PRESENTATION OF TEXT-BASED LEARNING CONTENT ON MOBILE PHONES USING RAPID SERIAL VISUAL PRESENTATION

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ABSTRACT
This study examines using Rapid Serial Visual Presentation (RSVP), a method for displaying the words in a text rapidly in a sequence, as a method to present text based content on mobile phones. A prototype for reading RSS-based content was developed and tested. The study was conducted in two parts. The first part was an experiment study, where university students read educational material, after which multiple-choice questions were answered in order to measure readability and comprehensibility. The second part was an observation study where the software was available for download by anyone, and where the usage of the predominantly news based content was logged. The results from the experiment indicate what previous studies of RSVP on computer screens have show, namely that reading speed and comprehensibility is high, but that users are uncomfortable with the technique. The results from the observation study showed that even among users used to read content on mobile phones, relatively few choose to use RSVP on a frequent basis.

KEYWORDS
RSVP, m-Learning, small screens, text readability, educational technology

1. INTRODUCTION
M-Learning is a new area of research, with different interpretations of what constitutes m-Learning. In our case, the long-term goal is to make m-Learning a part of regular courses in higher education, where every, or almost every, participant will be able to take advantage of the m-Learning infrastructure. This means excluding many technologies which is not widely available for most students, such as PDAs, laptops etc. One platform that remains, however, is to use mobile phones capable of IP data traffic, using Java MIDP software. Almost all students in Sweden own such a device, making systems relying on these technologies usable in this context.

Use of video-based and audio-based content on mobile phones for educational purposes is still much less popular among students than text based content, even without considering the technical difficulties and the high production and distribution costs for using audio and video (Hedin 2006). One reason for this is the difficulty to skim through media content with an inherent time component. Therefore, an important prerequisite for making educational content available for m-Learning is the development of methods for reading text on mobile phones.

Rapid Serial Visual Presentation (RSVP) is a method where the words in a text are presented one at a time in a rapid sequence, as opposed to for example page based or scroll based layouts like books or web pages. It should not be confused with the Quality of Service reservation protocol with the same acronym. A lot of research efforts have been used to investigate the use of RSVP on computers screens and in controlled experiments (Juola et. al. 1995, Masson 1983). Some work has been done on using RSVP on small screens (Juola et al. 1995, Sicheritz 2000, Cuellar and Eckles 2005) and some work has been done on using RSVP in non-experimental environments (Cuellar and Eckles 2005), but the use of RSVP on mobile
phones otherwise remains largely unexplored. Previous studies made on RSVP on computer screens, have shown that reading speed is not decreased, or even increased, with this method without decreased reading comprehension. For mobile phones, where reading longer texts are often considered difficult (Hedin, 2006), high reading speed combined with a high level of comprehension which is not affected by the small screen, should be ideal. A study on the user of RSVP on small screen display by Sicheritz (2000), indicated that readability and comprehensibility equaled that of books. If text readability, comprehensibility and user acceptance will be sufficient, and even come close to that of books, RSVP could be a good platform for text-based m-Learning.

The purpose of this paper is to evaluate RSVP as a method to present text based learning content on mobile phones, compared to spatial scroll based methods. We have investigated readability and comprehensibility of educational texts on mobile phones using RSVP compared to scroll based reading, users' attitudes to using RSVP for educational text, the attitudes to using RSVP in a non-experimental environment using news content, and reading speed.

The null hypothesis is that the level of text comprehension for complex texts is independent of whether they were read using scroll or RSVP on a mobile phone.

1.1 Previous work

The term RSVP in the meaning of rapidly displaying words in a sequence on the same visual location, was first used by Forster (1970). Forster used the technique to investigate the effect of how the complexity of sentences affects how well people can recall words in a sentence. Forster describes four experiments examining peoples' abilities to identify words in sentences presented with RSVP. The experiments were conducted by photographing individual words on film frames, and then playing the film on a projector using variable speed. After his initial pilot study, Forster chose to use a speed of 16 words per second in his experiments. (Forster 1970) This corresponds to 960 words per minute, which is well over what can be considered normal reading speed. Joula et al. (1982) reports the normal reading speed for English to be about 300 words per minute, and Björnsson (1968 quoted in Goldstein et al. 2003) reports the normal reading speed for Swedish to be about 240 words per minutes.

Forster (1970) found that the respondents, who were students, could identify about four of six words in sentences presented with RSVP at 960 wpm. He also found that the complexity of the sentences had an effect on the reading comprehension. The respondents reported a larger percentage of correct words in sentences with one underlying sentence, and fewer correct words in sentences with two underlying sentences. The worst results were achieved by using randomly chosen words without a meaning. (Forster 1970)

It has later been suggested that RSVP could increase the reading speed, since the method eliminates the time-consuming eye-movements during ordinary reading (Juola et al. 1982). It has also been suggested that RSVP could give advantages when skimming texts, since someone skimming a text page often misses vital information, and often does not read certain paragraphs (Masson 1983). Joula et al. (1982) introduced the computer as a medium for RSVP and showed that Forster's results from 1970 were generalizable to computers. Juola further showed that the reading comprehension for shorter texts was similar for RSVP and spatially presented text at various speeds, when read on a computer screen. Masson (1983) compared RSVP and spatial text representation when skimming texts. His theory was that RSVP could give better results than spatially presented text, since people often misses important information when skimming. RSVP would guarantee that every single word was exposed to the user. His study, however, showed that the respondents performed worse using RSVP than spatial text-based presentation, but Masson also found ways to improve the performance by introducing short pauses between each sentence. Masson interpreted this as an indication that a large amount of the conceptual processing of the content of a sentence happens at the end of the sentence in conventional reading. Later investigations have also shown good results when pauses have been introduced at the ends of sentences (Chen 1986, Williamsson et al. 1986, Castelhano and Muter 2001, Öquist and Goldstein 2002, Goldstein et al. 2003).

Another method for dynamical presentation of text that has been suggested as an alternative to RSVP is a method called Times Square (Joula et al. 1995, Kang and Muter 1989). This method, also going by the name 'leading', continually scrolls text over the screen from right to left. The method has got its name, Times Square, from its most famous implementation, the lightboards at Times Square in New York (Kang and Muter, 1989). Neither RSVP nor Times Square has positively proven to be better than the other, rather which technology is best seems to depend on the implementation. Kang and Muter showed that Times
Square is as effective as RSVP and is better liked by the readers, but their experiment was performed on a 16.5x10 cm CRT screen (Kang and Muter, 1989). Juola et al. (1995) compared RSVP with Times Square on a VHS VCR display, which could show a maximum of eight characters at a time, and found that RSVP gave better results regarding reading comprehension.

Later research on the area has covered how RSVP can be improved to increase its popularity, decrease the cognitive load and improve reading comprehension (Muter et al. 2001, Öquist and Goldstein 2002, Goldstein et al. 2003).

In a study of using RSVP on small screens, Sicheritz (2000) found that objective measures of reading speed, level of comprehension and performance remained unchanged compared to reading in a book, but that the users' subjective view of their comprehension and performance decreased.

2. METHOD

In order to be able to perform tests of RSVP on mobile phones, a prototype was developed, described in section 2.3. To evaluate the reading comprehension for academic texts, we chose an experimental approach, giving us full control of the conditions under which the evaluation was performed, described in section 2.1. To measure how reading speed developed over a longer period of time and how RSVP would be used in a non-experimental environment, we chose to make an observation study, described in section 2.2. In this study, anyone could download and use the RSVP reader to read news material from a Swedish newspaper, and any other Rich Site Summary (RSS) feed the users wanted.

2.1 The experiment study

The participants in the experiment were third year university students participating in a course in media perception. 10 of 37 students in the course chose to participate, 4 men and 6 women aged between 21 and 24. The RSVP prototype application for mobile phones had been pre-loaded with six texts, of which two were used for practice and the remaining four used in the test.

The four texts and their corresponding multiple choice questions used in the test were chosen from the Reading Comprehension (READ) subtest from The Swedish Scholastic Assessment Test, SweSAT. SweSAT is a national admission test used for measuring student's general aptitude for education, and the READ subtest measures Swedish reading comprehension in a broad sense (Stage 2002). Each text in our study consisted of 926 – 939 words, and were relatively complex with LIX values averaging 54. LIX is a readability index for Swedish texts, where values of 50 or more are considered difficult, and 60 or more is considered very difficult. Technical literature has been calculated to average 56 (Norrby and Lundqvist 1997). The LIX value is calculated as LIX= Lm+Lo, where Lm is the average number of words per sentence, and Lo is the relative number of words with 6 or more characters, expressed as a percentage. A normal SweSAT READ test consists of five texts with four multiple choice questions per text, which the students are given 50 minutes to answer, averaging 10 minutes per text. In our test, two speed settings were used, with which these texts gave 5 minutes per text for the slower speed and 3.5 minutes per text for the faster speed. Also, the students could not go back and look for answers in the text once they got the questions, which is possible in the SweSAT test. The shorter time given, and the lack of possibility to go back and look for answers, makes our test more difficult than the original SweSAT tests.

In our experiment, the students first read one text with RSVP to get familiar with the technology. This made the students familiar with the complexity level of the texts used. Half of the students were then instructed to read a new text using RSVP with the speed set to display each word 240 ms. This corresponded to 167 words per minute (wpm) for the texts used, including extra time added for long words and after punctuation, or about 5 minutes for the entire text. The other half started reading a text using scroll based technique. They were instructed to read at a comfortable pace and that they would be given a signal after half the time. The students then answered four questions about the text with multiple-choice answers. They were instructed not to guess if they did not know the answer. Next the procedure was repeated, changing reading method so students who started reading with RSVP now used scroll, and vice versa.

This procedure was then repeated with a new RSVP text with the delay set to 150 ms per word, corresponding to about 267 wpm or 3.5 minutes per text, and a new text read with the scroll based approach. For the scroll based text the students were this time instructed to read the text fast, and that they again would be given an indication after half the time. Finally, the respondents answered on a scale of 1 to 7, how comfortable they felt with each of the four methods, one meaning uncomfortable and seven
meaning comfortable. The order in which the texts were read were rotated in order to minimize the effect of possibly different difficulties of the texts had on the results.

The mobile phone used in the experiment was as a SonyEricsson Z800i, with a 176x220 pixel TFT display measuring 3.6x4.5cm.

2.2 The observation study

For the observation study, an article about the this study was shown on the web site and wap site of the Swedish newspaper Svenska Dagbladet for about two weeks. This newspaper also provided the initial feeds pre-configured in the software. This article was picked up by the weekly magazine Mobil, a magazine about mobile phones, which ran an article of their own shown on their web site and on their RSS feeds. Both articles provided links to a web page where anyone could get the software for free. In order to download the software, the users were required to fill out a form, where basic demographic information and information about their use of mobile news and RSS, was collected. Those participating in the study also participated in a lottery draw where they could win tickets to the movies, if they also entered their email address. The users could then download the software, and was provided with a unique identifier they had to enter in their phones once, and which they could use for the web interface where they could subscribe and unsubscribe to RSS feeds.

Each time the users started the software, information about the date, time and currently set reading speed was logged in a database. After the first use, the identifier did not have to be entered again, minimizing the effort to use the software. The study continued for 40 days before the database was closed and the data analysis commenced.

2.3 Technical overview

The software, named Feedo, was developed using Java MIDP 1.0, making it usable on most mobile phones. Two versions were developed.

Feedo Offline was used in the experiment study. Feedo Offline can display text both using RSVP and using a scroll-based scheme, as shown in Figure 1. In the experiment study, described in section 2.1, six texts were pre-loaded into the application.

Feedo RSVP, an RSS reader for displaying feeds using RSVP, was used in the observation study. Feedo RSVP can only show the summary of the text in the RSS feed, not the content of the page the entry in the feed refers to. After registering and downloading the software, the user gained access to a web page where a personal list of subscribed RSS feeds is maintained and can be edited. Four newsfeeds from the
newspaper Svenska Dagbladet were pre-installed, one of which contained the full news from the PDA-version of the newspaper.

The RSVP implementation displays one word at a time in a rapid sequence. Initially, the speed was set to display each word 240 ms, with extra time added for words longer than 6 characters, and for punctuation. For the texts used in the experiment this corresponded to roughly 167 words per minutes, slightly slower than the normal speed of 240 words per minute for reading Swedish (Björnsson 1968 quoted in Goldstein et al. 2003). The user can increase and decrease the speed when reading the text, and can also go back to the previous punctuation mark, meaning it is possible to go back, but not forwards in the text. The current speed is displayed in the upper right corner, and a progress bar is displayed under the text.

3. RESULTS

3.1 The experiment study

The two speed settings used, displaying each word 240 ms and 150 ms respectively, gives a theoretical maximum speed of 250 wpm and 400 wpm respectively, and the four cases tried were therefore abbreviated Scroll 250, RSVP 250, Scroll 400 and RSVP 400. However, since extra time was added for longer words and for punctuation, the actual speed for the texts used averaged 167 wpm for the slower setting and 267 wpm for the faster setting. Scroll 250, with plenty of time to read scroll based texts which is most similar to the way texts are read on phones today, gave the worst results for reading comprehension, and RSVP 400 gave the best result as shown in Table 1. Only two of ten students achieved their best test results using scroll 250, and seven got the best results using RSVP 400. Six students scored better results with RSVP 400 than Scroll 250, and only one student scored worse results.

<table>
<thead>
<tr>
<th>Respondent</th>
<th>RSVP 250</th>
<th>Scroll 250</th>
<th>RSVP 400</th>
<th>Scroll 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resp 1</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Resp 2</td>
<td>75</td>
<td>25</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Resp 3</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Resp 4</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Resp 5</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Resp 6</td>
<td>50</td>
<td>50</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Resp 7</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Resp 8</td>
<td>50</td>
<td>50</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Resp 9</td>
<td>100</td>
<td>25</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Resp 10</td>
<td>25</td>
<td>75</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Average</td>
<td>50</td>
<td>42.5</td>
<td>62.5</td>
<td>55</td>
</tr>
<tr>
<td>Avg correct answers</td>
<td>2</td>
<td>1.7</td>
<td>2.5</td>
<td>2.2</td>
</tr>
</tbody>
</table>

When looking at how comfortable the students were with these methods the results were reversed. Only one student preferred RSVP 400 over Scroll 250 and eight students preferred Scroll 250 over RSVP 400, as seen in Table 2.

<table>
<thead>
<tr>
<th>Respondent</th>
<th>RSVP 250</th>
<th>Scroll 250</th>
<th>RSVP 400</th>
<th>Scroll 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resp 1</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Resp 2</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Resp 3</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Resp 4</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Resp 5</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Resp 6</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Resp 7</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Resp 8</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Resp 9</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Resp 10</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Average</td>
<td>4.3</td>
<td>5.2</td>
<td>3.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.8</td>
<td>1.0</td>
<td>1.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>
3.2 The observation study

Feedo was downloaded and started at least once by 531 users during the first 32 days after made public, as seen in Figure 2. After 40 days a snapshot was taken of the database logs for these users, on which all information later is based.

![Figure 2. Number of users in the observation study](image)

After 40 days, 67 users had started the application at least 10 times as shown in Figure 3. Of these, 9 had never changed their reading speed, and are excluded when analyzing the development of the reading speed of the frequent users since they might never have discovered the possibility of changing speed. As seen in Figure 4 below, the median speed of these frequent users remained 240 ms/word, excluding extra delays for long words and punctuation, which was the initial speed corresponding to about 167 wpm. Users in the slower quartile decreased their reading speed (thereby increasing the time each word was shown) to reach an average of 277.5 ms/word on their 10th reading. The faster quartile increased their pace to an average of 152.5 ms/word, corresponding to roughly 265 wpm, on their 10th reading.

![Figure 3. Users starting Feedo at least n times](image)

Of the feeds read by these 67 frequent users, 44.7% of the reading events were generated from reading full text articles, which on one sampled day contained on an average 305 words (σ = 171) or 1611 characters excluding spaces (σ = 863), with an average LIX value of 43.4 (σ = 5.9). 36.5% of the reading events were generated from reading the three pre-loaded short RSS-feeds, which on a sample day contained on an average 28 words (σ = 5.8) or 154 characters excluding spaces (σ = 26), with an average LIX value of 27.2 (σ = 9.7). The remaining 18.7% reading events were from 57 feeds entered individually by the users, with varying content.
Of the 531 users who downloaded and used the program, 473 already read news on their mobile phones and 34 already read RSS feeds on their mobile phones. Of the 67 frequent users, the corresponding figures were 64 for mobile news, and 3 for mobile RSS feeds. As seen in Figure 5, no significant difference could be found in the previous use of mobile news and RSS between the frequent users and all users.

4. ANALYSIS

The null hypothesis was that the results in text comprehension would be unchanged for the four different methods. The analysis was conducted using SPSS 11.0 with its repeated measures General Linear Model. The dependent factors were the different text presentation methods (Scroll 250 vs. RSVP 250 vs. Scroll 400 vs. RSVP 400). The significance level was set to 5%. The variance analysis showed that the null hypothesis could not be rejected ($F[3,27]=1.089$, $p=0.371$). However, since none of the students had previous experience with using RSVP and had years of experience using scroll based methods for reading, and given the fact that both of the RSVP methods scored better results than the corresponding scroll method, the question whether RSVP is a better way to present learning material than scroll based methods on mobile phones remains very interesting.

The observation study mainly included readers who were used both to reading news on mobile phones and to RSS feeds, and who were also interested enough to download new software to their phones. This would make them more or less ideal candidates to read RSS feeds with RSVP. However, only 13% of the 531 users used the software 10 or more times during the observed period, indicating most readers did not like the technology enough to use it on a regular basis. However, there could be several other causes for this, such as Feedo lacking functions some user expects from an RSS reader, lack of interesting material to read, not discovering the possibility to alter the speed etc. The observation study showed that the majority mostly read the full-length articles, not the short RSS notices, indicating that RSVP can be used to read longer texts.

5. CONCLUSIONS AND DISCUSSION

Results from several other studies have shown that RSVP scores well in reading speed and reading comprehension on desktop computers. This study indicates these results are valid also for RSVP on mobile devices, even tough the number of participants in the experiment were too few to show the results are
statistically significant. The main obstacle for using RSVP remains that users feel uncomfortable with this technique, which is not unexpected due to the massive amounts of training invested in reading spatially presented text. Other problems compared to paper based text is the lack of possibilities to take notes and underline interesting passages, and how to deal with pictures. The transformation of textual presentation from a spatial to a temporal domain also introduces the problems associated with video and audio, namely the difficulties of not having random access to different parts of the content (Hedin 2006).

Still, a method like RSVP, making effective reading of long text-based educational content on standard mobile phones possible, could have a huge impact on m-Learning since the client platform already exists, and could be the platform for making learning anywhere, anytime a reality even today. We believe further exploration of this topic is very important for the m-Learning community.

An interesting m-Learning application would be to use RSVP to present advance organizers to students. These are short "introductions" of topics, which can help students assimilate learning material into their cognitive structures (Ausubel 1968). Instead of attending a lecture unprepared, a basic cognitive framework exists to which the content of the lecture can be related. An earlier study indicated that sending advance organizers to students is an appreciated m-Learning application, but that the length of the texts should be relatively short due to the difficulties of reading long texts on small screens (Hedin 2006). Using RSS as the distribution channel, and RSVP on mobile phones as the user interface could be an m-Learning method for using advance organizers of greater length than what would be acceptable with scroll based reading.

Further studies could also include to extend the experiment part of this study with more participants, making it possible to draw more statistically reliable conclusions. Finally, finding ways for navigating with hyperlinks between texts displayed using RSVP is an interesting topic, well worth exploring further.

REFERENCES


