multimedia environments is facilitated when the information is presented through the verbal and pictorial channels in a way that does not overload the working memory. From this perspective, reading comprehension can be facilitated by integrating both verbal and visual information in a hypermedia environment.

Mayer (2001) proposes a cognitive theory of multimedia learning that rationalizes the process of learning from verbal and visual input. The theory, which makes use of Dual Coding Theory and Cognitive Load Theory, includes three main assumptions. The first assumption, *dual channels*, posits that visual and verbal information are processed in separate channels. However, through interaction between the two channels, information in one channel may be transferred to the other. The second assumption, *limited capacity*, suggests that each channel has a limited capacity. Finally, the third assumption, *active processing*, suggests that learners are actively involved in the construction of knowledge.

Few studies have investigated the effectiveness of multimodal information in L2 learning. Mayer's (2001) evidence is based on studies conducted with native speakers of English, in an L1 situation. However, in the research review that follows, studies that investigated the impact of multimodal information provided through electronic glosses on L2 reading comprehension are described.

Review of Literature

Studies Involving Annotations and Hypermedia

There have been many studies involving annotations and reading on a computer. For instance, Knight (1994) investigated how the use of a computer dictionary affected reading comprehension by keeping track of lookup behavior and reading time. The 112 intermediate-level Spanish participants were randomly assigned to either a group with access to the dictionary or no access. They were then asked to participate in a recall task. The low verbal ability group, according to their verbal scores on the American College Test, showed a strong relationship between reading comprehension and word lookup while the relationship was negligible for the high verbal ability group. According to this study, it seems that low ability groups benefit substantially from dictionary lookup. The results also showed that dictionary access led to more time on-task for both groups. However, only in the low ability group did an increase in reading time lead to improved comprehension.

In a study involving 160 second-year German students, Chun and Plass (1996) asked the subjects to watch a video preview of a story, read the story, and then write a recall protocol about it. The reading included vocabulary annotations with textual, as well as graphic and video media, information. Some words had only one annotation type while others included a combination of text and pictures, or text and video. Results showed that most of the propositions in the video preview were included in the recall protocol, suggesting that the pre-reading video facilitated reading comprehension. Moreover, expressions that were annotated with both text and media were included in the recall protocol more frequently than those with only annotated text. No

relationship was found between the frequency of access of annotations and the number of propositions in the recall protocol.

Davis and Lyman-Hager (1997) investigated whether there was any relationship between the use of annotations and reading comprehension. They also looked at participants' attitudes towards the use of annotations in a computer environment. The study included 42 randomly selected intermediate-level French students. The subjects were asked to read a francophone literary text annotated with a variety of definitions, including the following: English and French definitions, grammar explanations, pronunciation of words, cultural background information, and graphics. Reading comprehension was measured through a multiple-choice test and a recall protocol in English. The use of annotations was tracked. The results showed that subjects accessed English definitions 85% of the time. Statistical analysis also showed that there was a positive relationship between achievement scores and comprehension scores.

In a companion study to the one described later in this article, Ercetin (2003) conducted a study with 84 intermediate and advanced ESL students. A text was prepared to include annotations of several media types. The study investigated the frequency of annotation access and amount of time spent on annotations of various types. The results showed that there were significant differences in the way the two groups accessed annotations. The intermediate-level subjects accessed all types of annotations more frequently. However, there was no difference in the total amount of time viewing annotations. Advanced subjects seemed to spend more time on annotations and to access fewer annotations. Textual annotations showing definitions of words and video annotations that provided information about the reading topic were the most accessed annotation types.

Generally, studies involving annotations and hypermedia indicate that participants will use computer annotations frequently when they are easily accessible. Annotation use also seems more beneficial to participants whose verbal ability or language proficiency is low. However, there doesn't seem to be a direct relationship between annotation use and reading comprehension, according to most studies.

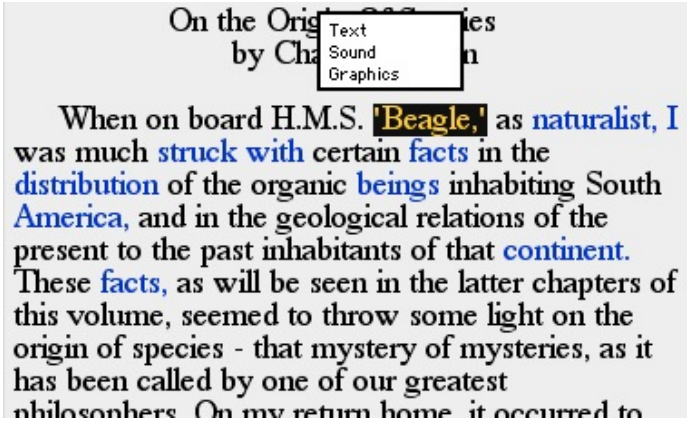
Template Design

A template was designed to facilitate the display of multimedia annotations. The original purpose of the template was to make available foreign language texts and several types of annotations for use by students. The design of the template started simply enough. A text was displayed and words with annotations were emphasized by color, bolding, or underlining. When students clicked on the emphasized words, the annotations appeared on the screen. The program worked by setting up a database of emphasized (annotated) words in the three original annotation categories: text, graphics and audio. The user of the template managed the database to include one, two, or all three annotation categories. The annotations were displayed all at once when the user clicked on the emphasized word.

The first modification involved the addition of video as a media type. The template database was increased to accommodate the added type. However, it became clear that too many annotations could be displayed simultaneously. Graphic annotations could compete for space and user attention with video annotations. Similarly, audio annotations could compete with the soundtrack of video annotations. The problem was solved with the addition of a small menu box. The box appears slightly above and to the left of any clicked word. It contains the annotation media types available for the clicked word. The user chooses the annotation type to be shown. As

a result, access to annotations became a two-click process. One click identified the word to be defined or illustrated and another click identified the annotation type to be displayed.

Figure 1. Screen shot showing menu box

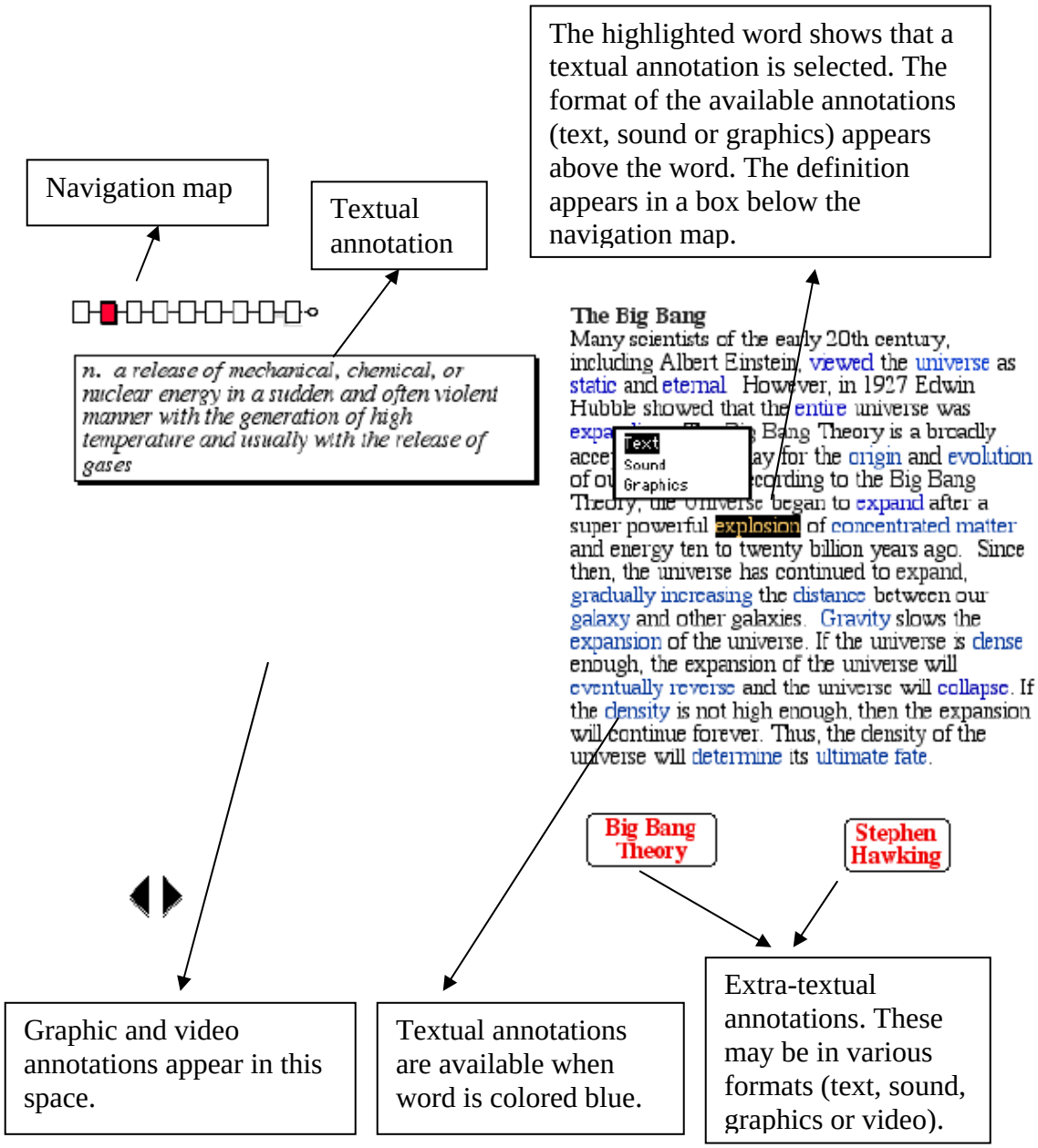


Ariew & Ercetin (2004) — In this example, the user clicked on the annotated word "Beagle". A menu box appears above the word to indicate the types of annotations available for the word. A second click on the annotation type would show the annotation on the screen.

The second major modification to the template was brought about by software improvements. The original software used to design the template was Apple Computer's *Hypercard*. That software was no longer supported by Apple and it became clear that continuing to use *Hypercard* would lead to frustration. *Macromedia Director* became the best substitute. Using version 7 of *Macromedia Director* made better media handling, larger and more colorful displays, and compatibility possible with both the PC and Macintosh operating systems. Today, the template makes use of *Director MX* (version 9).

Based on the interactive theory of reading, extra-textual glosses were added in the third modification. While textual annotations provide support for reading comprehension, they are not sufficient. They represent a bottom-up or decoding mode of reading and display information about the text itself, such as word definitions, help in pronunciation or illustration through graphics or video. Extra-textual annotations were added to provide additional information about the topic rather than about the specific words in the text. These annotations appear as buttons outside the text (above or below the text itself), rather than as emphasized words. When clicked, the buttons display text, audio, graphics or video in a manner similar to textual annotations.

Figure 2. Screen shot showing the screen layout

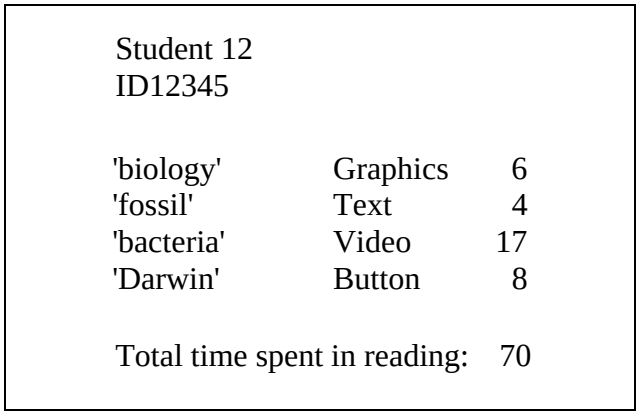


Ariew & Ercetin (2004)

The fourth major modification to the template was made to support research on reading behavior. There were now two additional requirements for the software: First, to track every access to an annotation. Every time the user clicked on a text word or on an extra-textual button, the software had to make note of the word or the button, the annotation type selected and also the amount of time spent on reading the annotation. The software also had to show the order of the

annotations accessed by the student. To better account for actual annotation reading time, the template was modified to have the user click on the word or button and hold the mouse button down to read the annotation. When the mouse button is released, the annotation disappears. The time of annotation use was then defined as the number of seconds starting when the mouse was clicked to select the information, and stopping when the mouse button was released. Second, the software was modified so as to output the information for the researcher as a log file at the end of the reading session. Each time an annotation is used, it is added on the list of annotations tracked. The list is eventually output as a file on the computer when the user completes the reading task. Also included in the list are annotation type (textual, extra-textual, graphics, audio, video) and number of seconds the annotation was used. The data is presented in a format that can be copied into a spreadsheet for further analysis. Also included is total reading time, total annotation reading time, number of times the annotations were accessed, and reading time on each annotation type. This log file is output to the hard disk or to a server.

Figure 3. Sample file output



Student 12
ID12345

'biology'	Graphics	6
'fossil'	Text	4
'bacteria'	Video	17
'Darwin'	Button	8

Total time spent in reading: 70

Ariew & Ercetin (2004) — In this example, Student 12 spent a total of 70 seconds in the reading activity. Four different annotations were accessed. The annotated words are shown as are the annotation types and the number of seconds the annotation was displayed. The last annotation, with annotation type Button was an extra-textual annotation.

The template was subsequently redesigned to improve ease of use. Inserting annotations, tallying annotation use, and reporting were improved. The template is not conceived to ever be in its final state. It is thought of as a work in progress in which modifications and improvements are made periodically, including ones in screen design, annotation display, and data collection. Among the variations, there have been the following:

Addition of a link annotation type. Clicking on an annotated word or button allows the choice of linking to a web page. The template invokes a chosen browser and displays the web page linked.

Presentation of text in a hierarchical format. Whereas normally the text is presented in a linear fashion, with each page following the other, text may be presented in a tree structure

where pages are displayed according to their position on the tree. This modification affects the order of presentation of the pages of the text. Annotations are accessed and displayed in the normal way.

Presentation of two text annotations. A second textual annotation appears when students point with the mouse to a text annotation displayed. The different annotation provides another level of textual help, including annotations in two different languages or of two different types (such as definitions and use of words in context).

Simultaneous presentation of annotations. In one research project (in progress), text and graphics were presented simultaneously without providing a choice of annotation types. This represents a return to an earlier format of the template. The purpose of this research was to test Mayer's (2001) Temporal Contiguity Principle, that is, whether the presentation verbal and visual information simultaneously or successively leads to better retention information. This research is in progress at this time.

The template was used in several studies concerning foreign or second language reading comprehension in an ESL context as well as in a French context.

Studies Using the Template

The French Study

Cooledge (2004) used a version of the template to collect data on reading behavior and reading comprehension. The subjects were all students in an intermediate-level course in French at the University of Arizona. The study dealt with the relationship between reading time, annotation access, and performance in tests of reading comprehension and recall. Also examined were the relationships between proficiency in French, the reasons for studying the foreign language, and reading comprehension scores.

All of the 85 subjects in the study were enrolled in French 202, the fourth semester of college-level French. There were 59 females and 26 males in the study, mostly American students. All subjects were given a French Computer-Assisted Placement Examination (F-CAPE) test. The test results were used as a proficiency measurement for French. Subjects used the template to read and access annotations in English and in the foreign language. They also completed a background questionnaire, a set of comprehension activities, a recall task, and multiple choice comprehension questions. A post-reading questionnaire was administered at the end of the study. Its purpose was to address reading strategies, computer and language learning, preference for the language of annotations, helpfulness of the annotations, and the like.

Cooledge (2004) began the study by selecting four texts from among those used in first and second year French textbooks. She then asked a group of 63 volunteers to read them silently and perform tasks to gauge the texts' comprehensibility/ readability, content appeal, and lexical and syntactic difficulty/complexity. She chose one of the passages as the one most fitting: an authentic francophone text entitled "Sita Ena," by Marie Angèle Kingué. (The unpublished text was used with permission from the author.)

She then asked another group of volunteers to read the passage to determine which of the words in the text were to be annotated. The volunteers were asked to underline all difficult

and/or unknown words and expressions as they read. They identified 138 words and expressions as candidates for annotations. Next, the items were pre-tested with two more groups of intermediate French students. Three words were dropped because they were known by 80% of the readers. Finally, 135 words were annotated in the text.

In this version of the template, Cooledge (2004) was only interested in textual annotations. There were no multimedia annotations and no extra-textual annotations. The template was therefore used to display only the text and annotations of a textual type. However, the annotations were on two levels: a first click on a word revealed either an annotation in French or "No information available". If a textual annotation was available, the student could slide the cursor onto the annotation and see a second level of information. This second level annotation was in English and it remained on the screen until the mouse button was released. The annotation path of French-then-English was designed for the users to be exposed to a large amount of French.

All of the annotations were available to all readers. However, a pattern of use emerged from the data. The readers were categorized into three groups according to their use of the annotations. Some students used no annotations at all, some used French-only annotations, and some used French annotations and quickly went to the English annotations. Most users preferred to read the French-then-English annotations. That is, they rarely stopped at the information presented in French, but opted for English in most cases.

Findings

Using scores on the multiple choice test and the recall activity, a comprehension factor score was calculated. This combined comprehension score was then used for the analyses. The French-then-English group that relied predominantly on English annotations had a significantly positive relationship with the comprehension factor score. There was no statistically significant relationship between the French-only group and the comprehension factor score. The F-CAPE (the test used as a proficiency measurement for French) had a significantly positive relationship with respect to the comprehension factor score. Readers scoring higher on the F-CAPE also scored better on the comprehension tasks.

Cooledge (2004) has shown a significant relationship between the use of textual annotations in the student's native language and comprehension. Since most hypertext studies do not find a significant link between the use of textual or various media annotations and comprehension, this is an important finding. According to Cooledge, there are many factors to consider in understanding these results. She proposes two that may be relevant because they differ from conditions normally encountered in hypertext reading studies: First, a two-prong approach was used to evaluate reading comprehension. Comprehension in Cooledge's study was evaluated as a combination of multiple choice items and a recall test. By combining the two scores into a comprehension factor score a better evaluation of comprehension may have resulted. Cooledge also suggests that the software template, the vehicle through which the reading materials are presented may have itself been a significant factor in the results. Cooledge suggests that further research involving various software used to present reading materials would be a useful study in itself.

The ESL Study

In a study involving 84 adult ESL students, Ariew and Ercetin (2004) used the template to explore the effect of hypermedia annotations on reading comprehension. The study investigated whether the effectiveness of annotations differs depending on the proficiency levels of students. They hypothesized that prior knowledge about the topic would be an important predictor of reading comprehension both for intermediate and advanced readers. They further posited that textual annotations and extra-textual annotations would facilitate reading comprehension for intermediate readers, but that use of annotations would not be a predictor of reading comprehension for advanced readers.

The participants were enrolled in classes to study English for Academic Purposes. The subjects represented a variety of language backgrounds. Out of the 84 participants, there were 58 male, 22 female, and four who did not indicate gender. Students were placed in the classes according to their performance on the Comprehensive English Language Test for Learners of English (CELT), a standardized placement test. There were 34 intermediate and 50 advanced participants in the study.

"Stephen Hawking's Universe," a program produced by the Public Broadcasting Service (PBS), was the basis for the text selected. Five intermediate and advanced readers who did not take part in the actual research were asked to work through the materials to investigate its difficulty and interest. They read the text on paper, underlined the difficult words and answered the comprehension questions. They were then asked to rate the difficulty of the content, vocabulary, and grammar. The raters also identified concepts that were difficult. These concepts later became extra-textual annotations.

The template was then used to annotate the text with various types of media to enhance reading comprehension. Textual annotations, graphics, audio, and video annotations were added based on the raters' identification of the difficult words. Similarly, extra-textual annotations were added to clarify difficult concepts and ideas.

In addition to the annotated text, several other data collection procedures were put into effect:

- A reading comprehension test. The test included 14 items: six short-answer questions, six multiple-choice questions, and two open-ended questions;
- A prior knowledge test. This test consisted of 10 true/false questions and focused on the subjects' prior knowledge about the reading topic;
- A background questionnaire. This instrument gathered information about the participants and their experience with technology as well as demographic information;
- A follow-up interview. Twenty volunteers participated in personal interviews one to three days after completing the comprehension test. These short interviews provided supplementary data concerning participants' use of the template and reading materials.

All data was collected in two sessions. The data collected included results from the prior knowledge test and the background questionnaire, a log file on the use of annotations, and results from the comprehension test. In a separate data collection phase, 20 volunteer participants were interviewed.

Two computer log files were generated as part of the data collection, one of which contained data on annotation use, and the other the participants' answers to the comprehension test. The file on annotation use was generated by the template as students used the various annotations. The data included a list of each annotation accessed, whether it was a textual or an extra-textual annotation, the media type (text, graphics, audio or video) and the amount of time spent in seconds on the annotation. The other file contained the subject's answers to the reading comprehension questions.

Findings

The Intermediate Group

There was a significant positive relationship between reading comprehension and prior knowledge. The more the intermediate group knew about the subject matter before reading the materials, the more likely they were to have a higher score on the reading comprehension test. The results also show significant negative relationships between reading comprehension and the time spent on extra-textual video and graphics annotations. It seems that intermediate readers did not profit from the use of the annotations to improve their reading comprehension except in a negative way. Time spent on extra-textual video or graphic annotations seemed to reduce rather than increase their comprehension scores. Correlations between reading comprehension and time spent on other types of annotations were either low or negligible.

The Advanced Group

For the advanced group, there was also a significant positive relationship between reading comprehension and prior knowledge. The relationship was weak, however. There were no other significant relationships identified in the analyses. The time that advanced readers spent reading or viewing annotations did not seem to improve their reading comprehension scores. However, as with the intermediate readers, prior knowledge of the subject matter helped in comprehension of the reading materials.

Qualitative Findings

Results of the analyses of data from the questionnaires and personal interviews show that participants thought that the annotations were useful and reading in a hypermedia environment was enjoyable, interesting, and easy to understand. Both the intermediate and advanced readers agreed that most types of annotations were useful. Word definitions (text annotations) were especially appreciated because they increased reading speed. The interviews also revealed that the intermediate group appreciated the audio annotations (the pronunciation of words and audio recordings) because they provided a good opportunity to improve pronunciation. Some participants did not like extra-textual annotations because they thought they provided too much information or because there was not enough time to use them.

Ariew and Ercetin (2004) hypothesized that annotations would enhance reading comprehension for intermediate level readers. That hypothesis was not confirmed. The use of extra-textual video annotations did influence reading comprehension, but in an inverse

relationship. Video annotations seemed to distract rather than help the readers and seemed to interfere with reading comprehension.

Ariew and Ercetin (2004) suggest that the video annotations results may provide evidence for the "short-circuit hypothesis" (Clarke, 1988). According to Clarke (1998), limited proficiency may lead to the use of poor reading strategies and result in "contextbiasedness" (Carrell, 1988). Consequently, intermediate readers might have relied too much on the video annotations to understand the text. Chun and Plass (1997) also provide several reasons for the negative effects of multimedia information. They suggest that there may be an attention split between the types of information provided. Readers may also have focused on the type of information based on their interest in the information and not on its usefulness to aid comprehension. Video annotations may draw attention to themselves and not on their ability to provide comprehension information.

Ariew and Ercetin (2004) also hypothesized that advanced readers would not rely on annotations for text comprehension. This hypothesis was confirmed. No relationship was found between the advanced readers' annotation use and comprehension. Advanced readers seemed to have focused on understanding the text; they consulted the annotations only when necessary.

Knight (1994) and Chun (2001) had similar results with advanced readers. Higher linguistic competence might have enabled advanced learners to use good reading strategies. This may provide evidence for the theory that good reading skills are activated at a certain threshold level of linguistic ability (Anderson, 1991; Clarke, 1988; Devine, 1988; Taillefer, 1996).

The study also confirmed that prior knowledge was an important predictor of reading comprehension for both intermediate and advanced readers. Prior knowledge contributed more to reading comprehension than annotation use.

Discussion

The two studies conducted using the template achieved results that add to our knowledge both about the reading process and about reading in a hypertext or hypermedia environment. However, the issue of whether annotation use improves reading comprehension is still to be debated. Most hypertext studies do not find a significant link between the use of annotations and comprehension. Readers' use of annotations in a hypertext or hypermedia environment does not yield measurable benefits. In Cooledge's (2004) study, however, this is not the case. She did find a positive relationship between the use of textual annotations in the student's native language and comprehension. This is in line with the findings of Davis (1989) and Lomicka (1998), who found glossing to be more useful than no glossing. In their study, Ariew and Ercetin (2004) suggest that annotations may in some cases hinder reading comprehension for intermediate-level ESL learners.

For intermediate readers, video annotations had negative impact on reading comprehension in Ariew and Ercetin's (2004) study. This is an interesting finding that may have some relevance to pedagogy since it suggests that video may be distracting or perhaps draw to itself too much attention. According to the cognitive theory of multimedia learning (Mayer, 2001), multimedia information may have deleterious effects on learning when a single channel is overloaded. In the case of video annotations, it is possible that there is an overload with both the verbal and non-verbal information received from the videos.

Ariew and Ercetin (2004) found no relationship between annotation use and reading comprehension for advanced ESL learners. This confirms the findings of Davis and Lyman-Hager (1997). The role of proficiency was also a factor in Cooledge's (2004) study, where

readers who scored higher on the F-CAPE scored better on comprehension tasks. On the other hand, prior knowledge was investigated in Ariew and Ercetin's (2004) study, which revealed that it was a significant predictor of reading comprehension for both the intermediate and advanced groups. However, it explained more variability in the reading comprehension scores of the intermediate group (26%) than the advanced group (9%).

Even though the use of annotations did not necessarily facilitate L2 reading comprehension, learners still perceive access to annotations useful in reading L2 texts. The subjects in Ariew and Ercetin's (2004) study seemed to find all annotations, including video annotations, useful. However, easy access may lead them to use the annotations excessively to look up even familiar information (Aust, Kelley, & Roby, 1993). Learners may select annotations not because they are important, but because they are interesting (Chun & Plass, 1997). The studies conducted using the template suggested that the design and implementation of hypermedia or hypertext materials are important factors in reading comprehension. The way that annotations are accessed and presented and the way the software behaves may have an impact on readers' comprehension.

Finally, it should be pointed out that improvements on the template have been continuous, where findings are fed back into cycles of innovation in the design of the template itself. This is what Bereiter (2002) calls *design research*. "Design research is not defined by methodology. All sorts of methods may be employed. What defines design research is its purpose: sustained innovative development" (Bereiter, 2002, p. 325). The template is being used for research and the findings of that research are fed back into the design of the template, modifying it, allowing for greater flexibility and choices. This iterative process has a good chance of making an impact on understanding reading comprehension in hypermedia contexts.

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Robert Ariew is Professor of French and member of the interdisciplinary Ph.D. program in Second Language Acquisition and Teaching (SLAT) at the University of Arizona, Tucson, Arizona, USA. He is Acting Chair of SLAT for the year 2007-2008. His areas of interest include computer assisted instruction for the teaching of foreign and second languages and materials design and development. He is the author of numerous articles on the subject of computer assisted language learning (CALL) as well as several textbooks for beginning and intermediate French.

Email: ariewr@u.arizona.edu