Mobile Learning
A Comparison of Presentation Methods for Reading on Mobile Phones

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A study compares traditional scroll-based methods for reading text-based content on mobile phones with Rapid Serial Visual Presentation (RSVP), a method that displays words sequentially.

Mobile learning is receiving increasing attention but has yet to reach maturity. To spread widely outside the research community and niche applications, m-learning requires a client platform that’s available to most learners anywhere, anytime, which excludes PDAs, iPods, and similar devices that aren’t widely available. However, we can expect almost all potential m-learning students to own, either now or in the near future, a mobile phone that can use Java MIDP (Mobile Information Device Profile) software and send and receive IP data traffic. Furthermore, m-learning content, produced either by teachers as learning material or by students for communication purposes, must be easy to produce and deliver for this platform. Numerous factors speak in favor of using text rather than audio or video—primarily, the vast amounts of available text-based content, the simplicity of producing such content, and the high cost of producing audio- or video-based content. So, finding good ways to create, deliver, and read text-based content on mobile phones is important to m-learning’s future.

The Rapid Serial Visual Presentation text-reading method presents text one word or a few words at a time in rapid sequence rather than using page- or scroll-based layouts like those of books or Web pages. Many researchers have investigated using RSVP on computer screens in controlled experiments. Some have also looked at using RSVP on small screens, primarily PDAs, but using RSVP on mobile phones remains largely unexplored. Studies on using RSVP on computer screens have shown that reading speed and comprehension don’t decrease with this method; speed might even increase. For mobile phones, where many consider reading longer texts difficult, fast reading combined with high comprehension should be ideal. One study indicated that reading speed and comprehension level using RSVP on small screen displays equaled speed and comprehension when reading books. If readability, comprehensibility, and preference rating are sufficient, RSVP could be a good platform for text-based m-learning.

Here, we evaluate four modes for reading texts on mobile phones in terms of users’ reading comprehension, efficiency, and preference ratings. We also discuss possible ways to publish m-learning content. This article extends and complements an earlier publication.

Previous work
Kenneth I. Forster first used the term RSVP to mean rapidly displaying words in a sequence in the same visual location. He used the technique to investigate how sentence complexity affects people’s ability to recall words in a sentence. Forster describes four experiments examining how well people could identify words in sentences presented with RSVP. He conducted the experiments 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, which corresponds to 960 words per minute. James F. Joula, Niklas J. Ward, and Timothy McNamara report the normal reading speed for English as about 300 wpm. Carl-Hugo Björnsson, quoted in a paper by Mikael Goldstein, Gustav Öquist, and Staffan Björk, reports the normal reading speed for Swedish as about 240 wpm.
Forster found that his respondents, who were students, could identify approximately four out of six words in sentences presented with RSVP at 960 wpm. He also found that sentence complexity affected reading comprehension. The respondents reported a larger percentage of correct words in simple sentences and fewer correct words in compound sentences (sentences with two independent clauses). The worst results came from using randomly chosen words.

Joula and his colleagues later suggested that RSVP could increase reading speed. Normally, while you’re reading text on paper, three things occur:

- fixations of the eyes in which you process information, a task requiring on average 330 milliseconds;
- saccadic eye movements or movement of the eyes between fixations, averaging 40 ms; and
- return sweeps, which occur when the eyes move to the next line of text, averaging 55 ms.

Using RSVP eliminates the need for saccadic eye movements and return sweeps, which can increase reading speed. For mobile phones, where reading normally requires much scrolling and many line sweeps, the effect could be even greater.

Joula and his colleagues also introduced the computer as a medium for RSVP and showed that Forster’s results from 1970 were generalizable to computers. They further showed that reading comprehension for shorter texts was similar for RSVP and spatially presented text at various speeds when read on a computer screen.

Michael E.J. Masson compared RSVP and spatial text representation when skimming texts. His theory was that RSVP could give better results than spatially presented text because people often miss important information and don’t read certain paragraphs when skimming. Using RSVP would guarantee that every word was exposed to the user. His study showed that the respondents actually performed worse using RSVP, but Masson also found ways to improve performance by introducing short pauses between each sentence. He interpreted this as an indication that in conventional reading, much of the conceptual processing of a sentence’s content happens at the end of the sentence. Later RSVP investigations have also shown good results when pauses occur at the ends of sentences.

Later research has covered improvements to RSVP that could increase its popularity, decrease the cognitive load, and improve reading comprehension. Monica S. Castelhano and Paul Muter also showed that preference for RSVP rapidly increases with practice.

In a study on using RSVP on small screens, Karin Sicheritz found that objective measures of reading speed, comprehension level, and performance remained unchanged compared to reading in a book. However, users’ subjective views of their comprehension and performance decreased.

Our hypotheses

We evaluated four methods: slow, self-paced scrolling corresponding to the common method of reading texts on mobile phones today; slow RSVP; fast scrolling; and fast RSVP. We investigate comprehension, measured as the number of correct answers to multiple-choice questions normalized to a value between 0 and 1; efficiency, measured as comprehensibility multiplied by reading speed in wpm; and preference rating, measured as a magnitude rating of the students’ like or dislike for the mode, again normalized to a value between 0 and 1.

In this work, we tested five null hypotheses. The first three relate to the entire test population:

H1: Text comprehension is independent of reading mode.
H2: Reading efficiency is independent of reading mode.
H3: Preference rating is independent of reading mode.
To attain more relevant results concerning using fast-paced RSVP as a platform for distributing learning content, we restricted the population to students whose preference rating for fast RSVP was neutral or better and was also equal to or higher than their preference for self-paced scroll. We did this because members of this group would be most likely to use RSVP for reading texts. Given this restriction, we formulated two more hypotheses:

H4: For this group, text comprehension is independent of using self-paced scroll or fast RSVP.
H5: For this group, reading efficiency is independent of using self-paced scroll or fast RSVP.

**Technical overview**

For our tests, we developed two versions of a prototype named Feedo. We used Java MIDP 1.0 so it would be usable on most mobile phones. Feedo RSVP is an RSVP reader for RSS. In an observation study we conducted, users downloaded the client and used it to read content from a newspaper as well as RSS feeds they chose. FeedoOffline, which we used in the experiment we discuss in this article, uses preloaded texts and can also display texts using scroll. (This isn’t allowed in Feedo RSVP.)

For the initial RSVP implementation, we set the speed to display each word for 240 ms, with extra time added for words longer than six characters and for punctuation. For the texts used in the experiment, this corresponded to roughly 175 wpm, slightly slower than the normal reading speed for Swedish. The user can speed up and slow down when reading the text and go back to the previous punctuation mark, meaning it’s possible to go back but not forward in the text. For scroll-based reading, the screen displays a progress bar on the right-hand side (see figure 1a); for RSVP, the screen displays the speed in the upper right corner and a progress bar under the text (see figure 1b).

**Figure 1. Screenshots of the Web emulations of a Nokia 6600 smart phone that study participants used for (a) scroll-based reading (including a progress bar showing time left on the right-hand side of the screen) and (b) reading using Rapid Serial Visual Presentation. The RSVP implementation displays the speed in the upper right corner and a progress bar under the text.**
Method

To measure the three parameters (comprehension, efficiency, and preference rating), we chose an experimental approach, which let us control the evaluation conditions. We conducted the experiment in two parts: a pilot study with 10 students and another study with 73 more students.

For the pilot study, the participants were third-year university students from a media perception course. Ten of 37 students in the course chose to participate—four men and six women from 21 to 24 years old. We preloaded the FeedoOffline application with six texts; the participants used two for practice and the remaining four in the test.

Choosing the texts

We chose the six texts and their corresponding four multiple-choice questions from the READ subtest from the Swedish Scholastic Assessment Test. SweSAT is a national admission test that measures students’ general aptitude for learning, and the READ subtest broadly measures Swedish reading comprehension. Each text in our study included 926 to 939 words and was 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 values of 60 or more are considered very difficult. Catrin Norrby and Aina Lundqvist calculated technical literature to average 56. 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 six or more characters, expressed as a percentage.

A normal SweSAT READ test consists of five texts with four multiple-choice questions per text. Students have 50 minutes to complete the test, averaging 10 minutes per text. Our test used two speed settings: 5 minutes and 20 seconds per text for the slower speed and 3 minutes and 30 seconds per text for the faster speed. Also, the students couldn’t go back and look for answers in the text once they got to the questions, although they can do so in the SweSAT test. The shorter time and inability to go back made our test more difficult than the original SweSAT tests.

Gathering data

In the pilot study, we used a Sony Ericsson Z800i with a 176 × 220 pixel TFT (thin-film transistor) display measuring 3.6 × 4.5 cm. The students first read one text with RSVP, which familiarized them with the technology and the texts’ complexity level. We then instructed half of the students to read a new text using RSVP with the speed set to display each word for 240 ms. This corresponded to 175 wpm, including extra time for long words and after punctuation, or about 5:20 total. The other half started reading a text using scroll-based reading. We instructed them to read at a comfortable pace and told them we’d give them a signal halfway through the reading time. The students then answered four multiple-choice questions about the text. We instructed them not to guess if they didn’t know an answer. We then repeated the procedure, changing the reading method so that students who started with RSVP now used scroll, and vice versa.

We conducted the test again, giving half the participants a new RSVP text with the delay set to 150 ms per word, corresponding to about 267 wpm or 3:30 total. We gave the other half a new text to read using the scroll-based method with the same time limit, this time with the instructions to read fast. Finally, we had the respondents rate the four modes on a scale of 1 (strongly dislike) to 7 (strongly like). We rotated the texts’ order to minimize the effects of possibly different difficulty levels.

For the second stage of empirical data gathering, we invited students in three courses to participate. The participants were third- and fourth-year university students participating in similar courses in XML programming. Seventy-three of 119 students in the courses chose to participate, 45 men and 28 women from 21 to 32 years old. We included the data from the pilot study when analyzing the data for a total of 83 respondents.
This time, the students performed the experiment in a Web environment. They used an applet emulating a Nokia 6600 smart phone running FeedoOffline for the RSVP test, and a Web page with an iframe emulating FeedoOffline's scrolling function (see figure 1). Both versions also included a progress bar indicating how much time remained. Participants navigated to a Web site, where an algorithm decided the order, speed, and method they should use for reading the four different texts to eliminate biases from these factors. We used the same texts as in the pilot, and the setup was identical. See the demo at www.hedin.mobi/dsonline-demo.

Results

Table 1 shows descriptive data for the study. The modes are named after the technology (RSVP or scroll) and nominal speed in wpm (250 or 400). Owing to the extra time we added for long words and punctuations, the actual speeds were 175 and 267 wpm; these are the values we used to calculate efficiency. Scroll 250 (self-paced scroll with plenty of time to read texts) is most similar to the way people read texts on phones today. For each mode, we measured comprehension, efficiency, and preference rating. The table includes data for all respondents (G) and for respondents with neutral or higher preference ratings for fast RSVP and equal or higher preference ratings for fast RSVP compared with self-paced scroll (G').

Table 1. Descriptive data for our study.

<table>
<thead>
<tr>
<th>G (n = 83)*</th>
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<tbody>
<tr>
<td>Mode</td>
<td>Comprehension (0–1)</td>
<td>Efficiency (comprehension × wpm)</td>
<td>Preference rating (0–1)</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>Standard deviation</td>
<td>Average</td>
</tr>
<tr>
<td>RSVP 250</td>
<td>0.40</td>
<td>0.26</td>
<td>70</td>
</tr>
<tr>
<td>Scroll 250</td>
<td>0.42</td>
<td>0.27</td>
<td>73</td>
</tr>
<tr>
<td>RSVP 400</td>
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<td>0.30</td>
<td>111</td>
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<tr>
<td>Scroll 400</td>
<td>0.36</td>
<td>0.28</td>
<td>97</td>
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<table>
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<th>G' (n = 31)†</th>
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<tbody>
<tr>
<td>Mode</td>
<td>Comprehension (0–1)</td>
<td>Efficiency (comprehension × wpm)</td>
<td>Preference rating (0–1)</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>Standard deviation</td>
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<td>Scroll 250</td>
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<td>RSVP 400</td>
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<tr>
<td>Scroll 400</td>
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</table>

*Data for all respondents
†Data for respondents with neutral or higher preference ratings for fast RSVP and equal or higher preference ratings for fast RSVP compared with self-paced scroll
For our first three hypotheses (H1, H2, and H3), we conducted our data analyses with SPSS v14.0, using analysis of variance (Anova) tests with the general linear model and repeated measures. The dependent factors were the different modes. The level of significance for our multiple comparisons was Bonferroni adjusted. For the final two hypotheses (H4 and H5), we used two-tailed paired t-tests. We set the significance level to 5 percent for all hypotheses.

Our analysis showed that H1 couldn't be rejected ($F[3,246] = 0.741, p = 0.392$) but that H2 could be rejected ($F[3,246] = 17.8, p = 6 \times 10^{-5}$). Subsequent pairwise comparisons showed significant differences between all modes, except RSVP 400 versus scroll 400 and RSVP 250 versus scroll 250. Of special interest is the high statistically significant difference in reading efficiency between the fast RSVP and self-paced scroll ($p = 0.0007$), as table 1 shows. This indicates that fast RSVP is more efficient than normal self-paced scroll, even when the users are new to the technique.

Our analysis also showed that H3 could be rejected ($F[3,246] = 37.5, p = 3 \times 10^{-8}$). Subsequent pairwise comparisons showed significant differences between all modes except between RSVP 400 and scroll 400. Especially noteworthy are the high acceptance of self-paced scroll and the relatively high standard deviation of RSVP 400 (see table 1). This indicates that many users rather strongly like or dislike fast RSVP. Thirty-one respondents, or 37 percent, either preferred RSVP 400 over scroll 250 or considered these modes equal and also gave a neutral or positive preference rating to RSVP 400. Members of this group are the most likely to actually use fast RSVP for learning in practice and are therefore of special interest, so our last two hypotheses focus on this group.

We found that H4 could not be rejected ($p = 0.10$), but our results indicated that users who like fast RSVP also perform very well using the technique. We also found that H5 could be rejected ($p = 0.0006$), indicating that this group would be well suited to use fast RSVP for mobile learning.

**Discussion**

Only six of the 83 students had tried RSVP before, and all had had years of experience using scroll-based methods for reading on mobile phones. Despite this, the results show comprehension is roughly equal for each mode for the whole group, and efficiency is significantly better with fast-paced RSVP than self-based scroll. Although our respondents significantly preferred slow scroll-based reading over fast RSVP, 37 percent of the students liked RSVP as much as or more than self-paced scroll and also gave neutral or positive preference ratings for fast RSVP. For this group, the mean value for efficiency using fast RSVP is more than twice that of self-paced scroll. Because preference for RSVP increases with practice, we could expect this group to grow in size if users were given opportunities to practice. Combined, the results show that RSVP is definitely an interesting technology for m-learning content delivery for a large group of students.

However, serializing text introduces problems, such as dealing with pictures, figures, tables, and other types of content that aren’t easy to serialize. Transforming 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. Developing navigational tools such as indexes, free text searches, and hyperlinks is therefore important.

The high cognitive load of using RSVP suggests that texts should be of a manageable size and that longer texts should be “chunked” into shorter sections. Using natural chunks such as chapters and sections could be a good starting point. Another approach is to write shorter texts. According to Diana Oblinger and James Oblinger, the “Net Generation” now entering universities will be unwilling to read large amounts of text anyway. Furthermore, the ability to read on mobile phones lets you take advantage of microlearning opportunities, such as while you’re waiting for a bus. Reading a complete shorter text at such times makes more sense than reading a fragment of a longer text.

Making content publishing as easy as possible is essential to making it usable in a learning context. The approach we used in Feedo RSVP (using RSS-based content) is flexible and makes publishing simple—for example, you can use blogs, technologies for multiple-channel publishing, or Web 2.0 services.
Because RSS is an open format, using an RSVP reader is only one of many ways to access the content; you could also use Web browsers, dedicated RSS readers, RSS-to-mail services, or RSS-to-Web services. Web sites such as www.talkr.com or www.xfruits.com even use text-to-speech technologies to offer RSS-to-voice-podcast services. The current Feedo implementation also makes it simple for teachers to add content for specific groups of users via a login database. This content becomes available to students the next time they access Feedo, making the system practical for use in courses.

Using RSVP on mobile phones as a platform for delivering teacher- or authority-produced content relates to a behaviorist learning paradigm. However, peers (that is, fellow students) could also produce the content, which relates to a collaborative learning paradigm. Peer learning, where students help each other to learn, is very effective, as described in many studies summarized by Nancy Falchikov. Laura Naismith and her colleagues identify mobile computer-supported collaborative learning as one of the major m-learning areas that “focus on the use of mobile technologies to promote, facilitate and enhance interactions and collaborations between students.” According to Oblinger and Oblinger, the Net Generation is open to this kind of social learning activity, is comfortable using blogs and other social software, and is used to instant access to information. Using blogs for such collaborative learning is especially useful for mobile RSVP; blogs can generate RSS feeds and are mainly text based, and entries are generally relatively short. RSVP on mobile devices is therefore a good way to move these social activities from the desktop to the mobile domain.

Although problems exist, a method such as RSVP that lets you effectively read long text-based educational content on mobile phones could have a huge impact on m-learning. The client platform exists, as do vast amounts of text-based learning content, and publishing content for this platform is simple. We believe further exploration of this topic is very important for the m-learning community.

In future studies, we plan to produce content for regular courses at our university and to make it accessible to students using Feedo RSVP or other RSS readers. We’ll investigate if, how, and when students use the content, focusing on mobile microlearning opportunities.

References


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