Radio Text Displays for Radio Captioning

Results from Three Studies

Accessible Digital Radio Broadcast Services

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Table of Contents

Table of Figures and Tables

Executive Summary

In three studies consumer preferences and memory performance for radio text displays was examined. In total over 140 consumers participated in this experimental program, including hearing, hard-of-hearing and deaf individuals. Laboratory testing (studies 1 and 2) was conducted on PC's with screen displays that simulated large radio displays (GPS size – 4" x 6") and smaller radio displays found currently in many automobiles (1" x 3"). Testing was conducted at NPR Labs during 2008. Variables of interest included:

- Look and feel of the displays
  - Size
  - Color
  - text font
  - Scroll style
  - text placement
  - line length
- Audio and text synchronization
- Emergency alert messages and emergency prompts for drivers
- Announcer identification schemes

In studies 1 and 2, participants were provided with several scenarios and asked to give their "preferences" for display look and feel. Additionally they were tested on their memory for text details in an immediate recall test (referred to as "performance"). In Study 2, deaf and hard-of-hearing consumers participated in both individual testing and focus group discussions. The following conclusions and recommendations are based on both individual testing and group discussions.

A third study was conducted on Election night, November 2008, in cities across the United States. Five host radio stations carried transcribed broadcasts of NPR election returns over large text displays and across the web. This activity was not a controlled study, but rather its goal was to gain information from a large number of deaf and hard-of-hearing consumers regarding prototyped text display radio technology.

We first present Recommendations for receiver manufacturers, based on results from these studies and the state of current radio technology. We then present conclusions from consumer testing, focus group questionnaires and worksheets and transcriptions recorded from group discussions.

Recommendations for Radio Receiver Manufacturers:

- ✓ **Size of Display:**
  - Large (4" x 6" GPS style) displays are recommended for all types of broadcasts including news, multi-announcer shows and emergency alerting. As is evident from test responses, all participants felt comfortable reading on larger displays and showed good retention for information. Deaf and hard-of-hearing consumers reported that they would purchase both home and car units and use them on a

- Small (1” x 3”) displays are recommended only for emergency alerting. Participants did not feel comfortable about reading for long periods when viewing one-line of text – either when several words were flashed or when continuous horizontal scrolling was used. Participants suggested that user-controlled scroll speed would be desirable if small displays were brought to market.

✓ **Synchronization for Real-time listening/viewing:**

- Audio should be synchronized to text for maximum pleasure and cognitive efficiency. Synchronized audio-text is defined as being able to see the words on the display at all times as the audio is played.
- Although participants felt the rate of synchronized scrolling was reasonable for large displays, they also felt that buffering playback-rewind should be available to assist those consumers who may not be able to read as quickly.

✓ **Look and Feel**

- Color choices
  - Although people found black on yellow more interesting, the white-on-black combination seemed better for memory performance, especially for deaf participants. It is probable that better performance was a result of the high level of white-on-black TV captioning to which deaf people are exposed. Whether recall performance would continue to be better after they were exposed to other color choices for longer periods is a question that field-testing may be able to answer.
  - Giving users control over both text and background color would be maximally efficient for various lighting situations (i.e., day, night, dusk, etc.) and multiple users (i.e., normally sighted consumers, consumers with low vision, consumers with color-blindness, etc.).

- Font choices
  - User-control is recommended for both setting font style and most importantly font size.

- Presentation of text
  - For large screens, both vertical scrolling and block text are recommended.
  - Left justification (as opposed to centering text) is recommended.

- Presentation by multiple announcers.
  - Text displays that feature more than one announcer or speaker (typical of radio broadcasting) should be color coded as well as identifying the announcer’s name in parenthesis.

- ✓ **Emergency Alerting**
  - Displays that are centered in the middle of the screen are recommended. Color change from text to emergency message is also recommended, as well as giving information in blocks.

- ✓ **Emergency Alert Prompting for drivers**
  - Prior to the full-text message appearing, color prompting with slow flashing is recommended to catch drivers' attention. Icons placed at the top of the screen to pictorially describe the specific disaster or emergency are recommended.
  - Slow-flashing alert messages on the dashboard, or seat shaker technology are recommended in order to display the emergency message in the most efficient and expeditious manner.

Conclusions from 3 studies:

Study 1: Preliminary testing of display features

- The large display was rated by participants as significantly more usable, pleasing and memorable than the small display
- Participants overwhelmingly preferred using the radio when the audio was synchronized to text
- No preferences were shown for presented color schemes - "white on black" or "black on yellow"
- Participants slightly preferred serif to sans serif typeface. They performed significantly better on the recall performance test when stories was presented in serif, but only when audio was turned off and they were merely reading the text
- No preference was articulated for line length (short or long)
- Participants reported having an easier time reading text when words were positioned closer to the bottom of the screen as audio was played versus when words were positioned closer to the top, presumably because they felt they had more time to read as scrolling ensued
- On small displays participants overwhelmingly preferred presenting text in blocks (2-4 words at a time) to times-square scrolling (continuous, letter by letter).

Study 2: Testing display features with deaf and hard-of-hearing consumers

- There were general differences in the ways deaf and hard-of-hearing participants rated all displays: hard-of-hearing participants felt that the displays were easier to read, they experience less fatigue, claimed they were better able to understand the text and more often said they would continue reading. However, immediate retention performance was equivalent between deaf and hard-of-hearing participants.
- When we categorized participants as "individuals deafened after 15" (early English readers) and "individuals deafened before 15" (late English readers), we found no preference or performance differences.

- For all participants combined, few meaningful differences were reported between two presented color schemes (white-on-black and black-on-yellow). Although participants thought black-on-yellow was more interesting and enjoyable to read, for deaf participants, memory performance was better with white text on a black background.
- No meaningful preferences or performance differences were reported for font type (serif vs. sans serif).
- Participants overwhelmingly rated colors as their preference for identifying who was speaking, as opposed to names of announcers in parentheses and photographs of announcers. They also felt spacing was very important, and were more comfortable with left-justification of text than centering. In memory performance, participants remembered significantly more of the text when announcers were color coded than when their names were in parenthesis or they were identified by photographs.
- During emergency alerts which interrupted regular programming, participants overwhelmingly preferred block and vertical scrolling to horizontal scrolling. Interestingly memory performance for vertical scrolling was not as good as block and horizontal scrolling.
- Participants did not have a preference for color schemes during emergency alerting, but preferred the emergency messages to be broadcast in the middle of the screen.
- For emergency alert driver prompts, most participants agreed that some form of color prompting was preferable as well as slow flashing (strobe-like flashing may cause seizures so it is not recommended). Participants liked the idea of an icon placed at the top of the screen to pictorially describe the specific disaster or emergency.
- For hard-of-hearing participants, strong preferences were indicated for complete synchronization (audio being played matched with words placed somewhere on the display).
- On small screens, participants preferred block presentation of a few words over times-square, continuous scrolling. A major complaint was that both block and continuous scrolling on a single line forced the reader to read at an unnatural pace and read “word by word” instead of in sentences.

Study 3 - Election night:

- The majority of consumers (58%) felt that real-time captioning as presented over the air seemed to be paced well and 69% felt the captioning was accurate. However, 73% felt the scrolling was too choppy which made following the text more difficult than had it been smoother.
- A strong majority (77%) claimed they would be interested in purchasing a text-display radio for home use and 66% of consumers claimed they would be interesting in purchasing a text-display radio for automobile use.
- Consumers felt that using text-display radio would be most valuable during times of emergency and for weather and traffic reports, and felt they would be most likely to use it in their car or with an iPod or other portable player.
- An overwhelming majority (86%) claimed that they would be interested in purchasing a "dual-screen" view (GPS for the driver and captioned radio for the passenger). About half of the participants suggested that would be interested in a captioned radio display for the backseat of their car.

Introduction

The purpose of this report is to recommend to receiver manufacturers best-practice technologies and display features for inclusion in accessible radio displays. Results from 2 consumer studies conducted at NPR Labs are included, as well as informal consumer assessments of real-time captioning of NPR's Presidential Election Night in November, 2008.

Results focus on the following:

- Color of the display screen and color of display text
- Font characteristics of display text
- Text presentation
- Formatting of emergency alerting messages
- Visual announcer identification
- Prompting the driver to emergency alerts
- Best synchronization practices
- Screen requirements (size and brightness)

Consumers served by captioned radio technology

The goal of text display radio technology is to provide content to people who are either unable to hear or have extreme difficulty hearing audio. Hearing loss is an international problem. According to the WHO, in 2005 "278 million people worldwide had moderate to profound hearing loss in both ears." The National Institute on Deafness and other Communication Disorders (NIDCD) claims that 17% of the U.S adult population or 36 million people have some degree of hearing loss.[1] These statistics show an 8.4% increase in hearing loss cases over the last 18 years, due to prolonged life expectancy and the aging baby boomer population developing age-related hearing loss.

Given the magnitude of hearing loss and growth in an aging population, we believe that text display radio technology must be developed for the broadest range of individuals in mind. To this end, we have included hearing, deaf and hard-of-hearing individuals in our test program.

Differences in preferences and performance across degrees of hearing loss

Hard-of-hearing and deaf individuals differ in more ways than the degree of their

1 NIDCD statistics on hearing loss can be found through the following link: http://www.nidcd.nih.gov/health/statistics/quick.htm

hearing loss. Due to their variable exposure to speech, preferences and performance differences are noticeable, particularly in reading rates and need for synchronized text and audio.

Many people who are born deaf or who have become deafened at an early age learn American Sign Language (ASL) as their first language and English as their second language. This, along with their inability to hear spoken English, may decrease their natural reading rate. Alternatively, individuals who are hard-of-hearing have commensurate reading rates with the population at large, and can "hear" audio effectively if they are given a "boost" in the form of captioned text. Because of this, for hard-of-hearing individuals, synchronization of audio and text is a vitally important area to explore.

Special considerations when designing captioned radios

In recommending design features, we have tried to be sensitive to special sensory-loss issues. Perhaps the most important of these is co-morbidity, where individuals have both hearing and vision loss. This occurs primarily with the aging population. Possible issues may include screen brightness or the inability to read the text being captioned using the limited real-estate of the radio screen.

Above and beyond the audio being displayed as captioned text, there are several features that consumers who are deaf and hard-of-hearing have called for and are important of mention:

- Ability to buffer captioned radio output so that consumers can re-read portions at their discretion
- Ability for consumer to control features, such as screen color and brightness, alerting features, line length and speed of scrolling, etc.
- Ability to display several colors on the screen at once

Emergency alerting

Accessible radio will provide deaf and hard-of-hearing individuals with mobile access to emergency information, news, traffic alerts, or other important information. Providing emergency alerting messages through captioned radio was a major motivation for this project, and as such we included consumer testing on emergency message presentation.

Structure of report

This report is comprised of 3 studies. Study 1, conducted primarily with hearing individuals, narrowed the field of testable variables that were included in the second study. Through a careful review of the literature several variables were uncovered that

required focused exploration, including text color and font, line length, placement of text synchronized with audio, scroll speed. Because it would have been prohibitive to test all variables on deaf and hard-of-hearing consumers, we decided to test a number of these variables with the general public first.

In Study 2, we conducted tests exclusively with deaf and hard-of-hearing participants to (a) verify results obtained in Study 1 and to (b) collect additional important information concerning presentation of emergency information, driver alerting schemes and announcer identification look and feel.

In Study 3 we evaluated NPR's real-time captioned broadcast of Election night, November, 2008 with deaf and hard-of-hearing consumers.

In total we collected data from almost 150 people, of which approximately 110 were deaf or hard-of-hearing.

Study1: Preliminary testing of display features

Participants

Participants for this study consisted of 31 hearing and 4 hard-of-hearing 18 to 65 year olds. Participants were recruited from the local community through both www.craigslist.com and outreach attempts. 75% were female and 25% were male.

Methodology

In Study 1 we presented participants with 16 stories, each approximately 2 to 3 minutes in length. This length was chosen so participants had adequate exposure to the stories to gauge the amount of eye strain and fatigue they would feel if they were actually reading captions on a radio screen. Stories were taken from NPR's transcript database, and carefully chosen based upon their content, reading speed, length and inclusion of two announcers. Selected stories ranged between 169 and 189 words per minute, which is typical of speech rates found in NPR broadcasts.

A multi-step process was used to create the test stories. Transcripts were found on the NPR intranet, and the corresponding audio was located in the NPR broadcast library. The audio was uploaded into a computer using a .wav lossless format. The audio tracks were edited to an appropriate length using the audio editing program, Audacity. Using a software program written by NPR Labs, the text documents were converted to scrolling text. The audio was then played while the software program produced the scrolling text. Because individual clips were faster in some spots, slower in others (as is typical of announcers speaking) selecting the correct scrolling speed included taking an average of the two speeds and ensuring that the "text" was always on the screen as the words were being spoken

Video capture software, Camtasia Studio 5, was used to create .avi movie files that were presented to the participants. E-prime software was used to embed the movie files into an experimental interface.

Pilot to ensure consistency among stories

In order to ensure that each of the stories used in Study 1 would be equally interesting and memorable to participants, we conducted a pre-test with eight participants (5 female and 3 male, average age of 37) to select 16 of 18 possible stories that we considered reasonably equivalent. In this test participants read all 18 stories presented to them on a 4" x 6" display. A 30 point font size was used along with the sans serif font style Tahoma. All clips were the same color combination of a golden yellow background with a black font.

In order to eliminate order and fatigue effects, presentation of the 18 clips was randomized. After reading each clip, participants answered both opinion based questions concerning the quality of their reading experience and content questions

designed to test their immediate retention of the stories.

Six preference questions were rated on a five point scale and were presented as follows:

1. How easy was it for you to read the text? (1 very hard to 5 very easy)
2. How interesting was the text passage? (1 not interesting to 5 very interesting)
3. What did you think of the speed of scrolling? (1 too slow to 5 too fast)
4. How tired did your eyes feel after reading? (1 very tired to 5 not tired at all)
5. How likely would you be to continue reading? (1 not very likely to 5 very likely)
6. How would you rate your overall enjoyment of this experience? (1 not enjoyable to 5 very enjoyable)

After responding to preference questions, participants were presented with three multiple choice questions concerning the content of the text clip.

Results of the Pilot Test

Analyses were conducted to see whether there were differences in preferences and in content question error rates between stories.

A two-way ANOVA was conducted on opinion question ratings with 18 stories as the between subject variable and the 6 opinion questions as the within subject variable. This analysis revealed no main effect of story (F (17, 126) = 1.602, p>.05 suggesting that all stories seemed comparable in “likeability, interest and scrolling speed”. However, two stories stood out from the others: #11 was rated somewhat higher than all other stories in likeability and interest, and #18 was rated somewhat lower than all other stories.

Accuracy on content questions between stories was analyzed by conducting a one-way ANOVA on error rates with the 18 stories as the between subject variable. No significant difference in error rates between stories was found (F (17, 126) = 1.402, p>.05), suggesting again that the stories were comparable.

Thus, we chose to eliminate #11 and #18 from our test, settling on the other 16 stories as comparable, in terms of likeability, interest, scrolling speed and comprehension.

Design of Study 1

In Study 1 we tested participants on both large screens (4” x 6”) and small screens (1” x 4”). For large screens, we used vertical captioning scroll, similar to “movie credit” scrolling found at the end of television shows. For small screens, we used horizontal captioning scroll (i.e., times-square scrolling), and block text.

For large screens, the following variables were explored:

- length of the line (short vs. long)
- start position of text on the screen as synchronized with speech (whether it was near the bottom or near the top)
- color of the background and text (black background with white text or yellow background with black text)
- style of font (sans serif or serif)
- synchronization (we played synchronized audio for half of the clips, and no audio for the other half).

For small screens, the following variables were explored:

- continuous scrolling vs. words in blocks
- color of background and text
- font style
- synchronization (we played synchronized audio for half of the clips, and no audio for the other half).

The number of variables and conditions totaled 48. However, because each story was approximately 3 minutes long, we felt that participants could not read all 48 stories without severely fatiguing. Therefore, they were divided into 3 groups, with an individual participant reading only 16 stories.

As with the pilot, presentation order of the clips was random, so no participants received the clips in the same order. After reading each clip, participants answered a series of questions, both preference-based questions concerning the quality of their experience and content questions designed to test their retention of the story content.

As with the pilot, six opinion questions were rated on a five point scale:

1. How easy was it for you to read the text? (1 very hard to 5 very easy),
2. How interesting was the text passage? (1 not interesting to 5 very interesting),
3. What did you think of the speed of scrolling? (1 too slow to 5 too fast),
4. How tired did your eyes feel after reading? (1 very tired to 5 not tired at all),
5. How likely would you be to continue reading? (1 not very likely to 5 very likely), and
6. How would you rate your overall enjoyment of this experience? (1 not enjoyable to 5 very enjoyable)

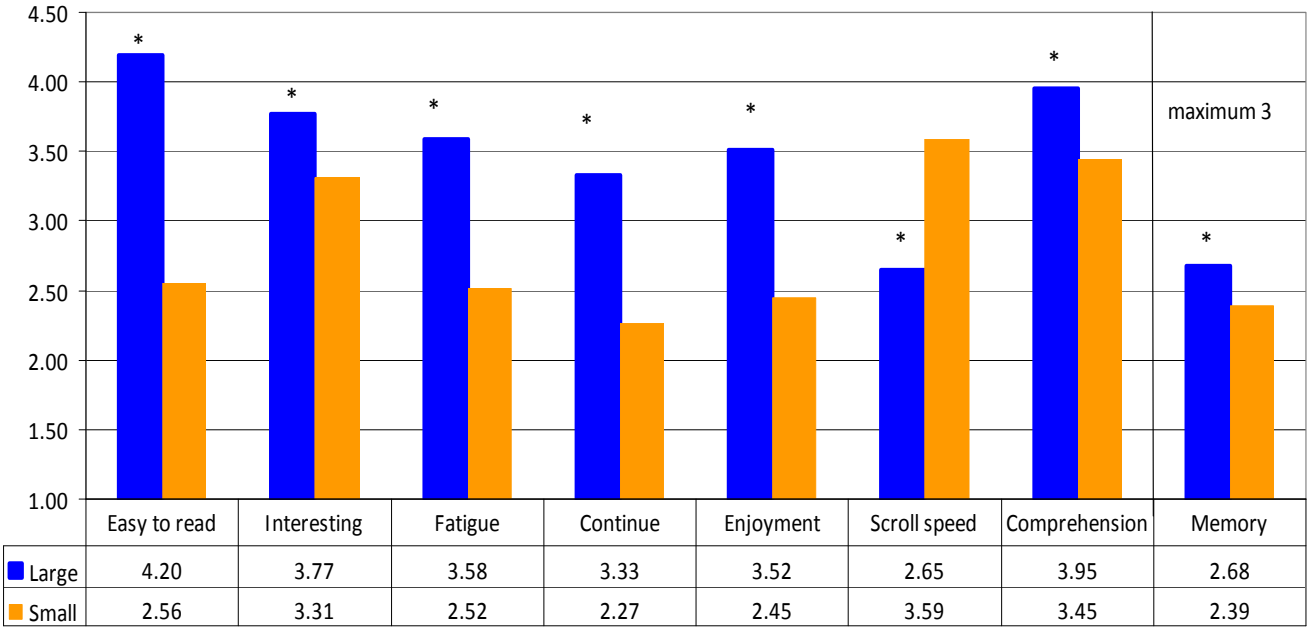
After responding to the opinion questions, participants were presented with three multiple choice questions concerning the content of the text clip they just read.

Results

Large displays vs. small displays

As is evident from Figure 1, participants consistently rated the larger display more favorably than the small display. When asked how easy it was to read the scrolling text, participants rated the large display favorably (M = 4.2) – significantly better than the small display (M = 2.6). They claimed they were significantly more interested in the text and significantly less fatigued when reading from the larger screen, and enjoyed the experience more. They also stated that they comprehended more when reading text on the larger screen, which was corroborated by their ability to recall facts about the stories. Further, they claimed that the scroll speed for the small display was significantly faster than average, indicating greater discomfort with the speed at which text would need to be presented if it were synchronized to audio. These results are not surprising, given the discrepancy of display size and scrolling method (i.e., the larger screen used vertical scrolling and the smaller screen used “times square” scrolling), but do give us insight into how consumers would react if display screen size is insufficient to carry enough text information. Further information on the small display can be found throughout this report.

Figure 1: Participants' overall ratings of large and small displays

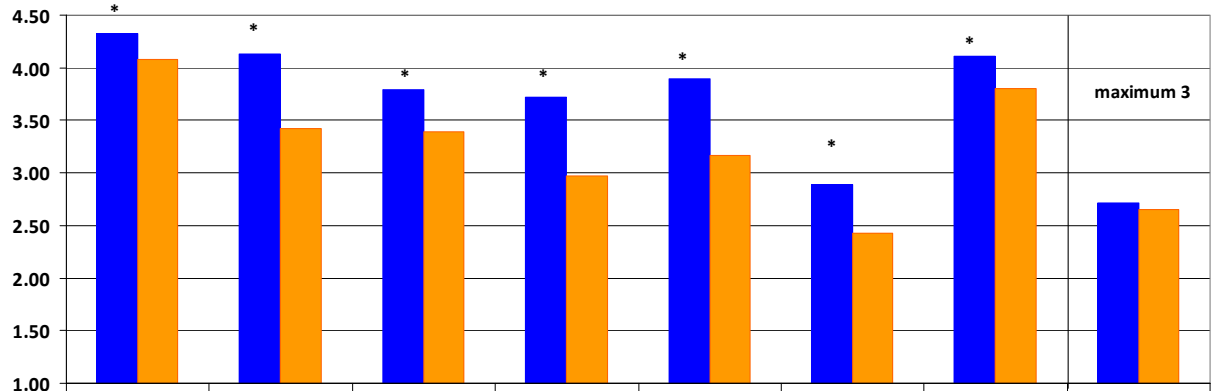


	Easy to read	Interesting	Fatigue	Continue	Enjoyment	Scroll speed	Comprehension	Memory
Large	4.20	3.77	3.58	3.33	3.52	2.65	3.95	2.68
Small	2.56	3.31	2.52	2.27	2.45	3.59	3.45	2.39

Audio on vs. Audio off

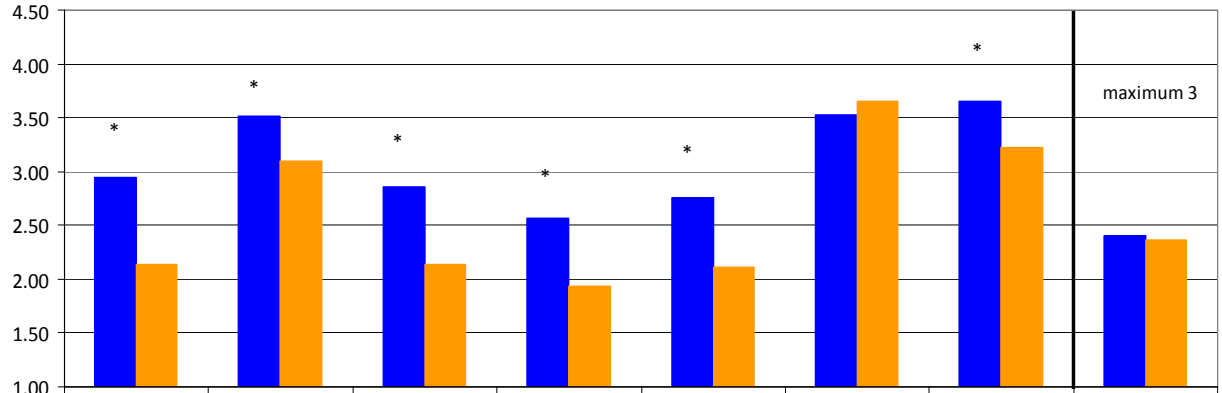
For all of questions we asked, participants preferred when the audio was on and synchronized to the text. Again, these results are not surprising since most of the participants were hearing individuals who were familiar with listening to radio. What is surprising is that participants' preferences and rating of their overall comprehension of the passages did not correspond to their memory for the passages, as shown by their performance on the immediate retrieval test, indicating that merely reading the text was as informative as hearing and reading the text simultaneously. Figures 2 and 3 show the breakdown of responses:

Figure 2: Audio on vs. audio off - Large Vertical Display



	Easy to read	Interesting	Fatigue	Continue	Enjoyment	Scroll Speed	Comprehension	Memory
On	4.32	4.14	3.79	3.72	3.89	2.88	4.11	2.72
Off	4.08	3.42	3.39	2.97	3.16	2.43	3.80	2.65

Figure 3: Audio on vs. audio off – Small Horizontal Display



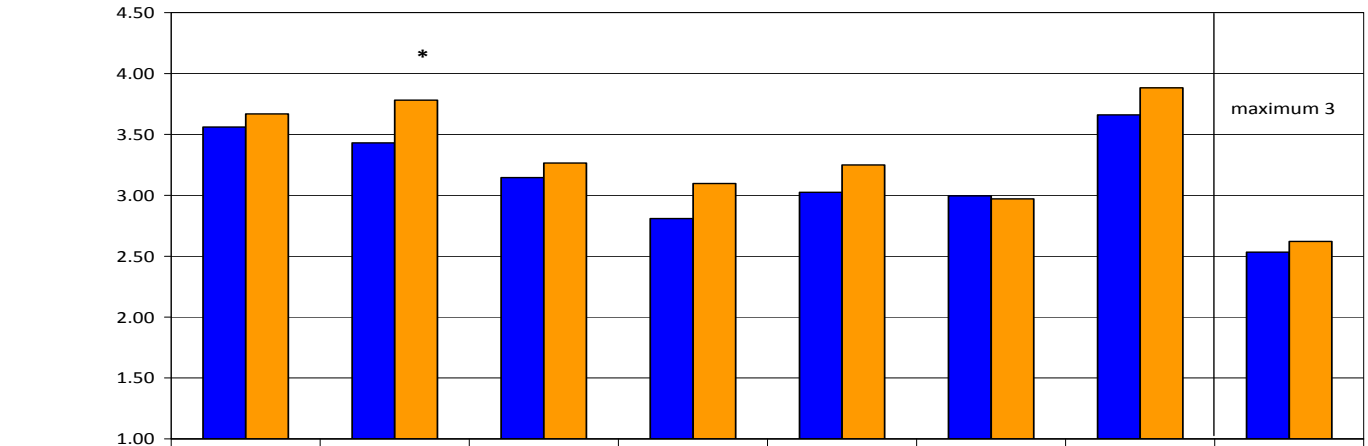
	Easy to read	Interesting	Fatigue	Continue	Enjoyment	Scroll Speed	Comprehension	Memory
On	2.95	3.51	2.86	2.57	2.76	3.53	3.65	2.40
Off	2.13	3.10	2.14	1.94	2.11	3.65	3.23	2.37

Color of Font

Participants were asked to examine “white text on black background” and “black text on yellow background” displays. As figure 4 shows, when asked how easy the text was to read, listeners had no preferences, however when asked what display they found more interesting, they reported that the black on yellow display was significantly more interesting, more enjoyable and helped their comprehension – these effects were most pronounced when passages were played on the small displays, suggesting that the color scheme may be more important when text displays become more compromised and reading

becomes more difficult. Table 1 shows the ratings participants gave for large and small displays when the audio was either kept on or turned off.

Figure 4: Font Color - combined scores for large and small displays



	Easy to read	Interesting	Fatigue	Continue	Enjoyment	Scroll Speed	Comprehension	Memory
White on Black	3.56	3.43	3.15	2.81	3.02	3.00	3.66	2.53
Black on Yellow	3.67	3.78	3.27	3.10	3.25	2.97	3.88	2.62

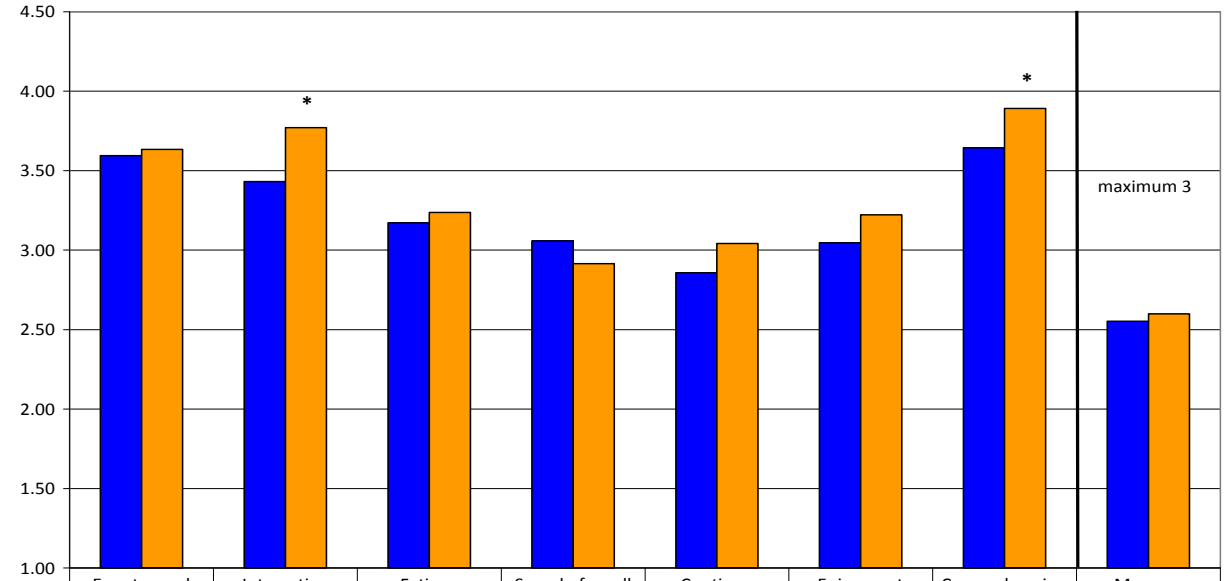
Table 1: Ratings for large and small displays when audio was on or off

	Large Display				Small Display			
	Audio On		Audio Off		Audio On		Audio Off	
	W/B	Y/B	W/B	Y/B	W/B	Y/B	W/B	Y/B
Easy to read	4.2	4.3	4.2*	3.9	2.8	3.0	2.0	2.3
Interesting	4.0	4.1	3.4	3.5	3.3	3.7*	2.7	3.6*
Speed of scroll	2.9	2.9	2.3	2.5	3.6	3.4	3.6	3.6
Fatigue	3.9	3.7	3.4	3.4	2.8	3.0	2.0	2.4
Continue to read	3.5	3.8	3.0	2.9	2.5	2.7	1.7	2.3*
Enjoyment	3.9	3.8	3.2	3.2	2.7	2.9	1.9	2.4*
Comprehension evaluation	4.1	4.1	3.7	4.0*	3.6	3.7	3.1	3.5
Memory score	2.7	2.6	2.4	2.7*	2.3	2.5	2.3	2.2

Font type

Participants were asked to compare texts presented in two fonts: Sans Serif and Serif. As shown in Figure 5, while few preferences were found between the two, participants claimed that the Serif font was significantly more interesting. Participants also claimed that they were slightly better able to understand the text in Serif font. However as with color, this had no bearing on their ability to remember facts in an immediate recall test. Although when results were combined, speed of scrolling was rated as equivalent, when audio was off people claimed that scrolling was quicker with the serif font. . Table 2 shows the ratings participants gave for large and small displays when the audio was either kept on or turned off.

Figure 5: Font type - combined scores for large and small displays



	Easy to read	Interesting	Fatigue	Speed of scroll	Continue	Enjoyment	Comprehension	Memory
Sans	3.59	3.43	3.17	3.06	2.86	3.05	3.64	2.55
Serif	3.63	3.77	3.24	2.91	3.04	3.22	3.89	2.60

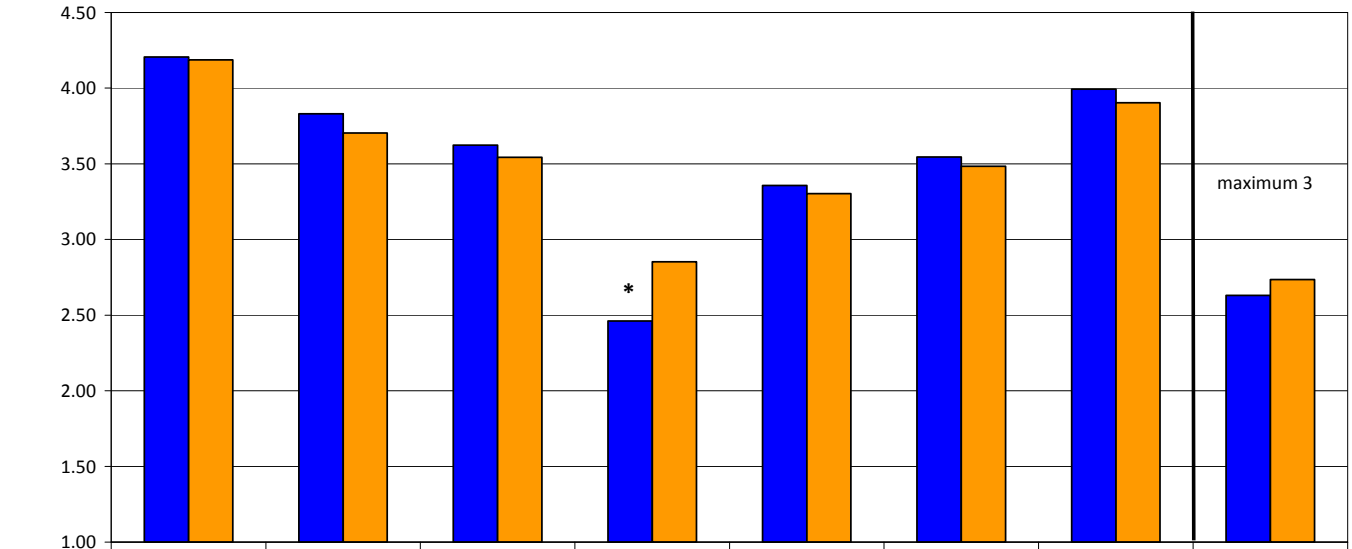
Table 2: Ratings for large and small displays when audio was on or off

	Large Display				Small Display			
	Audio On		Audio Off		Audio On		Audio Off	
	Sans	Serif	Sans	Serif	Sans	Serif	Sans	Serif
Easy to read	4.2	4.3	4.1	4.0	3.0	2.9	2.1	2.2
Interesting	4.1	4.1	3.1	3.7*	3.4	3.6	3.0	3.3*
Speed of scroll	2.9	2.9	2.6*	2.2	3.5	3.6	3.8*	3.5
Fatigue	3.7	3.9	3.4	3.4	2.9	2.8	2.2	2.1
Continue to read	3.7	3.7	3.0	3.0	2.4	2.7	1.9	2.1
Enjoyment	3.9	3.9	3.1	3.2	2.8	2.8	2.0	2.3
Comprehension	4.1	4.0	3.6	4.1*	3.7	3.7	3.0	3.5*
Memory score	2.6	2.6	2.5	2.7	2.5	2.3	2.2	2.3

Large Display: Long line vs. short line presentation

As shown in Figure 6 participants then compared longer and shorter lines of text. Despite reporting that shorter lines scrolled faster (which is the case) participants showed no preference for line length. Table 3 shows the breakdown of results when audio was turned on or off. Notice that the presence or lack of audio did not interact with the length of the line.

Figure 6: Comparison of short and long lines of text



	Easy to read	Interesting	Fatigue	Scroll Speed	Continue	Enjoyment	Comprehension	Memory
LongLine	4.21	3.83	3.62	2.46	3.36	3.55	3.99	2.63
ShortLine	4.19	3.70	3.54	2.85	3.30	3.48	3.90	2.74

Table 3: Comparison of length of line in display when audio was on or off

	Audio Off		Audio On	
	Long Line	Short Line	Long Line	Short Line
Easy to read	4.2	4.0	4.3	4.4
Interesting	3.5	3.3	4.1	4.1
Speed of scrolling	2.3	2.6	2.7	3.1
Fatigue	3.4	3.4	3.8	3.7
Continue reading	3.0	2.9	3.7	3.8
Enjoyment	3.1	3.2	4.0	3.8
Comprehension evaluation	3.8	3.8	4.2	4.0
Memory score	2.7	2.6	2.6	2.8

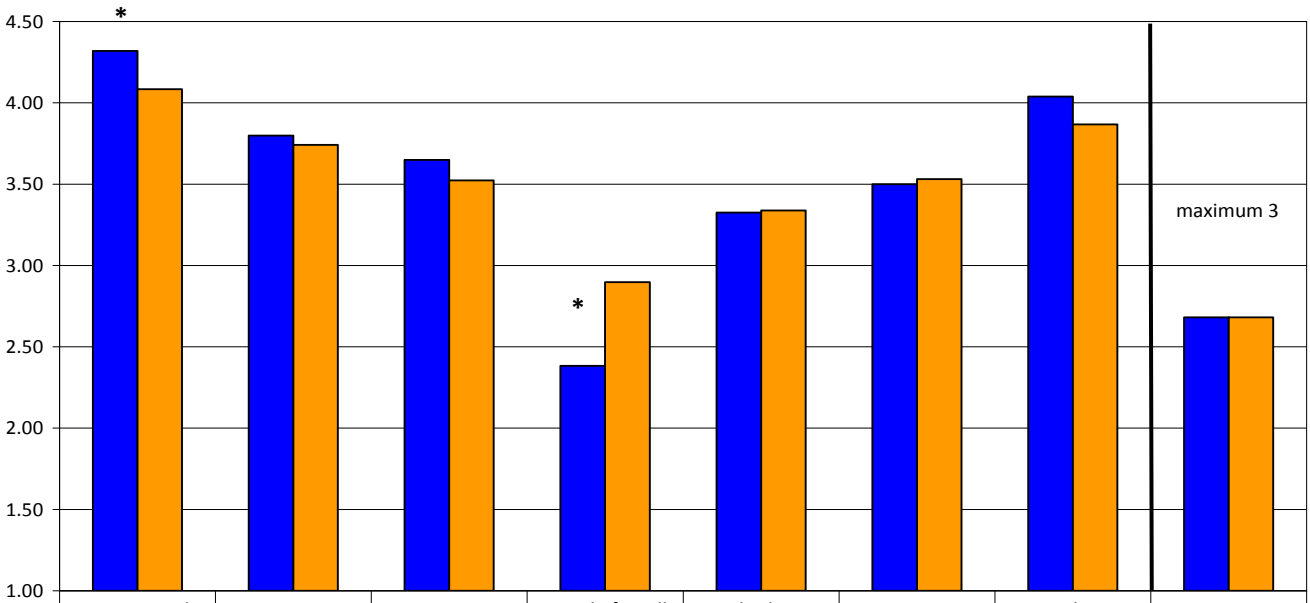
Text position – Bottom or Top

Figure 7 shows participants' reaction to a choice of two text positions: where the script first appeared at the bottom of the screen in synch with the audio, and where the script appeared in the middle-to-top of the screen in synch with the audio. In general, participants found script presented at the bottom slightly easier to read, but this was only significant when they heard the audio while reading.

Participants felt that the scrolling speed was significantly faster when text was presented at the top of the display, although the speed was identical between these conditions. We assume that they felt the scroll was faster in the top condition because they had less time to read the text as it disappeared more quickly than when it was started at the bottom of the screen.

Table 4 shows that when audio was turned off participants felt that their comprehension was better when text was placed at the bottom of the screen. However, this did not affect their memory performance score.

Figure 7: Comparison of placement of text – bottom or top of screen



	Easy to read	Interesting	Fatigue	Speed of scroll	Cibtubye	Enjoyment	Comprehension	Memory
Bottom	4.32	3.80	3.65	2.38	3.32	3.50	4.04	2.68
Top	4.08	3.74	3.52	2.90	3.34	3.53	3.87	2.68

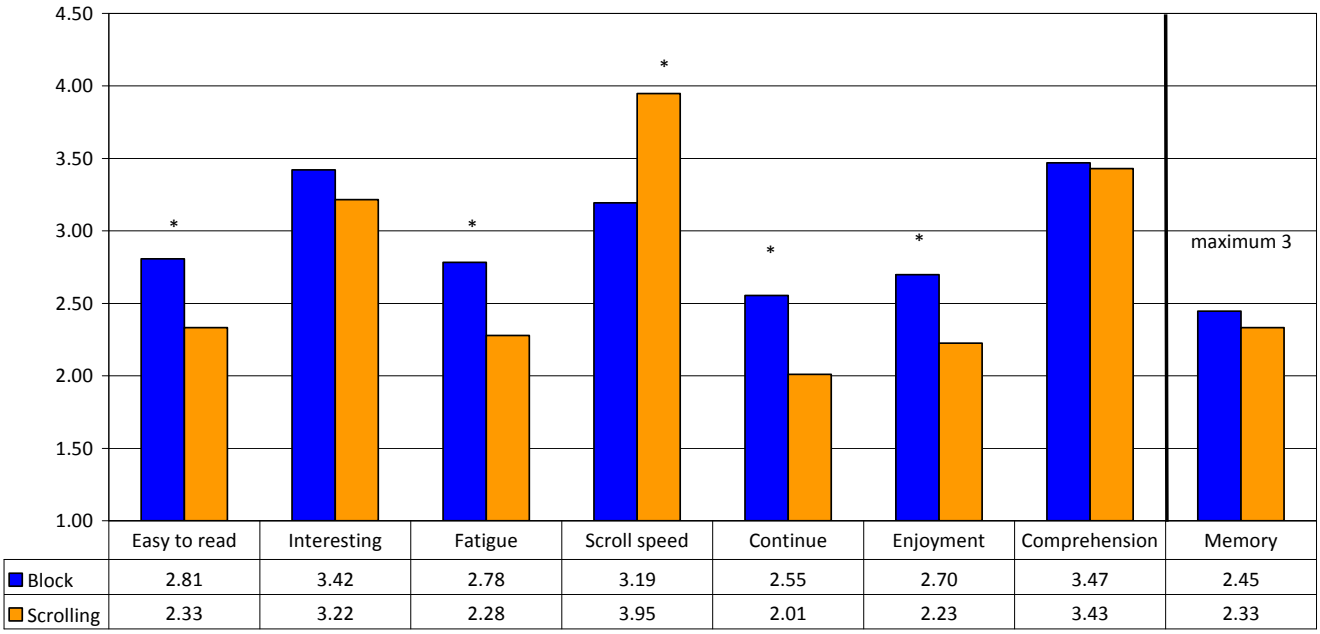
Table 4: Comparison of line position when audio was on or off

	Audio Off		Audio On	
	Bottom	**Top**	**Bottom**	**Top**
Easy to read	**4.2**	**4.0**	**4.5***	**4.2**
Interesting	**3.4**	**3.4**	**4.2**	**4.1**
Speed of scroll	**2.2***	**2.7**	**2.6***	**3.1**
Fatigue	**3.6**	**3.2**	**3.7**	**3.8**
Continue to read	**2.9**	**3.1**	**3.8**	**3.6**
Enjoyment	**3.1**	**3.2**	**3.9**	**3.9**
Comprehension evaluation	**4.0***	**3.6**	**4.1**	**4.1**
Memory score	**2.7**	**2.6**	**2.6**	**2.8**

Scrolling type for small display

Finally, Figure 8 shows participants' preference for block scrolling vs. continuous (times-square type) scrolling in one-line, small displays. As is evident from the figure, on almost all preference measures, people preferred block scrolling, where phrases were replaced with new phrases at fixed intervals. As mentioned previously, participants did not register enjoyment with this display, and this is clearly evident from the low scores received on most measures. However, Table 5 shows that when audio was on, participants voiced more pleasure with block scrolling than when audio was off, suggesting that under limited circumstances, block scrolling could be used to adequately convey information on small displays.

Figure 8: Comparison of scroll type on small display – block vs. continuous



	Easy to read	Interesting	Fatigue	Scroll speed	Continue	Enjoyment	Comprehension	Memory
Block	2.81	3.42	2.78	3.19	2.55	2.70	3.47	2.45
Scrolling	2.33	3.22	2.28	3.95	2.01	2.23	3.43	2.33

Table 5: Block vs. Scrolling Audio On-Off

	Audio Off		Audio On	
	Block	**Scrolling**	**Block**	**Scrolling**
Easy to read	**2.2**	**2.0**	**3.4***	**2.6**
Interesting	**3.0**	**3.1**	**3.8***	**3.2**
Speed of scroll	**3.2***	**4.0**	**3.1***	**3.8**
Fatigue	**2.3**	**2.0**	**3.2***	**2.5**
Continue to read	**2.0**	**1.8**	**3.0***	**2.2**
Enjoyment	**2.3**	**2.0**	**3.1***	**2.5**
Comprehension evaluation	**3.0**	**3.4**	**3.9***	**3.4**
Memory score	**2.3**	**2.4**	**2.5**	**2.3**

Study 2: Testing display features with deaf and hard-of-hearing consumers

Given results from Study 1, we were interested in re-running a subset of conditions with deaf and hard-of-hearing consumers to corroborate findings and test them on new variables of interest.

Participants

Forty one deaf and hard-of-hearing people participated in the study. Of this sample, 27 were hard-of-hearing and 14 were deaf. All participants were recruited through outreach e-mails sent to prominent members of the deaf and hard-of-hearing community, who forwarded the request to major sources and posting messages on deaf list serves and email groups. All participants received $100 for completing the session. Participants consisted of 24 females and 17 males and included participants between the ages 18 and 70.

Methodology and Results

Eleven sessions were conducted, each session lasting approximately 2½ hours. Sessions were conducted either at National Public Radio's headquarters in Washington DC or at Towson University. Equipment used for testing in each location was the same.

Participants were grouped into sessions according to whether they were deaf or hard-of-hearing. Communication assistance, ASL interpreters or a CART system, was provided during the sessions, depending on the group's needs.

Each session consisted of both independent computer work and focus-group discussions. Several variables of interested were examined during the session, including (a) font and color of the text display (b) ways to identify announcers (c) introduction of emergency alerting messages, and (d) synchronization of the captioned text with the audio (for hard-of-hearing individuals). In order to study each of these variables, the test sessions were divided into several segments. Participants began each segment by completing an independent, computer-generated series of tasks. These tasks were followed by a group discussion. At the end of the session, participants were shown a PowerPoint slideshow featuring possible future technology, and were asked to comment on various displays.

Deaf participants completed segments (a) through (c). Hard-of-hearing participants additionally completed the segment (d) focusing on synchronization.

All participants completed independent computer work on Pentium 4 Dell Desktop computers with 17 inch LCD panel monitors. The screen resolution of the monitors was 1280 X 1024 pixels and the color was set to highest quality. The participants made all responses using a mouse. Computer displays were created to simulate radio screens and were always centered on the monitor. The size of the large display was six inches wide by three and a half inches high. This size was chosen to represent an average double DIN in-

car navigation screen or single DIN flip-out head unit screen. The size of the small display was four inches wide by a half inch high. This size was chosen to represent an average single DIN one-line radio display. The rest of the computer screen was “grayed out”, and this gray background was also used for the question-answer sessions.

As with study 1, participants read NPR radio stories that lasted between 2 and 3 minutes. A total of 22 radio stories were read by hard-of-hearing participants, while deaf participants only read 19.

As with Study 1, a multi-step process was used to create the test clips (see Study 1 for details).

For the majority of the stories, audio was not played along with the scrolling text. However, the audio played a role in creating the captioned story segments because it was used as a guide to determine how fast the text should scroll up the screen. The three stories used during the synchronization segment had audio synched to text.

Study subsections were always presented in the same order (i.e., font and color, speaker identification, emergency alert, and synchronization). Presentation order of the stories used *within* each experimental section was randomized; therefore, participants received the stories varying order.

After reading each clip, participants were asked both opinion questions and content questions designed to test their retention. The participants responded to all questions through radio buttons presented on the screen by clicking on the appropriate response number.

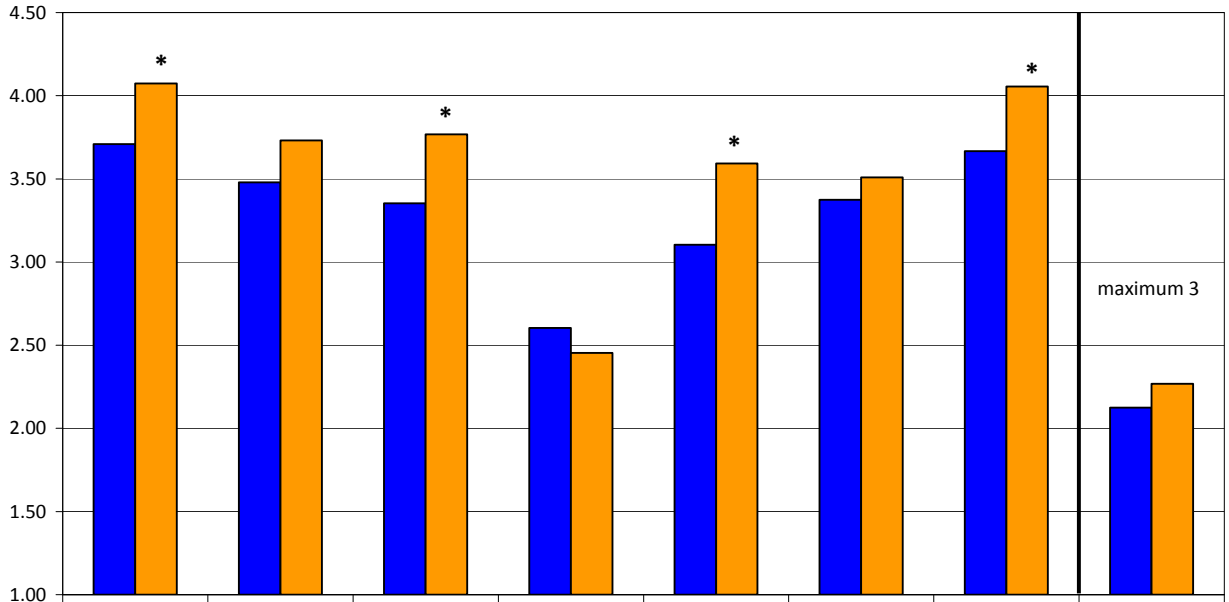
Group discussions

Group discussions were conducted for the following areas: (a) font and color; (b) speaker identification; (c) emergency alerting format; (d) synchronization and (e) driver alerting. All discussions were digitally recorded and later transcribed into text for analysis. Before discussions took place, participants were asked to fill out worksheets on aspects of the independent work. Large displays showing the conditions were placed in front of the room for participants to refer to as they completed the worksheets.

Preliminary Analysis of deaf vs. hard-of-hearing participants

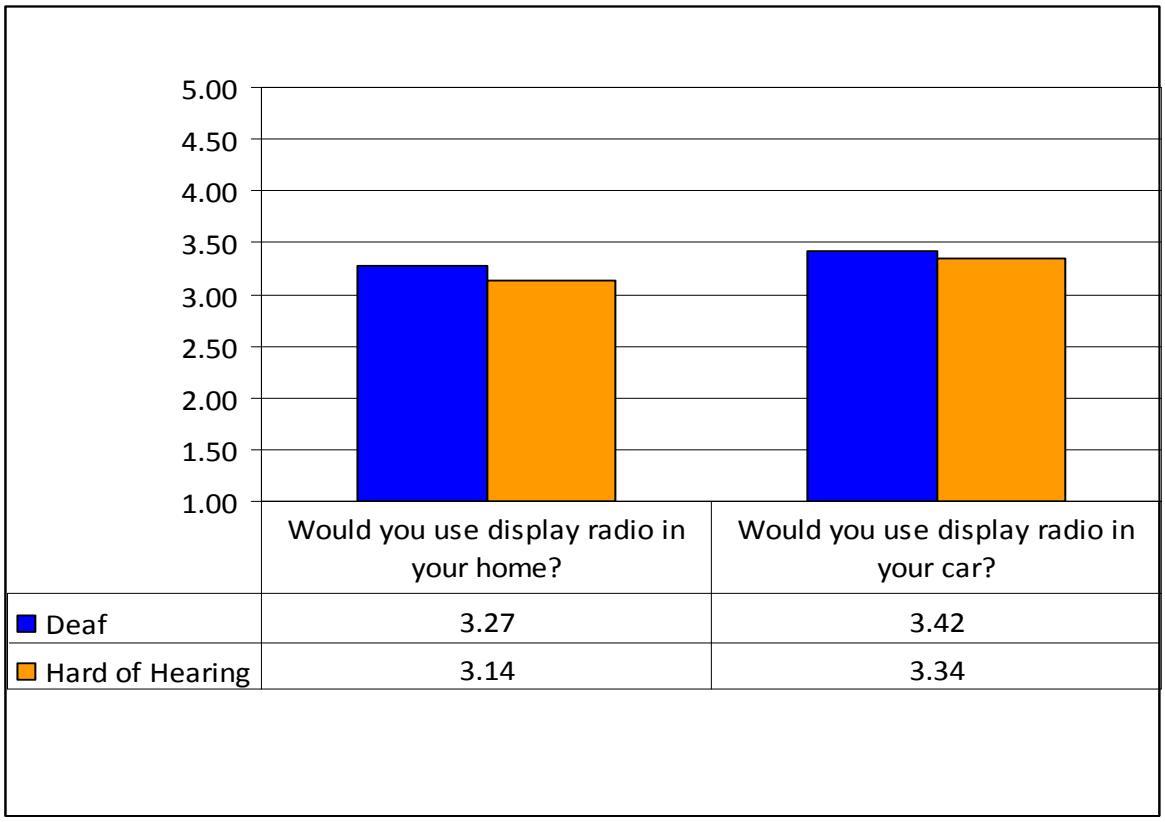
A preliminary analysis of deaf and hard-of-hearing participants was conducted to explore differences in preferences and performance between the populations. Overall, individuals who are hard-of-hearing found the text easier to read and experienced less fatigue than deaf individuals. They were also more likely to continue with the program and felt that they were better able to understand the text (although memory testing did not corroborate this feeling). Both groups found the program equally interesting and equally satisfied with the scroll speed. Both groups registered equal levels of enjoyment. Figures 9 and 10 combines participants preferences for <u>all samples</u> viewed during test sessions.

Figure 9: Comparison of deaf and hard-of-hearing responses



	Easy to read	Interesting	Fatigue	Scroll speed	Continue	Enjoyment	Comprehension	Memory
Deaf	3.71	3.48	3.35	2.60	3.10	3.38	3.67	2.13
Hard of Hearing	4.07	3.73	3.77	2.45	3.59	3.51	4.06	2.27

Figure 10: How often participants would use display radio at home and in their cars (1 = never; 5 = always)

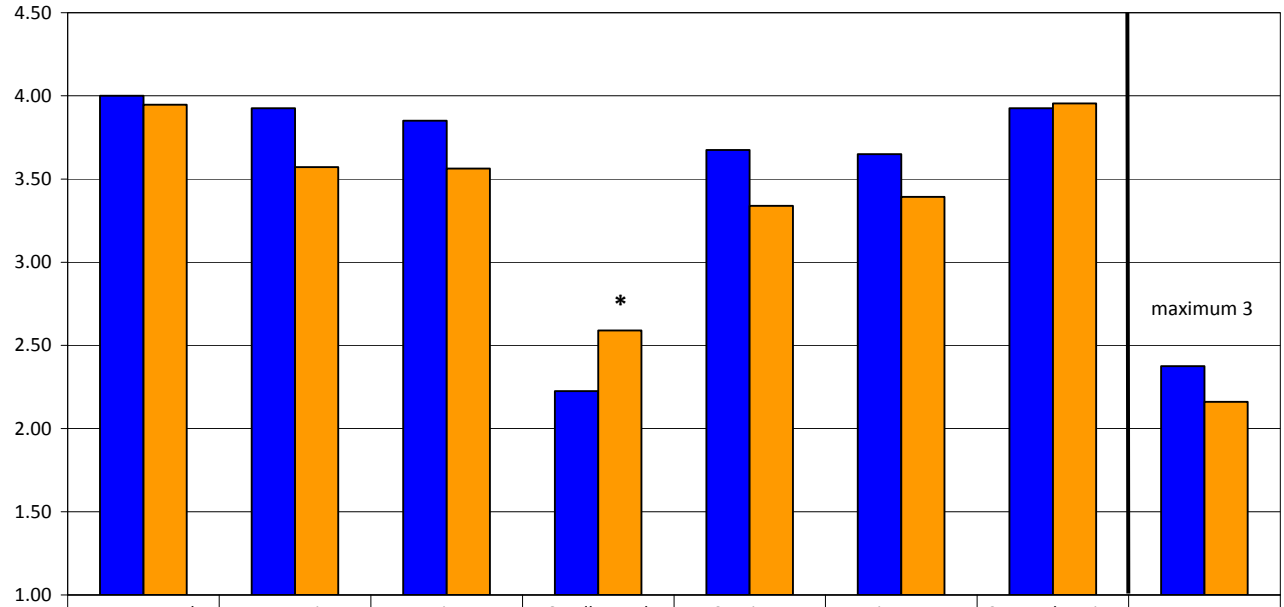


Preliminary analysis of Age of Hearing Loss Onset

Our participants were then divided into two different groups - those whose hearing problems had begun after the age of 15 and those whose hearing problems had begun before the age of 15. This analysis was done to uncover any differences “early” and “late” readers may have while reading the radio text display.

The only significant difference came scroll speed, in which individuals who were deafened "before 15" were comfortable with the scroll speed (3 = average speed, well paced) whereas people who were deafened after age 15 felt the scroll speed was slightly too slow (see Figure 11).

Figure 11: Comparison of preferences and performance between early and late deafened participants



	Easy to read	Interesting	Fatigue	Scroll speed	Continue	Enjoyment	Comprehension	Memory
After 15	4.00	3.93	3.85	2.23	3.68	3.65	3.93	2.38
Before 15	3.95	3.57	3.56	2.59	3.34	3.39	3.96	2.16

Because there were small differences between deaf and hard-of-hearing participants, in preferences and no differences in memory performance, we combined participants to analyze the remaining variables. However, when there were significant differences between the two groups, we also highlighted these.

Experimental Segments

Text Color

Participants read four text passages, which included all combinations of color (black background with white text, yellow background with black text) and fonts (serif – Times New Roman, sans serif – Tahoma). Only large screen (6” x 4”) displays were used, as results from Study 1 indicated that smaller displays were not particularly satisfying to consumers. However, for verification purposes, at the end of the study during the PowerPoint presentation, deaf and hard-of-hearing consumers were shown smaller, horizontal displays and asked as a group to evaluate them.

After viewing each clip, participants answered the following questions on a scale of 1 to 5:

1. How easy was it for you to read the text?
< 1 = Very Hard Very Easy = 5 >

2. How interesting was the text passage?
< 1 = Not Interesting Very Interesting = 5 >

3. What did you think of the speed of the scrolling?
< 1 = Too Slow Too Fast = 5 >

4. How tired did you or your eyes feel after reading?
< 1 = Very Tired Not At All Tired = 5 >

5. How likely would you be to continue reading?
< 1 = Not Very Likely Very Likely = 5 >

6. How would you rate your overall enjoyment of this experience?
< 1 = Not enjoyable Very enjoyable = 5 >

7. How much do you think you comprehended form the text you just read?
< 1 = No Comprehension Full Comprehension = 5 >

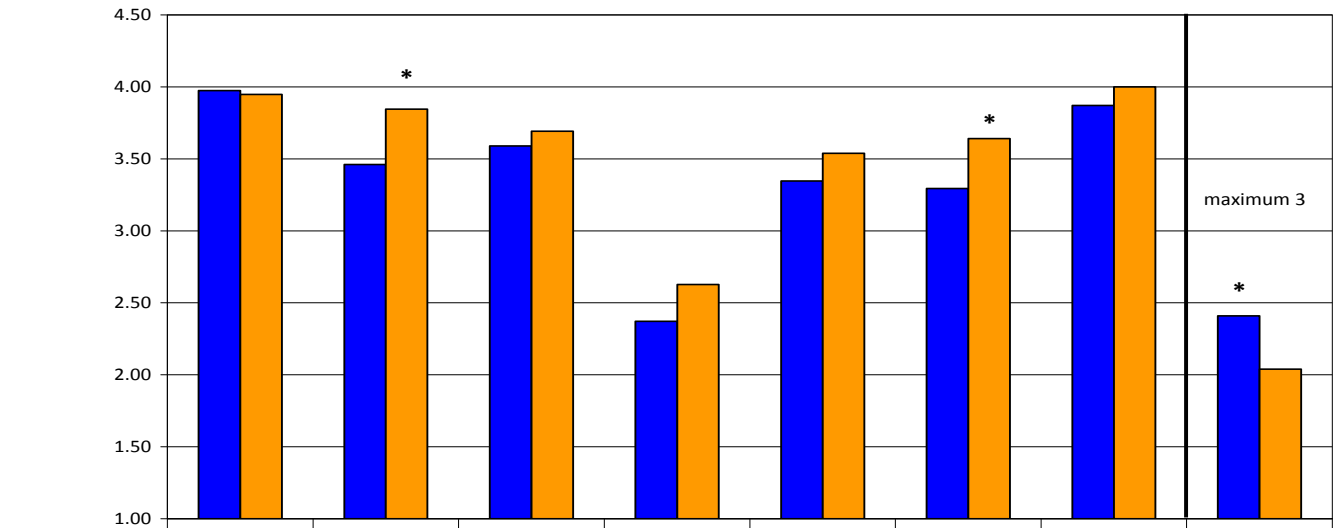
8. If this text display was included on your home radio, how often would you use it?
< 1 = Never Always = 5 >

9. If this text display was included on your auto radio (and you were the passenger), how often would you use it?
<1 = Never Always = 5 >

Text Color Results

As shown in Figure 12 few preferences were found between the two color schemes. Both colors were equally easy to read, comprehensible and were not fatiguing. Participants claimed that black on yellow was significantly more interesting to read and more enjoyable. However, performance on memory testing showed that participants remembered more target items for white type on a black screen than they did for black type on a yellow screen. What could account for this superior performance? It is likely that deaf participants have had significantly more experience with white on black captioning and this familiarity helped them to encode the text more easily. Table 6 shows a comparison of participants' responses in studies 1 and 2. Notice that there were few differences, although participants from Study 2 found all of the text displays less easy to read. Additionally, the poorer performance seen in Study 2 participants' recall was attributed to their memory for black on yellow text.

Figure 12: Text color



	Easy to read	interesting	fatigue	Scroll speed	Continue	Enjoyment	Comprehension	Memory
White on black	3.97	3.46	3.59	2.37	3.35	3.29	3.87	2.41
Black on yellow	3.95	3.85	3.69	2.63	3.54	3.64	4.00	2.04

Table 6: Comparison of Study 2 and Study 1 – Text Color

	Study 2			Study 1		
	White Black	Black Yellow	Total	White Black	Black Yellow	Total
Easy to read	3.97	3.95	3.96**	4.24	4.16	4.20
Interesting	3.46	3.85*	3.65	3.68	3.85	3.77
Scroll Speed	2.37	2.63	2.5	2.60	2.70	2.65
Fatigue	3.59	3.69	3.64	3.61	3.56	3.58
Likely to continue	3.35	3.54	3.44	3.35	3.42	3.33
Enjoyment	3.29	3.64*	3.47	3.47	3.56	3.52
Comprehension	3.87	4.00	3.94	3.87	4.04	3.95
Total memory	2.41	2.04*	2.22**	2.63	2.73	2.68

* White on black significantly different from Yellow on Black
** Study 2 significantly different from Study 1

In order to further explore the issue of font color, we analyzed whether and where differences occurred between deaf and hard-of-hearing participants. Table 7 shows these results. Notice that significantly fewer story items were remembered for deaf individuals when the story was presented in yellow on black, but this was not the case for individuals who are hard-of-hearing.

Table 7: Comparison of color with deaf and heard-of-hearing participants

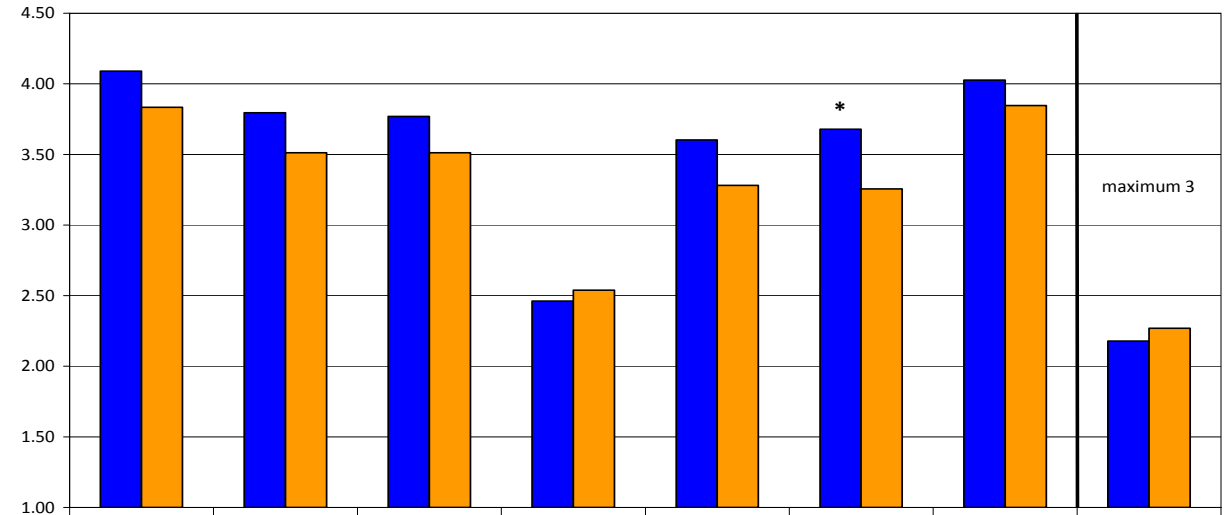
	Deaf		Hard-of-hearing	
	White on Black	Black on Yellow	White on Black	Black on Yellow
Easy to read	3.75	3.67	4.07	4.07
Interesting	3.29	3.67*	3.54	3.93*
Scroll Speed	2.58	2.63	2.28*	2.63
Fatigue	3.30	3.42	3.72	3.81
Likely to continue	2.96	3.25	3.52	3.67
Enjoyment	3.25	3.5	3.31	3.70
Comprehension	3.67	3.67	3.96	4.15
Memory	2.46	1.79*	2.39	2.15

* White on black significantly different from Black on yellow

Font Type

Participants compared texts offered in both Sans Serif and Serif font. As is shown in Figure 13, participants' choices between the two fonts did not show a clear preference. They felt that both fonts worked equally well with regards to how easy the text was to ready, how interesting the text was, how fatigued they felt, whether they would continue to read the passage, how fast the scrolling seemed, and how memorable the text was. However, in one category, Sans Serif font was judged to be significantly more enjoyable. Memory testing indicated that participants remembered story components equally as well with both the serif and sans serif font type. Table 8 shows that there were few differences between participants' reactions between Study 1 and Study 2. Although participants in Study 2 claimed they had a harder time reading the text, this was not a function of whether the type face was serif or sans serif. The same is true of memory performance – although participants in Study 2 did not recall as many items as participants in Study 1, the type face had no significant role in this finding.

Figure 13: Font Type



	Easy to read	Interesting	Fatigue	Scroll speed	Continue	Enjoyment	Comprehension	Memory
Sans	4.09	3.79	3.77	2.46	3.60	3.68	4.03	2.18
Serif	3.83	3.51	3.51	2.54	3.28	3.26	3.85	2.27

Table 8: Comparison of Study 2 and Study 1 – Font type

	Study 2			Study 1		
	Sans Serif	Serif	Total Font	Sans Serif	Serif	Total Font
Easy to read	4.09	3.83	3.96**	4.17	4.21	4.20
Interesting	3.79	3.51	3.65	3.58	3.95	3.77
Scroll Speed	2.46	2.53	2.5	2.75	2.55	2.65
Fatigue	3.76	3.51	3.64	3.52	3.64	3.58
Likely to continue	3.60	3.28	3.44	3.30	3.36	3.33
Enjoyment	3.67*	3.26	3.47	3.45	3.58	3.52
Comprehension measure	4.02	3.84	3.94	3.83	4.06	3.95
Total memory	2.18	2.27	2.22**	2.62	2.74	2.68

*** Serif significantly different from Sans serif**
**** Study 2 participants different from Study 1**

Table 9 shows few differences when comparing deaf and hard-of-hearing individuals' preferences for font type. Deaf participants claimed they were more likely to continue to read with sans serif but this did not hold for hard-of-hearing participants. Both deaf and hard-of-hearing participants expressed more enjoyment with sans serif than with serif.

Table 9: Comparison of deaf and hard-of-hearing – Font type

	Deaf		Hard-of-hearing	
	Sans Serif	Serif	Sans Serif	Serif
Easy to read	3.86	3.54	4.18	3.96
Interesting	3.63	3.33	3.87	3.59
Scroll Speed	2.70	2.50	2.35	2.56
Fatigue	3.58	3.13	3.85	3.69
Likely to continue	3.41*	2.79	3.68	3.50
Enjoyment	3.67*	3.08	3.68*	3.33
Comprehension measure	3.75	3.58	4.15	3.96
Total memory	2.04	2.21	2.24	2.30

*** Serif significantly different from Sans serif**

Speaker Identification

For this portion of the test, all regular text passage material was featured in black text on a yellow background. Three different speaker identification methods were presented. The first display featured the name of the speaker placed in parenthesis before the text. For this display, text was centered and there were no spaces between the lines of text when there was a change of announcer (see Figure 14). The second display used color coding to

differentiate speakers. This display was left-justified, and space was inserted when there was a change of announcer (see Figure 15). The third display featured archived NPR pictures of the speakers to the left of the text. Additionally, announcers were identified with their name and their role in text (see Figure 16). For people that called in, a picture of a telephone was inserted next to their comments. In this display text was left justified and space was left between announcers. For this display, the usable margin was smaller than the other two, because a portion of the left margin containing the photographs.

Figure 14: Announcers identified by name in parenthesis

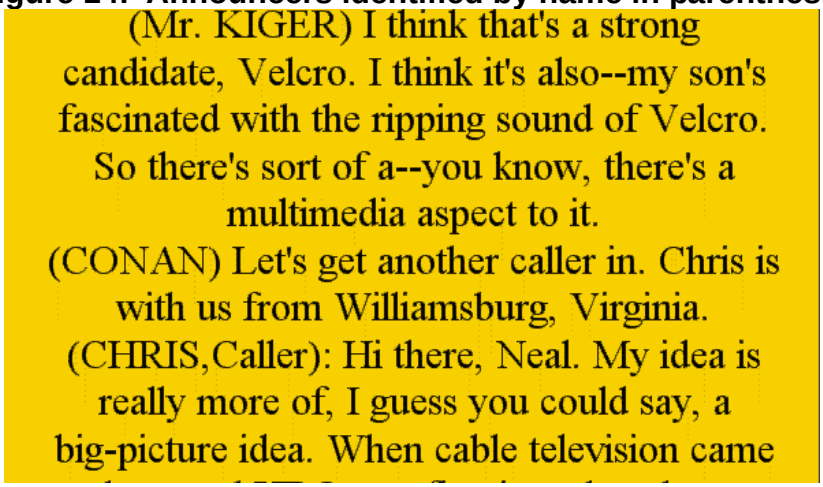


Figure 15: Announcers identified by color

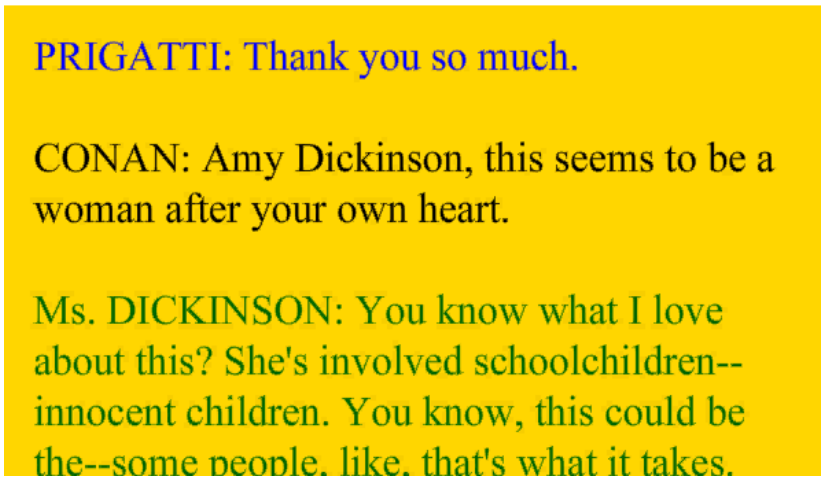
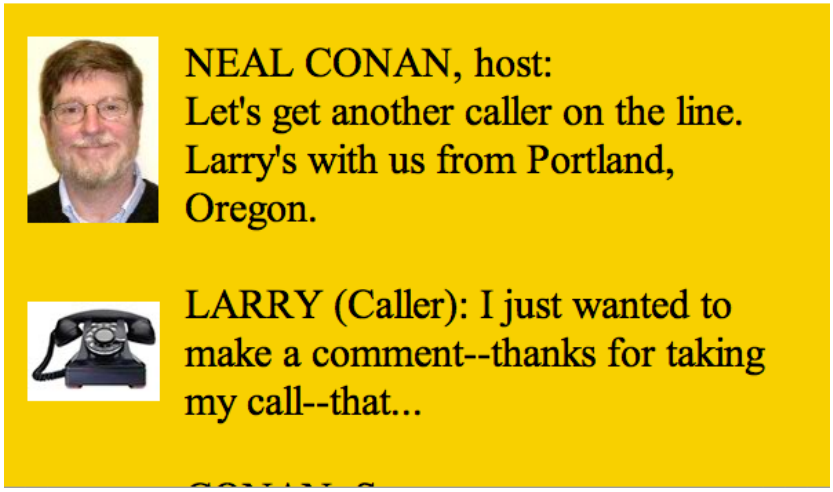


Figure 16: Announcers identified by picture



The following are the opinion questions which the participants answered after viewing each clip.

1. How easy was it for you to comprehend the story text?
<1 = Very Hard Very Easy = 5>

2. How tired did you or your eyes feel after reading?
<1 = Very tired Not at all tired = 5>

3. How likely would you be to continue reading?
<1 = Not very likely Very likely = 5>

4. How interesting was the text passage?
<1 = Not Interesting Very Interesting = 5>

5. How would you rate your overall enjoyment of this experience?
<1 = Not enjoyable Very enjoyable = 5>

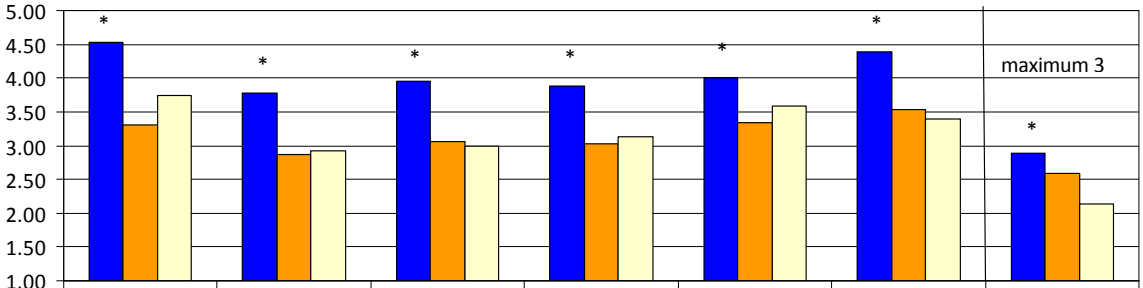
6. How easy was it for you to differentiate between speakers?
<1 = Very hard Very easy = 5>

Speaker Identification Results

As shown in Figure 17, using different colors to identify the speakers was participants' overwhelming favorite. In every preference category, including how easy it was to identify the speaker, how interesting the display was, how likely they were to continue to look at the display, their enjoyment of the experience, how tired they became over time and their understanding of the text, color was rated significantly higher than placing the speakers' names in parentheses and using a picture placed to the left of the speaker's text.

The same was true for memory performance: when colors were used to identify speakers participants had a significantly easier time encoding and recalling text.

Figure 17: Identification of speaker on program



	Identifying speaker	Interesting	Likely to continue	Enjoyment	Fatigue	Comprehension	Memory
Colors	4.53	3.78	3.94	3.89	4.00	4.39	2.89
Names in ( )	3.31	2.86	3.06	3.03	3.33	3.53	2.58
Pictures	3.75	2.92	3.00	3.14	3.58	3.39	2.14

Table 10 shows that both deaf and hard-of-hearing participants were unanimously in favor of colors to identify speakers. Although in general hard-of-hearing participants' ratings were higher, this was not a function of a particular identification method.

Table 10: Comparison of deaf and hard-of-hearing participants – Speaker Identification

	Deaf			Hard-of-hearing		
	Colors	**Name in ( )**	**Pictures**	**Colors**	**Name in ( )**	**Pictures**
Identifying speaker	**4.5***	**3.3**	**3.4**	**4.6***	**3.3**	**3.9**
Interesting	**3.6***	**3.1**	**2.7**	**3.9***	**2.8**	**3.0**
Likely to continue	**3.6***	**2.7**	**3.1**	**4.1***	**3.2**	**3.0**
Enjoyment	**3.7***	**3.1**	**3.0**	**4.0***	**3.0**	**3.2**
Fatigue	**3.6***	**2.9**	**3.2**	**4.2***	**3.5**	**3.7**
Comprehension	**4***	**3**	**3.2**	**4.5***	**3.7**	**3.5**
Memory	**2.7***	**2.5**	**2.3**	**3.0***	**2.6**	**2.1**

Table 11 summarizes discussion group comments concerning speaker identification methods, divided into pros, cons, and suggestions for improvements. The number in parenthesis after the comment indicates the number of participants who made the same or similar comment.

Table 11: Speaker Identification: Discussion Group Comments

	Pros	Cons	Improvements/ Suggestions
Name in Parentheses	None	It is unclear who is talking **(3)** Difficult to identify speaker	Prefer left justified over center
Color ID	Clear who is announcing, especially when strongly contrasting colors were used. Spacing in between the segments made it easier to read. While not perfect, the colors provide enough of a cue to be sufficient The space in between speakers is very important -- creates the feeling of reading a conversation and not just one person speaking **(9)**	Does not identify role of the speaker (i.e., host, guest, or caller). The changing colors distracted me	Changing the colors may be helpful. Users should be able to pick their own colors Color plus name in parentheses makes it easy to identify who is speaking without having to go back and look at their name all the time
Picture ID	Faces are easy to remember. Identify with the pictures. It's fascinating to see their pictures. (i.e., it is like seeing live pictures while reading a book—cool). Young people may like the pictures better. Go, Go, Go generation that almost likes information overload. As you get older you just want to the context of what's being said and the picture doesn't have to be there.	Focus on the pictures and miss the text. You will not know the name of the person, just what they look like. Going back between the pictures and the text made me confused and made the text seem like it was moving too fast. Participants don't want to see the person—it's not television The pictures made it harder to follow the conversation Have to remember what people look like—an additional (unnecessary?) memory cue If there are just 2 or 3 speakers, you just see 2 or 3 pictures, which you get tired of because it is the same thing over and over. If the speakers were always changing than the picture method may hold your attention.	Helps give emotional cues. More visuals would be great. The picture of the phone is too old fashioned. New generations may not be familiar with the rotary phone. Using a more modern phone may be better

Emergency altering format

Twelve message styles were tested using the following variables: text color (orange text on a black background or white text on a black background), screen position of the emergency alert message (middle or bottom of the screen), and scrolling type (vertical, horizontal, or block). Participants viewed a standard yellow background with black text vertical scrolling clip. About half way through the clip, the screen would change to a blank black screen. The emergency alert would then be shown in a specific format depending on the clip. The emergency alert would present a different message for each clip. The participants were asked questions at the end of the clip based on the content of the alert. This was done to determine if presentation style had any effect on the retention of the message.

Participants answered the following questions after viewing each clip.

1. How easy was it for you to read the text?
< 1 = Very Hard Very Easy = 5 >

2. What did you think of the speed of the scrolling?
< 1 = Too Fast Too Slow = 5 >

3. How helpful did you think the alert was in getting across the message?
< 1 = Not helpful at all Extremely helpful = 5 >

4. Did you like the color the emergency alert was presented in?
< 1 = I didn't like it I liked it = 5 >

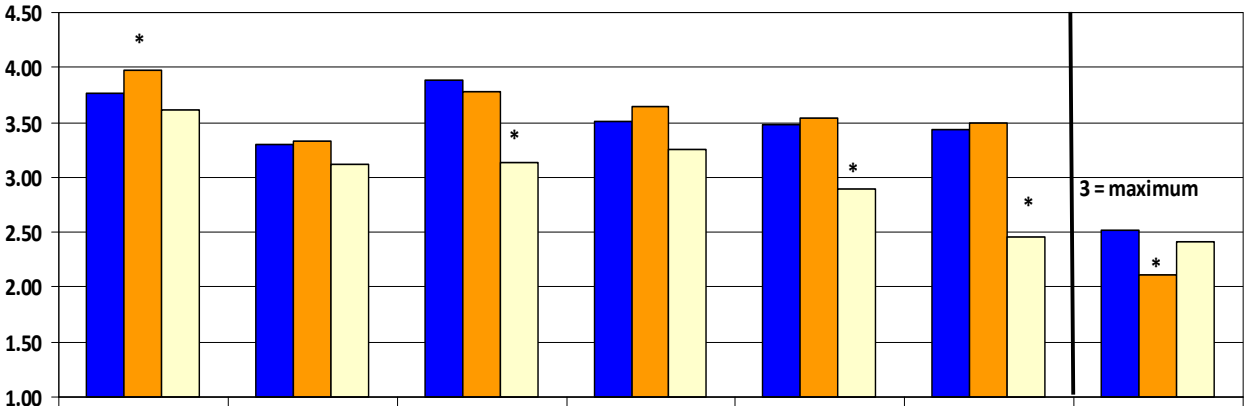
5. Did you like the position on the screen in which the emergency alert appeared?
< 1 = I didn't like it I liked it = 5 >

6. Did you like the way the emergency alert message was presented on the screen?
< 1 = I didn't like it I liked it = 5 >

Emergency Alerting Results

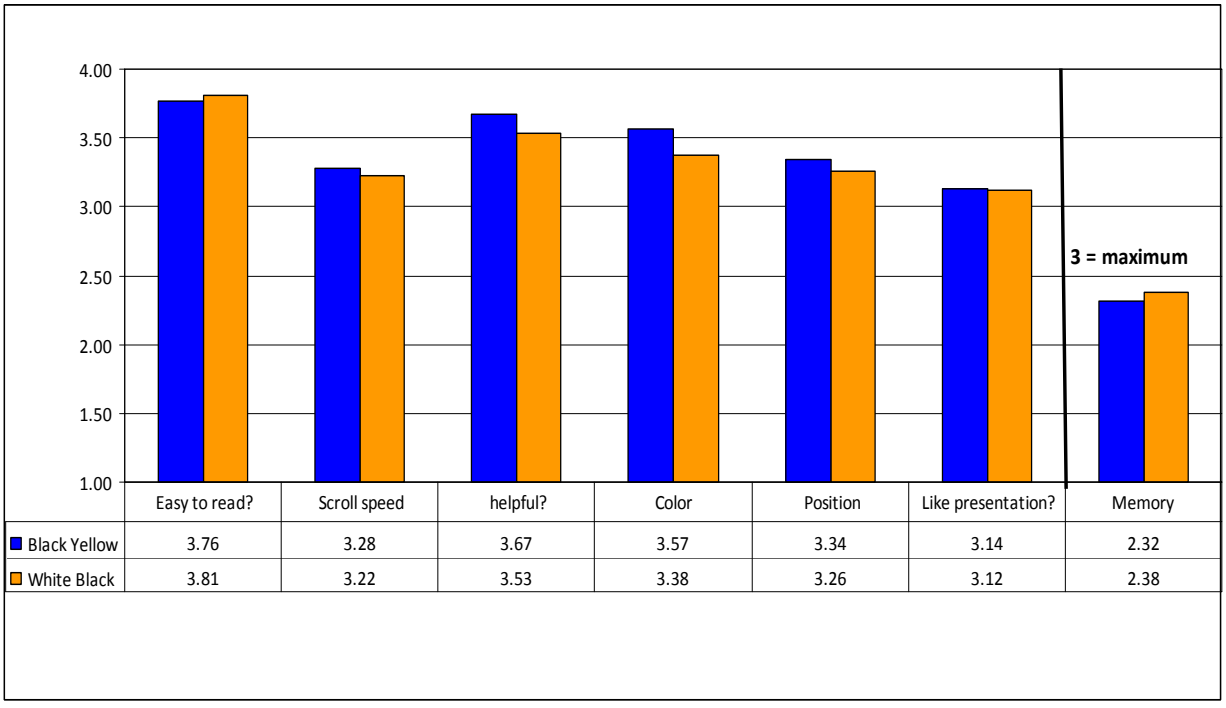
As figure 18 shows, block text and vertical text scrolling were equivalently rated. These two methods were preferred in every preference category. Interestingly, in memory performance, vertical scrolling produced significantly poorer scores than block and horizontal scroll presentation. Participants were additionally asked to determine which of the two color options - black on orange or white on black - they preferred as their emergency alert color scheme. No preference was found between the two color options in any of the categories, as shown in figure 19. However, figure 20 shows that participants preferred emergency alerting messages to appear in the middle of the screen. Interestingly, participants' memory performance was slightly better when emergency information was presented on the bottom of the screen.

Figure 18: Emergency Alerting Scroll types



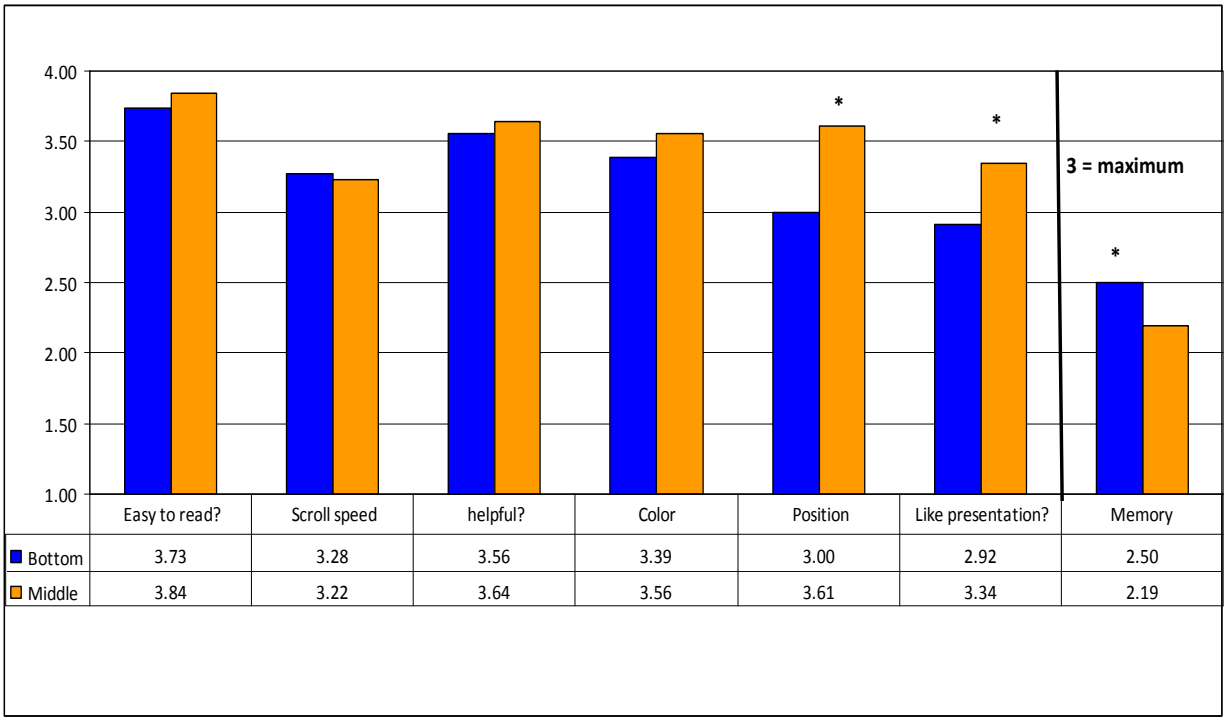
	Easy to read?	Scroll speed	helpful?	Color	Position	Like presentation?	Memory
Block	3.76	3.30	3.88	3.51	3.48	3.43	2.51
VerticalScroll	3.98	3.32	3.78	3.64	3.54	3.49	2.12
HorizontalScroll	3.62	3.13	3.14	3.26	2.89	2.46	2.41

Figure 19: Emergency Alerting Color Schemes



	Easy to read?	Scroll speed	helpful?	Color	Position	Like presentation?	Memory
Black Yellow	3.76	3.28	3.67	3.57	3.34	3.14	2.32
White Black	3.81	3.22	3.53	3.38	3.26	3.12	2.38

Figure 20: Emergency Alerting Text positioning on display



	Easy to read?	Scroll speed	helpful?	Color	Position	Like presentation?	Memory
Bottom	3.73	3.28	3.56	3.39	3.00	2.92	2.50
Middle	3.84	3.22	3.64	3.56	3.61	3.34	2.19

Focus group comments – Emergency Alerting

- When using block formatting participants found that they did not miss any part of the message and were able to read it at their own speed. Faster readers appreciated being able to skim read messages, which was not possible with the scroll.

- Despite being very good at conveying a sense of emergency, horizontal scrolling was found to be choppy and too fast.

- With regards to Emergency Alert prompts, the participants found that a black and white emergency color scheme may offer better contrast, of particular importance when transitioning from normal radio text to emergency text.

- Some participants expressed frustration at low priority emergency alerts having the hallmarks of high priority alerts (use of flashing colors and exclamation points).

- A Sans Serif font was judged more comfortable to read than a Serif font, which some found fuzzy.

- The white on black text display came across as comfortable and familiar, reminiscent of TV captioning. However, some participants found white text on black hard to read when the text was scrolling, though this was not a problem with the block display. A black on yellow display, while refreshing to some was over-stimulating to others. Participants claimed that black on yellow display could work best for day-time viewing.

- Horizontal scrolling was also described as choppy and as restricting the supply of information.

Synchronization

Three displays were presented with accompanying audio. One display presented the scrolling text with audio synched to the words around the middle of the screen. Another display presented the scrolling text where the audio was lagging behind. With this display, the words would scroll up the screen and would be off the top of the screen before the accompanying audio would play. The last display presented the scrolling text with the audio ahead of the text. With this display, the audio would be heard before the accompanying text could be read. As with all other sections, after reading each story participants were prompted with both opinion and content questions.

The following are the opinion questions which the participants answered after viewing each clip.

1. How easy was it for you to comprehend the story text?
< 1 = Very Hard Very Easy = 5 >

2. How tired did you or your eyes feel after reading?
< 1 = Very tired Not at all tired = 5 >

3. How likely would you be to continue reading?
< 1 = Not very likely Very likely = 5 >

4. How interesting was the text passage?
< 1 = Not Interesting Very Interesting = 5 >

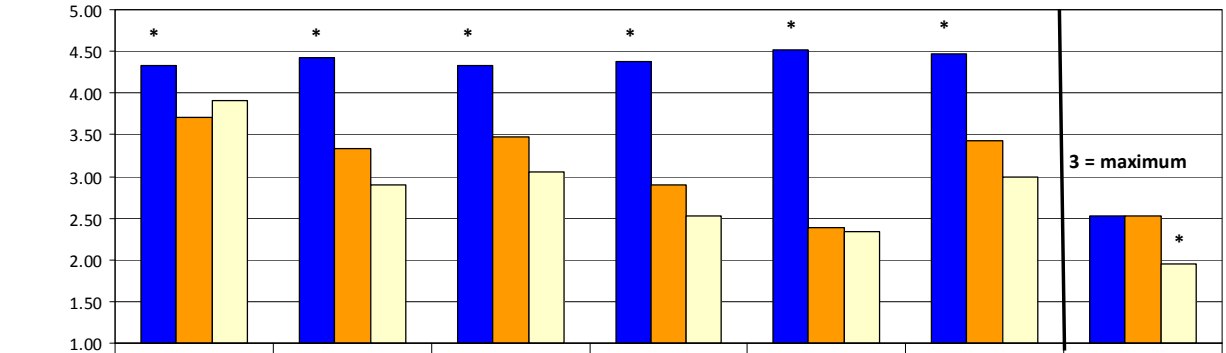
5. How would you rate your overall enjoyment of this experience?
< 1 = Not enjoyable Very enjoyable = 5 >

6. How likely would you be to still use this captioning based on the synchronization of the audio and text?
< 1 = Not Likely Very Likely = 5 >

Synchronization Results

As figure 21 shows, participants clearly preferred synchronization where the text was on the screen while they heard the audio. When text was presented first, participants did significantly more poorly on recall.

Figure 21: Comparison of three synchronization schemes



	Fatigue	Continue	Interesting	Enjoyment	Still use?	Comprehension	Memory
Synched	4.33	4.43	4.33	4.38	4.52	4.48	2.52
Audio First	3.71	3.33	3.48	2.90	2.38	3.43	2.52
Words First	3.90	2.90	3.05	2.52	2.33	3.00	1.95

Focus Group comments

Not surprisingly, as corroborated by the focus group comments, participants preferred the words and sound to be closely synchronized. It even made some participants feel that their experience was truly equal to that of a hearing person's. When the words preceded the audio, people were confused and tempted to turn the audio off completely. Having the audio precede the words was met with wider approval. The closer the synchronization between sound and words, the more they liked it. Table 12 identifies participants' comments on synchronization schemes.

Table 12: Focus group comments on synchronization schemes

	Pros	**Cons**	**Improvement Suggestions**
Words First	None	Missed information looking for words Scrolling seemed fast I hated it (12)	Turn the audio off
Audio First	A little behind is ok, still understandable	If it's all delayed, I'm too busy trying to figure out where they are and then I've lost the information. It's when the delay is such that someone speaking -- and there's nothing on the screen, and they're talking and there's nothing on the screen, it's very difficult when it comes up to make those words go together	
Close Synch	I enjoyed it because I could hear what they were saying. It made me think that I was really watching and enjoying like a hearing person It gave me the option to read with it or ahead	I found that when it was completely in synchronization I didn't listen as much as reading.	

PowerPoint Presentation

At the conclusion of the independent computer sections and group discussions, participants were shown a PowerPoint presentation that included three areas of inquiry. The first area of inquiry was finding a way to capture a home user's attention to alert them of an incoming message. The second area of inquiry was finding a way to alert a driver of an incoming emergency alert. The third area of inquiry was determining if a small one line display would be usable in displaying text depending on the presentation scheme.

In the beginning of the PowerPoint presentation, a video was shown that presented possible ways of alerting consumers at home. The first method included changing the scrolling text display to a screen with a black background where in the top corners were two symbols that were boxes with large exclamation points inside them. The majority of the screen consisted of a large flashing rectangle. The video clip showed this style of display three times with the flashing rectangle being three colors: red, yellow and green. After the flashing rectangle was displayed for four seconds the emergency alert was displayed while the large exclamation points remained in the top corners of the screen. The second method was similar to the first except instead of a flashing rectangle of various colors, it flashed the following words in white text on a black background: High Priority, Medium Priority, and Low Priority. Similar to the first method, there were exclamation points in the top corners of the screen. After the flashing words were displayed, the emergency alert was displayed. The third method displayed the words, THIS IS AN EMERGENCY, at the top of the screen. The words were presented in white text on a black background. These words remained on screen for the duration on the emergency alert. After participants viewed the video they were asked to comment and discuss what they did and did not like. They were also asked to offer any suggestions on ways to better present emergency alert information.

The second area focused on the limitations of visual presentations of emergency messages for drivers. Because we were concerned about diverting drivers' attention from the road, we presented participants several possible methods of alerting them. One possible method was presenting the driver with a corresponding symbol that would alert them to an emergency. Another possible method was a simple blinking light that would alert the driver that they would need to pull over and read an emergency alert. The participants were then asked to discuss and comment on what they saw. They were also encouraged to offer any alternative ideas on alerting drivers to emergency information.

Table 13 lists participants' comments from the emergency alert prompting focus group sessions.

Table 13: Emergency Alert Prompts Focus Group Comments

	Pros	Cons	Improvements/ Suggestions
Flashing	The red flashing helps indicate something new—something you need to pay attention to (2) Liked the flashing—was indifferent to the color. Strobes are effective to catch attention Some deaf people would really like flashing colors because they are more visual anyways. Preferred the symbol if it was flashing.	The strobe-like effect may be disorienting or worse. For people with epilepsy the flashing may cause an episode (2)	An adaptor that connects to lamps/other visual queues would help if the radio wasn't in the room
Color Prompting	I like red because red means emergency Color gets your attention quicker. Really catches your eye (3) Levels of color help you know whether the alert is necessary to pay attention to	Would prefer black and white flashing over color flashing. Different colors of emergencies unnecessary—all emergencies should be red or they shouldn't be emergencies	The colors / words should be combined so it would be accessible for both regular and colorblind deaf. Different colors of emergencies unnecessary—all emergencies should be red or they shouldn't be emergencies The prompting color could be kept on as a background throughout the message.
Word Prompting		The words are easier to miss than the color. Was not efficient at alerting me to the emergency message (2) Words may be hard to read while driving	May be better to use a more common word, such as "emergency". (3)
Icon at the top of the screen	Because if it's a hurricane or tornado or lightning, you can put that image up there. So you can see very clearly what's going on and the text can say what county you're talking about. More specific information – I do like the icons better You don't have to read words—you can know immediately what is happening. Definitely prefer the icons for ease of use		The symbols themselves could change colors depending on the emergency. Would be able to distinguish between emergencies easily with icon that represents the emergency (2) People thought the 'marker' should be kept on the screen throughout the entire message
The words "Emergency"	Having just "emergency" would be good.	Only use during an actual emergency. If it's not a severe emergency it may panic people unnecessarily	

Horizontal Display discussion

The third area of the PowerPoint presentation focused on presenting text horizontally on a small one line screen. Participants were shown two styles of text presentation - block and “times square” (continuous scrolling) and asked their opinions of the displays. In general, participants suggested that block presentation was better suited for multiple lines – much like TV-style captioning - but they still preferred it over continuous scrolling, which seemed blurry and confusing. A major complaint was that both block and continuous scrolling on a single line forced the reader to read at an unnatural pace and read “word by word” instead of in sentences. Because of this participants suggested that user-controlled scroll speed would be desirable.

Election Night Consumer Assessment

NPR Labs conducted a subjective assessment activity on election night, November, 2008 when five host radio stations across the United States carried transcribed broadcasts of NPR election returns over large text displays and across the web. This activity was not a controlled study, but rather its goal was to gain informal information from consumers regarding features of text display radio technology.

There were three main components of the assessment activity:

- Deaf and hard-of-hearing consumers watched a big screen presentation of the captioned election coverage. This presentation ran throughout the entire 3 hour assessment activity. The type of screen used for this presentation varied across locations, with some using a projector system and others using a large television screen. Consumers were asked to fill out a questionnaire regarding their experience reading the captioned text on the large screen display (i.e., see Appendix A for a copy of the big screen questionnaire).

- Consumers viewed a PowerPoint presentation that included interactive displays designed to capture the following information:

    - Whether consumers would use captioned radio as a home unit, alarm clock, in a car, as a portable boom box, as a portable iPod.
    - How important it was to receive emergency information, news, entertainment, and weather or traffic reports.
    - How important it was to have a bed shaker for alerting, a strobe for alerting, and the ability to see music lyrics.
    - How important it was to have radio show name, host, story title, station frequency, and date/time on the captioned radio screen.
    - Consumer's general interest in in-vehicle captioning displays, including cost limits, as well as interest in backseat text displays.
    - How to disseminate emergency information to drivers over the captioned radio system, including how to get the driver's attention.
    - Consumer's opinions of identification methods, such as using colors or pictures to differentiate one speaker from another.
    - Consumer's opinions of the way the captioned text moved across the screen, including block and scrolling styles.

- An online activity based at a computer station. This activity consisted of reading the election coverage in captions over the internet. After viewing, consumers were taken to an online survey and asked questions regarding the quality of their reading experience over the captioned internet feed.

Approximately 150 guests visited 5 locations (Baltimore, Boston, Denver, Phoenix and Washington) on election night. 75 deaf and hard-of-hearing participants responded to questions concerning 3 displays.

- Large Display captioned Radio Election Coverage (73 participants)
- Accessible Radio Slide Show (70 participants)
- NPR internet feed of captioned election coverage (75 participants)

Participant demographics

	19-30	31-40	41-50	51-60	61-75	75+	Unknown
Female	9%	1%	12%	19%	8%	2%	
Male	5%	5%	4%	7%	13%	1%	
Unknown				3%			4%

Results

Table 14: Results from Large Display Radio Election Coverage

	All respondents
In terms of speed of captioning, did you think the text presentation was:	
Too fast	29%
Too slow	14%
Inconsistent	3%
About right	58%
How did reading this display compare to reading television captioning?	
Slower	34%
Faster	22%
The Same	43%
Did you think the presentation was accurate?	
Extremely accurate	69%
Accurate	26%
Inaccurate	5%
In terms of understanding, how did you comprehend the text?	
Completely understood the information	55%
Had some difficulty understanding	42%
Had significant difficulty understanding	3%
In terms of attractiveness and readability, did you think the text was fine as is, or too choppy?	
Fine	27%
Too choppy	73%
If you could have a display like this on a radio at home, would you be interested in purchasing it?	
Yes	77%
If you could have a display like this on a radio in your car, would you be interested in purchasing it?	
Yes	66%

Table 15: Results from Slide Show

	Deaf	Hard-of-hearing
On a scale of 1-10, 1 being "I wouldn't use it at all" and 10 being "I would use it all the time, how often would you use an accessible radio in the following environments?		
Home (table top)	6.4	6.9
Alarm clock	6.8	5.1
Car	7.4	6.5
Portable (boom box)	6.2	4.9
Portable (iPod)	7.4	7.1
On a scale of 1-10, 1 being "not at all important" and 10 being "extremely important", how important do you think having an accessible radio would be to get information in the following genres:		
Emergencies	9.7	9.5
News	8.2	7.9
Entertainment	6.2	7.7
Weather/Traffic reports	9.2	8.1
On a scale of 1-10, 1 being "not important" and 10 being "extremely important", how important do you think the following features are important to include		
Bed Shaker for alerting	7.5	7.7
Strobe for alerting	8.1	6.8
Ability to see music lyrics	6.7	7.4
On a scale of 1-10, 1 being "not important" and 10 being "extremely important" what kind of information do you want to see on the radio display:		
Radio Show Name	8.4	8.3
Host	8.4	7.7
Story title	8.6	8.6
Station frequency	7.8	7.8
Date Time	8.8	7.5
All respondents		
Would you be interested in purchasing a dual-screen view display (GPS for the driver and captioned radio for the passenger?		
Yes	86%	
No	13%	
Maybe	1%	
How much would you pay for a dual-screen view display?		
Under $50.00	12%	
$50-$99	36%	
$100- $149	24%	
$150-199	20%	
$200+	8%	
Would you be interested in a captioned radio display for the backseat?		
Yes	46%	
No	18%	
Maybe, depending on the cost	36%	
In a driving situation, what would the most effective way of getting the driver's attention be?		
Flashing light in dashboard	39%	
Flashing light in radio	12%	
GPS Message	11%	

Shaker in car seat	24%
Stead light in dashboard	17%
What visual display on a radio would best correspond to a "warning sound" (the tone used to break into a program alerting the driver that an important message will follow).	
Flashing color and font change	45%
Bright colors	36%
Words	19%
I don't know	7%
Which announcer identification scheme did you like the best?	
Photo of announcer and name	60%
Color and name	27%
Name only	13%
In a large screen display (4" x 5"), which method of line presentation do you like best?	
Block (3 lines)	16%
Scrolling (star wars)	69%
Equally fine	12%
Neither	3%
In a small screen display (1" x 4"), which method of line presentation do you like best?	
Block (3 words)	35%
Scrolling (times square)	42%
Equally fine	13%
Neither	10%

Table 17: Open-ended question: If you could change anything about the display, what would it be? (Answers were group in the following categories)

Identifying announcers' comments:

Need to know who is talking - name of person
Put name next to the statements or change colors.
Different colors for different speakers. Use full names at beginning of each segment and then initials when speaker changes
identify person by color
identify person by color
It needs to add "name" so we know who is speaking--it would benefit me for traffic or weather information.
distinguish the text for speakers with color
Who is talking?
Identify who is speaking.
I would recommend putting someone's name in front of the speech to indicate who is speaking.
I would insert speaker's names in parentheses to distinguish text.
Lines to be clearer - name people who speak.
Block--and who is speaking? Maybe some colors (background). Maybe similar as navigation system when I stop and read news.
Would like the name before the options -- for example, on my blackberry, my name is always right before the captions and so is the person I'm talking to.. i.e.: John: How are you? Wendy: I'm fine. Having a display in my vehicle would greatly benefit me as I tune in to find out how is the traffic before I venture out to any highway, plus the weather report and other reports related to traffic.
Identification of speakers to the extent possible. This is especially important if the program has a well known reporter or public figures involved in the discussion. Captioned radio may

be most attractive to people who have some hearing. For me it works better to have captioned television-- the visuals are important. Captioned radio gives me just the words - no facial expressions, no laughter, etc... No sense of the whole scene. I think maybe, a couple of times the captioning indicated "cheering," but the effect was not the same as seeing captioned TV.
Visually separate the speakers -- >> is insufficient. All caps inhibit readability.
Add gender of the speaker so that we can have a visual image because right now I'm not sure how many voices they are and maybe you could change the font of the voices and maybe the sizes.

Scroll Format comments:

I would like the information to scroll the opposite way (new text on top)
Text would come in from top rather than bottom. Continuous feed rather than jumping in with a block of text. Announce breaks/commercials - "music"
more lines and scroll as each line was available
Try to have caption scroll out from left to right. The reading would be more appealing--along with the right pace.
I really need to hear and see the display at the same time to judge how I'd change it. But offhand, I'd like it to scroll up rather than popping up.
I'm not sure if maybe it only displayed 3 lines at a time it might be easier to read. I would try to drive and read the radio at the same time!
Make the display move slower, otherwise fine.
I'm more used to word by word like CART or live news broadcasts. The line by line here takes getting used to. I prefer word by word, seems more on top of things + easier to follow.

Smoother Scroll comments:

that jerky try to change to smooth
should scroll smoothly instead of stepping with each line being filled with text
When the line advances, my eyes have to re-target what I was reading before the line advanced. Would be nice to have smooth transition
smoother scrolling
smoother scrolling
Make sure the text isn't too choppy keep it ongoing smooth.
It would be nicer to give smooth scrolling effect in order to eliminate the choppiness.
Try to use a paragraph message -- hard to follow up reading while too choppy. Wonder if Sidekick II wireless pager can get NPR messages
Just more smoother--more like TV captioning. Need to add tone/if serious/funny/ etc.
Scrolling would be much better than the choppy-blocky display we had tonight.

Text format comments:

different font that's easier to see and read
There were many words that were stuck together. Also I would suggest capitalizing at the beginning of the line.
Reading white text is very difficult for long periods of time. Please aim for black text on a fairly neutral background - yellow, tan, cream, etc.
I would also try to include visual aids of important information in the background to aid in relay of the message. Could this be put into Tom-Tom?
User control of font and color contrast to change w/ speaker at his / her preference as an option. I would like to see audio cues (noisy background, cough, laugh) and to include tone of voice. The captioning does not convey emotion-- system that can be developed via font styles + formatting to convey background noise, atmosphere, tone of voice, etc.
Make it self paced -- radio equipment could have some buffering ability to permit such self pacing. The all caps are also impeding readability. It should be in lowercase -- all caps lines slow down reading! Just compare, who would want to read the whole book or newspaper all in caps?
All caps are a challenge. The choppiness of the sentence format inhibits reading flow or scanning. As a universal design advocate I would love to see this technology feature integrated into all radios.
Yes - sentences too short -- text into a more natural sentence format -- Longer lines. Jerky motion why few lines. Identify speakers. But I'd be most interested in having radio like this with a display on my TV at home. Consider applications for elderly-- many hearing + vision impairment. Consider applications for foreign language speaking populations and classrooms in urban areas like ours. Visual processing of audio produces a greatly enhanced effect to students who have English as a second language. Caption radio service could also be great on airplanes, airports, other public areas where audio transmission may be limited and can be enhanced.

Other comments:

My hearing loss is not that significant. But it is an interesting concept and might prove useful to me for emergencies
TV is more like a live radio as it has visual access where we can see the facial expressions while hearing people would hear the tone of voices -- consider NPR-TV? =)
In some way we can learn to use it.
I liked the number of lines available.
I'm the primary driver and this would be too distracting
Be consistent -- either show one line @ a time & change one line at home or leave multiple lines up for longer (in order to read) and change whole paragraph at a time.
Sync it with the spoken radio service. Text ran about 20 seconds ahead of spoke source, which will irritate aging baby boomers and CI users, both of which have some hearing.
Instead of relaying via text, all info relayed in ASL is preferable.
It's just too new for deaf access. One day it will improve as technology adjusts
Maybe a block of text that changes all at once, as opposed to the scroll on display. If this came to my blackberry, I would use it.

Table 18: Web survey results:

In terms of speed of captioning, did you think the presentation was:	
Too slow	64%
Too fast	7%
Just about right	29%
In terms of captioning, how does reading this display compare to reading television captions?	
Slower	65%
Faster	9%
The same	26%
In terms of accuracy, did you think the presentation was	
Extremely accurate	10%
Accurate	56%
Inaccurate	35%
In terms of understanding, did you:	
Completely understand the information	35%
Have some difficulty	47%
Have significant difficulty	19%
If you could have access to captioning on the internet for NPR shows, how often do you think you would use it?	
All the time	18%
Often	35%
Sometimes	35%
Rarely	10%
Not at all	3%

Acknowledgements

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