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Development and experimental evaluation of an interactive reading application designed for comprehensibility and interest

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Abstract: This study reports on the design and use of a second language reading application for enhanced comprehension and pleasure reading. The study shows the application design in depth, relating it to existing second-language acquisition theories. Quantitative reading comprehension scores were compared between reading by using the application and reading by using regular text and it also evaluates qualitatively how users perceived the application. Results indicate that the software was successful in improving reading comprehension by guiding user behavior through its design. However, not all students were optimistic about the application as a learning tool given its implicit approach. How the work stands in relation to extensive reading is also discussed.

Keywords: CALL, DBGL, text comprehension, extensive reading, foreign language L2, reading

1. Introduction

Language acquisition gains from foreign language reading have been shown in past research many times (Yamashita, 2008; Yang, 2001). Pleasure reading, often using narratives, where readers engage in reading as a leisure activity, allows for reading of large volumes of content, which leads to high gains in language acquisition, but shows various problems, like in the time it takes to show those gains or in the acquisition of infrequent vocabulary (Cobb, 2007; Harris, 2001). Present research shows that the higher the understanding of the text, the higher the language acquisition gains, so higher understanding could be used to overcome the problems in pleasure reading. For example, higher understanding results in incidental vocabulary learning needing less repetitions in order to be effective. Computer-assisted language learning applications have tried to increase the gains of reading through various means but, in exchange, not being focused on recreation, they have trouble motivating students to read large volumes of content (Wang Y.-H. , 2016; Wang Y.-H. , 2014). The problem is that, currently, present research has shown no activity that allows for pleasure reading while offering deeper understanding to overcome its shortcomings.

In order to solve this problem, Furtado, Hirashima and Hayashi (2017) presented an application that is designed to support comprehensibility and interest, which results in better language acquisition, while still being designed to use narratives to more easily allow for pleasure reading by using a structure similar to the one used in certain games. The similarity to games is merely structural and not based on extraneous gamification mechanics like achievements or leader-boards and the application's elements have been designed for taking in to account both cognition and motivation.

This paper further elaborates on the work shown by Furtado, Hirashima & Hayashi (2017), giving more details on the design, the development process and on the preliminary experiment.

The application uses a combination of text and image to tell a story while also allowing users to create dialogs and then experience those created dialogs. The design of the dialog construction and its feedback is made to induce a behavior that best benefits learners who are having trouble in either comprehensibility or interest, in order to increase overall understanding of the text and help users with foreign language acquisition.

2. Related Works and Theories

2.1. The reading process and reading comprehension

When explaining reading, the purpose of reading plays a big role. Two examples are reading for learning and reading for general comprehension (Khalifa & Weir, 2009). Reading for learning is usually done at schools, with the goal of attaining new information and relating it to previous knowledge. Reading for general comprehension is the usual reading done by native readers. This is the reading done when reading a story for entertainment, or just to get a general idea of what the text is about. According to Grabe and Stoller (2013), reading for general comprehension is more demanding than reading for learning. That is because reading for general comprehension by a native reader is done at a faster pace, uses automatic word processing and has high demands on forming a general idea on a small amount of time. Hours of reading would be necessary to achieve this (Grabe & Stoller, 2013).

2.2. Language Acquisition Through Reading

Acquisition through reading, specially extensive reading (reading large volumes of content for enjoyment), has been amply researched, with gains being shown in multiple areas, such as reading comprehension (Hafiz & Tudor, 1989; Hitosugi & Day, 2004), reading strategy (Nishino, 2007), reading rate / speed (Hunt & Beglar, 2005), vocabulary acquisition (Horst, 2005; Pigada & Schmitt, 2006), grammar (Yang, 2001), writing (Elley & Mangubhai, 1983) and attitude/motivation (Yamashita, 2013).

2.2.1. Relation to Comprehensibility and Interest

The input theory states that, for acquisition to take place, content must be both interesting and comprehensible to the reader (Krashen S. , 2005; Krashen S. , 1982). Those 2 elements are taken into account in almost, if not all the programs cited in extensive reading research and can be seen in the fact that extensive reading classes often allow users to decide what they want to read (thus allowing them to pick the content that interests them the most) and are based on graded-readers (which allows users to gauge the comprehensibility of a book and try to read content appropriated to their levels).

2.2.2. Limitations of Extensive Reading

The gains of extensive reading take time to show up and show up at different rates (Yamashita, 2008), which stands in the way of extensive reading adoption.

The work of Harris (2001) goes over many other limitations of extensive reading, of interest to this research is content selection. The problem is not the lack of content but the abundance of content, which may make users demotivated if they choose an unsuitable text, a problem also cited by Brown (2000).

Cobb (2007) argues that it is extreme unlikely that learners can acquire an adequate L2 reading lexicon through reading alone, because many of the words are not frequent enough.

2.2.3. The Role of the Computer in Supporting Reading.

After pointing out limitations in extensive reading, Cobb (2007) points out to how computer assisted technologies could support extensive reading to alleviate these problems, such as by linking texts with a corpus to provide more context in to which words appear. He also suggests using computer generated problems for assisting users in acquiring vocabulary encountered during reading. Examples of computer-assisted reading with a similar line of thought to that of Cobb's have been done and they showed good results (Wang Y.-H. , 2016; Wang Y.-H. , 2014). However, those approaches, while succeeding at increasing vocabulary, are far from the voluntary reading described by Krashen (2005), which empowers students to read in great volume. Other works have shown good results in increasing reading comprehension but are not focused on reading in volume, instead being focused on

understanding and recalling (Alkhateeb, Hayashi, Rajab, & Hirashima, 2015; Alkhateeb, Hayashi, Rajab, & Hirashima, 2016). Research that attempted to combine the benefits of both sides has not been found.

2.3. Digital Game Based Learning, computers and reading comprehension

One definition for Digital Game Based Learning (DBGL) is "the innovative learning approach derived from the use of computer games that possess educational value or different kinds of application applications that use games for learning and education purposes such as learning support, teaching enhancement, assessment and evaluation of learners." (Tang, Hanneghan, & El Rhalibi, 2009)

While there have been numerous studies focusing on increasing reading comprehension by using computer software and games, they do not fit well with the extensive reading context. In some studies they detract too much from reading in order to deepen the understanding (Alkhateeb, Hayashi, Rajab, & Hirashima, 2015; Alkhateeb, Hayashi, Rajab, & Hirashima, 2016). DBGL has been used successfully for language learning, but even when they do go into reading, they do not integrate deeply with the reading process or they are not compatible with long texts (Shelton, Neville, & McInnis, 2008; Yudintseva, 2015; Vahdat & Behbahani, 2013; Hitosugi, Schmidt, & Hayashi, 2014). There has been little research that focused specifically on designing a software focused on supporting reading as the main activity in the context of DBGL and foreign languages.

2.4. Gameful Design

One core element of games is challenge. Appropriate challenge that matches the skill of the user will greatly affect the experience (Deterding, 2015). If it's too easy, the player will be bored. If it's too hard, the player will be discouraged. This fits with the conditions to achieve flow state, a popular construct in entertainment research (Bowman, 2008). It also fits with the need for competence from the Self Determination Theory (Deci & Ryan, 2012; Przybylski, Rigby, & Ryan, 2010).

However, game design is not about arbitrarily creating challenge. A game must be both accessible and easy to use while still providing a hard experience for the player (Juul & Norton, 2009). This means that a game's challenge should not be born from usability issues. It's necessary to focus on usability in game design. Also cited as an important element is for the player to have freedom to fail and try again, as much as he needs or wants (Deterding, 2015).

3. Methodology

3.1. Problem Statement

As it could be seen in the previous section, an application that can support the gains and shortcomings of reading while offering narratives for pleasure reading, as far as researched in this article, does not exist at this moment.

This research aims to fill this gap by presenting an application design that focuses on supporting reading comprehension by focusing on comprehensibility and interest, while still being based on narrative content to allow for pleasure reading, in accordance to the theories previously discussed.

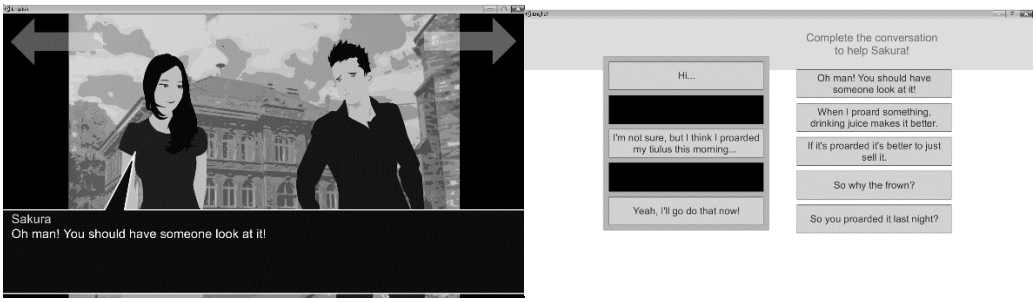

Figure 1 Screenshots of the application. To the left we have the story segment (A). To the right, the conversation construction segment (B)

3.2. Application Introduction

The application consists of story segments and conversation construction segments. Screen-shots of both segment types can be seen in Figure 1.

As an example of story segment, imagine that Figure 1 (A) shows a boy and a girl meeting and exchanging greetings. Both the boy, the girl, the background and their dialog can be visualized by the user and the conversation only proceeds upon player input. These segments are linear.

To exemplify the conversation construction activity, imagine that in the previous scenario the boy is angry about something and the girl wants to ask him why without angering him further. The player is requested do create a conversation, from the girl's perspective, that succeeds in asking about why he is angry without further angering him. When the user finishes constructing a conversation, the system will show the consequences of the constructed conversation. If those consequences are appropriated (in this case, if the girl succeeds in asking why he is angry) then a new linear story segment will continue. If not (if the girl angers him further), then the user will be requested to try again.

The conversation construction is where most of the user interaction takes place, where the main efforts to increase comprehensibility and interest lie and its design is where most behavior influencing is focused on.

3.3. The Conversation Construction Activity's Design

This activity consists of constructing a conversation and watching it play out. If the constructed conversation is inappropriate, a new conversation will be formed that will give the user insight into why that conversation is wrong and into how to create the appropriate conversation. From now on we'll refer to the phase of constructing a conversation as the assembling phase and the phase of watching the conversation play out as the result phase. Those two phases will be further developed in the subsections below.

The ideal behavior of the user for this activity can be seen in Figure 2.

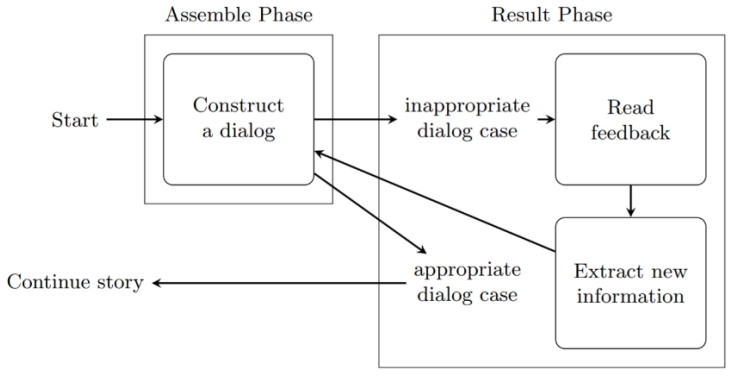

Figure 2 Ideal user behavior flow for dialog construction activity

3.3.1. Dialog Construction's Assembling Phase

This phase consists of forming a sequential dialog by inserting dialog pieces into a grid, like in Figure 1 (B). However, the user can only insert the pieces related to what one person says. What the other person says is already fixed on the grid and cannot be moved. This was a deliberate decision to reduce ludo-narrative dissonance (Hocking, 2009): if players ask themselves "if I am the main character in the narrative, how come I can control what the other person will say?" that would break immersion.

Whenever a student fills up all vacant spaces with dialog pieces a button will appear in the interface, pressing that button will take the student back to the visual novel section and the result of the conversation will play out.

In regards to Figure 2, this refers to the "Construct a dialog" node.

3.3.2. Conversation Construction's Result Phase

First, the system must check if the conversation is appropriated or not, by comparing it to the answer. If the conversation is appropriate, it will be shown to the player as it is and the story will go on. This refers to the "appropriate dialog case" in Figure 1.

However, if it's incorrect, the system must logically assemble a new conversation based on the player's constructed conversation. It is done by the following steps:

1. Find the player's first mistaken dialog piece in the conversation by comparing the correct conversation with the assembled conversation from top to bottom;
2. Discard all dialog pieces below the player's first mistaken dialog piece;
3. Insert the text that has been previously prepared as a reaction to the mistaken dialog piece. This text will show up after the mistaken dialog piece;
4. Insert the text that has been previously prepared as a clue for the correct dialog piece that would fit in the position the player made his first mistake. This text will appear after the text of the previous step.

In Figure 1, this would be the inappropriate dialog case.

This new generated conversation is then shown to the player and, after it's over, the player will go back to the conversation construction screen. This process can be better understood on Figure 3.

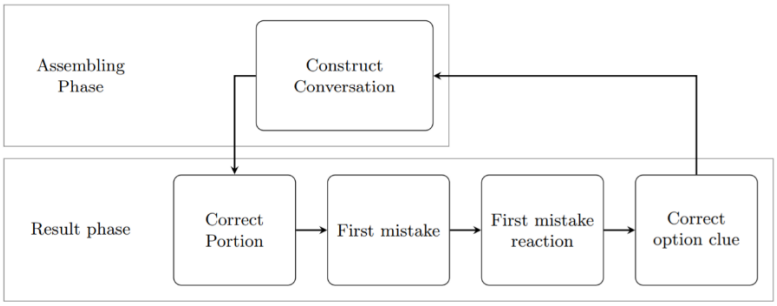

Figure 3 Application flow chart for mistakes during conversation construction

In the "First mistake reaction", when the conversation goes in to an unexpected flow, the actual feedback to the user begins, where they will acquire information on why the card related to the "first mistake" is unappropriated and insight in to what dialog piece would be appropriate in that time. Users who are reading attentively will also be able to clearly point out which dialog piece has been considered inappropriate, since the feedback (the change in the conversation flow) begins at that moment. This feedback is effective because it uses the player's inappropriate input to generate a conversation, instead of simply stating "this conversation is wrong, the correct one is this one", thus allowing players to reflect on their input in a more effective way. This approach is similar to error-based simulations which have been used in other works before (Horiguchi, Imai, Toumoto, &

Hirashima, 2014). This refers to the "Read feedback" and "Extract new information" nodes in Figure 1.

3.4. Relation to pleasure reading and Gameful Design

The application uses narratives and would work with long texts, unlike previously discussed CALL approaches, both of which are compatible with what is usually used in pleasure reading on extensive reading programs.

As for Gameful Design theory, our approach for challenge has been through natural, emergent difficulty. As we've previously shown, reading comprehension for L2 learners can be a fairly difficult task. On extensive reading there is a focus on choosing texts with appropriate difficulty to mitigate this difficulty. Our dialog task involves extracting information from the text and using that information. As such, it should have a difficulty similar to the reading comprehension process. The main difference is that we provide feedback. In our feedback loop, progress will make it simpler for him to solve the activity. In this way, every time the user tries to solve the task, he should have more information and the task should become easier.

About freedom to fail, the user is free to fail in our design, not being punished. Furthermore, he is also rewarded with feedback from his failure. Also, the way the story proceeds is similar to visual novels, a popular game genre (Cavallaro, 2009), which involves reading through long periods of time, thus being compatible with pleasure reading. The setup of story sections intersected with dialog construction is very similar to the structure of popular games, like Danganronpa released by Chunsoft (2010), suggesting that the insertion of the conversation construction activity would not negatively impact the recreational aspect of reading.

4. Experiments and Results

4.1. Experiment Description

12 students from a Japanese University's Undergraduate Courses were divided into two groups, group A and group B. Both groups were asked to interact with the application and with a digital text document. Group A interacted with the application containing content 1 and, afterwards, read a document containing content 2. Group B interacted with a text document containing content 1 and with the application containing content 2. Both content 1 and content 2 had between 15 and 20 lines of text and have had certain words replaced with dummy words. Both groups then were asked to answer the same questions of reading comprehension and of dummy word partial meaning acquisition. This setup is illustrated in Figure 4.

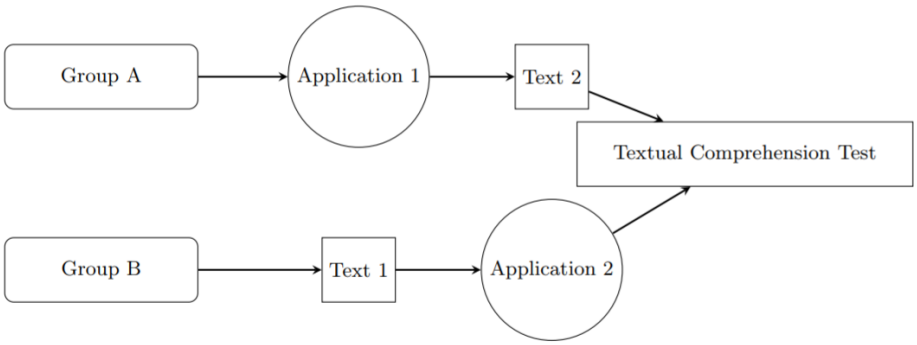

Figure 4 Flow Chart for the experiment

Both contents had two dialog construction activities each. Going through them usually took participants between 10 and 15 minutes, with application use taking up more time, since users had to create the appropriate dialog.

For this experiment we considered that there was no significant gap in difficulty between content 1 and content 2 and also that, since doing the application and the text does not take a lot time, the order of application-text and text-application will not significantly influence the score.

The questions both groups had to answer were divided into 3 sections:

1. Remembering section
2. Textual interpretation section
3. Partial word comprehension section

In the remembering section users were asked to write as much as they could remember with as much detail as possible. The textual interpretation section asked questions about the content such as "Did Brian ever get angry in the story? If so, why did he get angry?" The third section showed a small excerpt from the text which contained dummy words and asked questions related to the meaning of the words. For example, "What is the meaning of the word proard? Describe it to the best of your abilities. A vague description and guessing are both fine".

Afterwards, 7 of the users were asked to answer a user perception survey. For the text comprehension section, we have 2 hypothesis:

1. Scores related to content in the application will be higher than the ones related to the content in the document;
2. Differences between the two groups will not significantly affect the scores.

For user perception, our only hypothesis is that user will be positive towards the software.

4.2. Results

Table 1: Average scores and standard deviation for the two groups and also for all participants.

Groups	Application	Text
A	0.78 (SD 0.08)	0.53(SD 0.18)
B	0.77 (SD 0.17)	0.44(SD 0.21)
All	0.78 (SD 0.13)	0.48(SD 0.20)

Of the 12 participants, only one participant scored higher by reading the text than by using the application. If it is assumed that there is no difference between the reading condition and the application condition, the probability that of 12 people 11 would score higher is 0.0063 ($p < 0.01$) by a double-sided binomial test. Based on this result, we can say that the application condition is better than the reading condition for comprehension.

Furthermore, by assuming that the two contents are equivalent in difficulty and that the order of use does not matter, an analysis of variance has been run with two factors, group A/group B and application/text, and the difference in groups was shown to not be statistically significant, while the difference between application and text is significant. Average score and standard deviation of each group, and for the combined group, can be seen on Table 1. Calculating Cohen's d, for the combined group gets us an effect size of 1.78. Both Hypotheses have been met.

Table 2: Survey results

Question	Strong negative	Negative	Neutral	Positive	Strong positive
1	-	-	42.8%	28.6%	28.6%
2	14.3%	-	-	28.6%	57.1%
3	-	-	42.9%	42.9%	14.3%
4	-	14.3%	-	14.3%	71.4%

As for the user perception survey results, results can be found in Table **2**. The questions are similar to a Likert scale. Favoring the application would be interpreted as positive and favoring text documents as negative. The questions are:

1. Which one is easier to understand, the application or the text document?
2. Which one makes you want to read it more, the application or the text document?
3. Which one do you think is better for studying English, the application or the text document?
4. Was the application easy to use?

The following trends were found:

1. In the area of interest, all users except for one had a positive opinion towards the application, with over half of the users completely favoring the application;
2. On perceived comprehensibility and perceived learning, half of the users had a positive opinion while the other half had a neutral opinion;
3. On usability, one user found the application a little bit hard to use, while the vast majority thought the application was easy to use;
4. The user who felt the application is a little bit hard to use is the only one user that was unfavorable towards the application in any of the areas. He also favored printed text in the area of interest.

Those trends show that the hypothesis was true. About the one user that was unfavorable towards the application, his scores were checked in order to see if his opinion affected his scores. Surprisingly, he was the only user to get a perfect grade related to the content in the application version he used, suggesting that the comprehensibility scores are not affected by dislike of the application for short passages.

5. Conclusion(s)

This application has shown promising results in offering a gain in reading comprehension while still offering narrative content for pleasure reading. Further research with a bigger sample size would create the base for further research to investigate if this leads to further gains in foreign language acquisition.

User's higher comprehensibility when using the application can be attributed to being able to read the feedback information to solve the dialog assembling problems. This suggests that users were performing according to the ideal behavior previously defined, indicating that our efforts to create an activity that can only be practically solved by displaying the needed behavior have been successful. While this sort of approach is not the best for every type of application, when we talk about reading, which follows a linear path, this approach is promising.

As for the qualitative results, they have been overall positive, which fits well with past results suggesting good affective reception from learners in relation to DBGL (Hainey, Connolly, Boyle, Wilson, & Razak, 2016).

As for the perception of the application as an English studying tool in comparison to the paper version, around half of the users pointed to them being equally effective. And yet the comprehension scores for the application version have been much higher. This contradiction between user's perceived learning effectiveness and the actual effectiveness has also been reported before (Shelton, Neville, & McInnis, 2008). Low perceived learning is also one of the challenges of extensive reading, so making DBGL tools have a higher perceived learning by students should positively impact their performance and studies in that direction are necessary, such as measuring differences in flow and motivation between implicit and explicit learning.

Remaining issues would be the low perceived learning, the small sample size and the fact that the design relies on the presence of conversations. Expansions to this research could focus on making learning more explicit by mixing the narratives with explicit vocabulary teaching, thus making the learning process more obvious to the student. Another problem is that, currently, producing content for the application is a complex task. Creating a tool to assist this process would allow content to be created by teachers and other content creators.

Another direction would be creating a new application design in the same vein but with a content agnostic approach, allowing it to be used in texts that do not contain conversations. And finally producing enough content to test the application in an extensive reading context in order to measure second language acquisition gains.

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