An analysis of real-time captioning errors: implications for teachers

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An Analysis of Real-time Captioning Errors: Implications for Teachers

Master’s Project

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Abstract

This study focused on the occurrence of errors during real-time captioning of live news programs. An analysis was conducted of the types and frequencies of errors that took place during a span of 5 hours of live captioned television. Thirty-minute segments from 10 different live news programs were randomly selected for analysis. Each error was recorded as it was detected and a list of errors, along with the corresponding spoken messages were compiled. A total of 235 caption errors were identified with an average of 23.5 errors on each station. The most common error categories were spelling errors (33%), word substitution errors (19%), and phonetic system errors (13%).

Teachers should become actively involved in the process of preparing deaf students to mentally repair these errors when possible. In order to foster incidental learning, strategies are suggested for educators to use in the classroom to better prepare their deaf students to deal with the most common types of errors that they will face during real-time caption viewing.


Introduction

Real-time caption errors often hinder comprehension of the material and information presented by a program. Not only can this be frustrating to deaf viewers, but it can also lead to a serious lack of understanding about current events and missed opportunities for incidental learning.

An analysis of the types of errors that frequently occur during real-time captioned live news programs is the focus of this study. Knowing which types of errors are most prevalent may lead to a better understanding of the information by deaf viewers.

Given the importance of news programs to inform and educate, it is suggested that educators of deaf students become actively involved in improving their students' accessibility to this information. By taking the time to specifically teach methods for mentally repairing common types of caption errors, they will be encouraging their students to be well informed and empowered to overcome such obstacles to learning through television and other captioned media. Educators need to promote a broad world view and understanding of the environment in which their students live.

Literature Review

Captioned Television

Research has shown that captions have great benefits for deaf viewers for acquisition of information and content of a television program. Captions can help increase comprehension, expand vocabulary, and motivate deaf students to learn. Captioned television can also be used in the classroom as a tool for teaching reading and for giving deaf students access to knowledge (Boyd & Vader, 1972; McCoy & Shumway,
1979; Koskinen, Wilson, Gambrell & Neuman, 1993). Fortunately, captioning technology in televisions is now widely available to all who want to take advantage of this access. The Television Decoder Circuitry Act of 1990 required that all new televisions made after June 1993 have built-in decoders to display closed-captioned programming (Koskinen, et.al, 1993).

It is not enough that all television sets provide access to captioned programs if very few programs are captioned. That is why the Telecommunications Act of 1996 requires that all cable television operators, broadcasters, and satellite distributors use closed captioning in their television programs. This is to be accomplished in phases, requiring that 100% of all programs have closed captions by January 1, 2006 (The National Captioning Institute,7/18/2003, http://content.epnet.com). This means that within the next few years access to programs should have no limits for deaf viewers.

However, access to information through real-time captioning will still be limited due to the errors that frequently occur. There are two common forms of captions that appear on television, offline captioning and online captioning. Offline captioning is also known as “additive” captioning, because they are prepared ahead of time for prerecorded programs and then added during the programs airing. These captions have fewer errors because they are prepared from a script of the show and there is time for the captions to be edited before their use with deaf viewers. Offline captioning is typically used for sitcoms and talk shows that have been prerecorded.

Online captioning is also known as “real-time” captioning, because the captions are created as the program is taking place. These captions are created using a stenographic keyboard by a captionist who is often hundreds of miles away from where
the broadcast is taking place. Real-time captions are displayed in a scroll fashion at the bottom of the screen and are typically used during live news programs and sporting events (NETAC, 7/18/03, http://www.netac.rit.edu/publication/tipsheet/captioning.html). These nearly verbatim real-time captions are presented at an average rate of 141 words per minute (WPM). One problem that occurs is that the captions move very quickly off the screen which does not allow the viewer much time to look back at previous information as is possible with printed texts (Jensema, McCann, & Ramsey, 1996; Lewis & Jackson, 2001).

Challenges for Incidental Learning

Many hearing children and adults learn indirectly from television news programs by simply “overhearing” what is being said. Most deaf children and adults can miss this incidental learning because of their lack of auditory input (Marschark, Lang, & Albertini, 2002). Access through real-time captioning on television addresses the need for such incidental learning opportunities for deaf people, but there are various challenges associated with this technology. Television has been shown to play a large role in influencing a person’s social skills and learning. However, deaf viewers often miss these influences due to a lack of essential reading skills needed to understand captioned television (Lewis & Jaskson, 2001). The amount of incidental learning that can take place through watching television programs is strongly dependent on the viewers reading level and language development (Braverman, 1981; Jorgensen & Murphy-Berman, 1980).

Research shows that about 84% of the time deaf viewers watch television programs is focused on viewing the captions. This leads to the conclusion that viewing
captioned television is mainly a reading task. Since the average person watches about 30 hours of television per week, it may be that deaf television viewers typically spend about 25 hours each week looking at printed texts (Jenesema, Danturthi, & Burch, 2000). This may present problems for a viewing population of deaf readers who on average are several grade levels behind hearing peers in reading ability (Marschark, Lang, & Albertini, 2002).

Errors in Captioning

Incidental learning depends not only on the deaf viewer’s reading level but also on the quality of the captions. Many times, errors can occur that would cause confusion to even the best reader. In order to understand essential information presented in a live program, often deaf viewer’s have to be able to mentally “repair” the errors that occur within the captions. Possessing quality repair strategies may be essential to comprehending and gaining knowledge from television.

With real-time captioning there is less opportunity to edit what will be presented to the public. Mistakes can occur when the captionist presses the wrong key or when the computer software incorrectly translates the phonetic code. Words and sounds must be entered into the computer in order for the stenographic type to be changed into English on the screen. Often the captionist will need to type a word that is not recognized by the computer, resulting in phonetic errors. For example, if the captionist does not have the term “mosquito” programmed into the computer dictionary, the word may appear as “moss key toe”. This is because the computer does not recognize the syllables as a word (The National Captioning Institute, 7/18/2003, http://content.epnet.com).
Other types of errors can occur when the captionist lacks knowledge of the specific vocabulary used. The wrong word may be used in the wrong context, without the captionist making the proper modification. An example would be the homonyms “hair” and “hare.” If a captioned science segment of the news was discussing the rabbit population and the captionist repeatedly presented the word “hair” instead of “hare” the story could become quite confusing, especially for young audiences.

Still another type of error may be introduced through electrical “noise” when the captions are transmitted through various forms of telecommunication over large distances.

Repair Strategies

Learning and using strategies to mentally repair captioning errors is critical for deaf viewers if they are to acquire adequate knowledge and comprehension from a news program. This process of figuring out the correct word or words that should replace the error often involves guessing. Research shows that in order to guess an unknown word in context a reader must be able to recognize, on sight, most of the other words in the sentence (Huckin & Coady, 1999). Research conducted with the cloze procedure shows that in order to gain clues about the unknown word the reader must employ knowledge of many aspects of the English language. This includes structural information within the sentence and paragraph, semantic information, and thematic content knowledge (Huckin & Coady, 1999).

This can pose a major problem for typical deaf viewers of real-time captioning programs. Research has shown that deficiencies in vocabulary and syntactic knowledge
are prevalent among deaf readers and that these two processes directly and adversely affect reading comprehension (Kelly, 1996). Because of these factors, guessing and repairing strategies may be limited. Accurate guessing requires accurate word recognition, a good understanding of the context, a knowledge of most of the surrounding words, and good reading strategies (Huckin & Coady, 1999). Good guessing skills also appear to be important when trying to mentally fix errors while viewing real-time captioning.

Currently, little is known about captioning repair strategies used by deaf television viewers.

**Purpose of Research**

This study will focus on real-time captions, particularly those used during live news programs, which can provide opportunities for educational and incidental learning. In order to better prepare deaf viewers for adjusting to the captioning errors that can occur in real-time captioning it is necessary to know what they are up against. Research has helped to identify the benefits of captioning, but little has been researched about the specific types of errors that can occur and the implications of these errors for incidental learning through real-time captioned news programs. This study will identify both frequency and type of real-time captioning errors in a sample of news segments from major television news channels. An analysis of these errors will be conducted to find out which types of errors occur most often and how frequently errors in general occur within live news program that are real-time captioned. Based on the findings, recommendations
will be made to classroom teachers for helping prepare deaf students with repair strategies.

Methods

Data Collection

Real-time caption data was collected from live news programs on ten television stations. Out of the ten, three were local news programs, three were national news programs and four were cable news programs. The programs represented were as follows: ABC local, ABC national, CBS local, CBS national, NBC local, NBC national, CNN, CNBC, FOX NEWS and MSNBC.

At least, one hour of video was recorded from each of the ten news programs at randomly selected times and dates. A 30-minute section of each channel was then selected to be analyzed for errors. The time and date of the video sections used for analysis were also randomly selected. A total of 5 hours of video containing real-time captions was selected to be analyzed.

Error Identification

Each program’s 30-minute section was examined separately using a VCR to play back the recorded news programs. The station, video number and counter number of the program on the video were recorded. Each recorded segment was carefully studied and the errors that were found in the real-time captions were recorded.

The identification of errors involved listening to the speech of the news presenters and reporters and then comparing what was said to what appeared in the real-time
captions. In this analysis, an "error" was defined as a caption that did not appropriately match the spoken message. Each time that an error was identified, the counter number on the video was recorded, as well as the spoken and captioned versions of the information being presented.

This process was continued throughout each 30-minute program, with the exception of the time consumed by commercials. The error data for each program was recorded separately and saved to be categorized.

**Categorization**

To ensure that the error types were identified correctly for categorization, the researcher consulted with two professors at the National Technical Institute of the Deaf. After discussing a sample of the errors, three major error types were established: 1) Missing Information; 2) Additional Information; and 3) Substitution Errors. Each of the major categories was then broken down into a total of 15 error type subcategories. Each error type was then defined and an example was decided on for reference. The final analysis was conducted with the following error types:

### Table 1. Categories of Captioning Errors

**Missing Information:**

Type 1: WORD MISSING – one real word is missing from the caption

Ex. Caption: "I not disappointed"

Should say: "I was not disappointed"
Type 2: WORD CLUSTER MISSING – two or more real words are missing from the caption.

Ex. Caption: “how the storm”
Should say: “how they weathered the storm”

Type 3: WORD ENDING MISSING – the proper word ending is missing from a word in the caption.

Ex. Caption: “the poll are open”
Should say: “the polls are open”

Additional Information:

Type 4: ERRATIC LETTER/S ADDED – one or more erratic letters added to the caption.

Ex. Caption: “wz we are”
Should say: “we are”

Type 5: ERRATIC NUMBER/S ADDED – one or more erratic numbers added to the caption.

Ex. Caption: “May 6th, 19616789”
Should say: “May 6th, 1961”

Type 6: TECHNICAL ERRORS ADDED – technical garble (not letters) added to caption in place of words.

Ex. Caption: “is#$%&$ instead of”
Should say: “is done online instead of”

Type 7: WORD ADDED – one real word added to the caption.

Ex. Caption: “report it if a product”
Should say: “report if a product”
Type 8: WORD ENDING ADDED – an improper word ending is present on a word in the caption.

Ex. Caption: “others things”
Should say: “other things”

Substitution Error:

Type 9: HOMONYM SUBSTITUTION ERROR – a wrong word substituted for the appropriate word in the caption because the two words sound identical.

Ex. Caption: “paws”
Should say: “pause”

Type 10: SPELLING ERROR – one or more words in the caption are spelled wrong resulting in a word/s that are not real. May also be the result of a missing space between words.

Ex. Caption: “superbendent”
Should say: “superintendent”

Type 11: PHONETIC SYSTEM ERROR – one or more words in the caption are incorrect, due to a phonetic representation.

Ex. Caption: “Jay son Williams”
Should say: “Jason Williams”

Type 12: WORD SUBSTITUTION ERROR – one incorrect real word replaces the correct word in the caption.

Ex. Caption: “from an early ache”
Should say: “from an early age”

Type 13: WORD CLUSTER SUBSTITUTION ERROR – one or more incorrect words replace the correct word/s in the caption.

Ex. Caption: “association peck a few delays”
Should say: “so you should expect a few delays”
Type 14: NUMBER SUBSTITUTION ERROR – one or more incorrect number/s replace the correct number/s in the caption.

Ex. Caption: “2.5-5.6 Billion dollars”  
Should say: “2.5-2.6 Billion dollars”

Type 15: ENDING SUSTITUTION ERROR – a base word with an appropriate ending that has an incorrect ending used in the caption.

Ex. Caption: “ordered”
Should say: “orders”

Once the error types were established, each individual real-time caption error was categorized as one of the fifteen error types. After the categorization was completed by the researcher, the reliability of the categorization process was estimated.

Reliability

To study the reliability of the categorization of error types, a random stratified sample of 30 caption errors was selected in order to have a representation of the various errors in the analysis. Four professionals were given the sample of 30 caption errors that was selected for the analysis, as well as the descriptions and examples of error types. They were also given the original spoken messages (what was actually said during the news program). The participants were asked to categorize each of the 30 caption errors.

Overall, the average percentage of agreement between the participants and the researcher was approximately 80 percent. One of the raters produced data that was particularly inconsistent. When this one rater was dropped from the analysis, the
remaining four raters (including the researcher) had approximately 85 percent agreement in categorization of errors.

Results

The analysis of the five hours of video containing real-time captions from live new programs resulted in a total of 235 errors. This translates to an average of 23.5 real-time caption errors occurring during a 30-minute live news program. The number of errors ranged from 14 to 42, as shown in Table 2.

Table 2: Number of Errors Per Half-Hour News Segment

<table>
<thead>
<tr>
<th>Network</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC local</td>
<td>18</td>
</tr>
<tr>
<td>ABC national</td>
<td>24</td>
</tr>
<tr>
<td>CBS local</td>
<td>21</td>
</tr>
<tr>
<td>CBS national</td>
<td>14</td>
</tr>
<tr>
<td>NBC local</td>
<td>21</td>
</tr>
<tr>
<td>NBC national</td>
<td>30</td>
</tr>
<tr>
<td>CNN</td>
<td>42</td>
</tr>
<tr>
<td>CNBC</td>
<td>18</td>
</tr>
<tr>
<td>FOX NEWS</td>
<td>20</td>
</tr>
<tr>
<td>MSNBC</td>
<td>27</td>
</tr>
</tbody>
</table>

Categorization of Errors

Categorization of the 235 caption errors indicated that Substitution Errors were the most frequent type found in this analysis, accounting for 77.5 percent. This was followed
by Additional Information (13 percent) and Missing Information (9.5 percent). These results are summarized in Figure 1.

Figure 1. Results of Categorization by Major Error Types

**Three Main Error Types**

![Pie chart showing percentages of error types](image)

Within each major category the following percentages of error types occurred:

**Table 2: Missing Information Error Type Percentages**

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Errors</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1: Word Missing</td>
<td>8</td>
<td>36%</td>
</tr>
<tr>
<td>Type 2: Word Cluster Missing</td>
<td>13</td>
<td>59%</td>
</tr>
<tr>
<td>Type 3: Word Ending Missing</td>
<td>1</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Table 3: Additional Information Error Type Percentages**

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Errors</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 4: Erratic Letter/s Added</td>
<td>8</td>
<td>26%</td>
</tr>
<tr>
<td>Type 5: Erratic Number/s Added</td>
<td>3</td>
<td>10%</td>
</tr>
<tr>
<td>Type 6: Technical Errors Added</td>
<td>5</td>
<td>16%</td>
</tr>
<tr>
<td>Error Type</td>
<td>Errors</td>
<td>Percentage</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>Type 7: Word Added</td>
<td>13</td>
<td>42%</td>
</tr>
<tr>
<td>Type 8: Word Ending Added</td>
<td>2</td>
<td>6%</td>
</tr>
</tbody>
</table>

Table 4: Substitution Error Type Percentages.

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Errors</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 9: Homonym Sub. Error</td>
<td>8</td>
<td>4%</td>
</tr>
<tr>
<td>Type 10: Spelling Error</td>
<td>78</td>
<td>43%</td>
</tr>
<tr>
<td>Type 11: Phonetic System Error</td>
<td>31</td>
<td>17%</td>
</tr>
<tr>
<td>Type 12: Word Sub. Error</td>
<td>44</td>
<td>24%</td>
</tr>
<tr>
<td>Type 13: Word Cluster Sub. Error</td>
<td>16</td>
<td>9%</td>
</tr>
<tr>
<td>Type 14: Number Sub. Error</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Type 15: Ending Sub. Error</td>
<td>3</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 5: Summary of Error Analysis Across 15 Subcategories

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Errors</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1: Word Missing</td>
<td></td>
<td>3.4%</td>
</tr>
<tr>
<td>Type 2: Word Cluster Missing</td>
<td></td>
<td>5.5%</td>
</tr>
<tr>
<td>Type 3: Word Ending Missing</td>
<td></td>
<td>.5%</td>
</tr>
<tr>
<td>Type 4: Erratic Letter/s Added</td>
<td></td>
<td>3.4%</td>
</tr>
<tr>
<td>Type 5: Erratic Number/s Added</td>
<td></td>
<td>1.3%</td>
</tr>
<tr>
<td>Type 6: Technical Errors Added</td>
<td></td>
<td>2.1%</td>
</tr>
<tr>
<td>Type 7: Word Added</td>
<td></td>
<td>5.5%</td>
</tr>
<tr>
<td>Type 8: Word Ending Added</td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Type 9: Homonym Sub. Error</td>
<td></td>
<td>3.4%</td>
</tr>
<tr>
<td>Type 10: Spelling Error</td>
<td></td>
<td>33%</td>
</tr>
<tr>
<td>Type 11: Phonetic System Error</td>
<td></td>
<td>13%</td>
</tr>
<tr>
<td>Type 12: Word Sub. Error</td>
<td></td>
<td>19%</td>
</tr>
<tr>
<td>Type 13: Word Cluster Sub. Error</td>
<td></td>
<td>6.8%</td>
</tr>
<tr>
<td>Type 14: Number Sub. Error</td>
<td></td>
<td>.8%</td>
</tr>
<tr>
<td>Type 15: Ending Sub. Error</td>
<td></td>
<td>1.3%</td>
</tr>
</tbody>
</table>
This study shows the immense obstacles that must be overcome in order for deaf viewers to benefit from the information presented through real-time captions. Results showing that within 5 hours of live news programming there were a total of 235 errors detected are staggering, but yet not surprising to many deaf viewers who have had to deal
with these challenges for years. Obviously, real-time caption errors within live news programs are prevalent and at this time unavoidable.

Knowing which types of errors are the most common can lead to a better understanding of how to prepare deaf students to face these challenges. This study showed that the main type of error that occurs are spelling errors (33%), followed by word substitution errors (19%) and phonetic system errors (13%). The assumption can be made, therefore, that these are the main types of captioning errors that deaf viewers of real-time captioned news programs will face. Twelve other error types were identified, although their frequency of occurrence was much smaller.

Given this information, the question is how can educators better prepare their students to deal with these specific types of errors that will occur during television viewing? It is critical that deaf viewers have the skills necessary to mentally repair these errors, when possible, in order to comprehend live news programs. Enhanced comprehension through repair strategies may enhance incidental learning.

One of the most important things that educators of deaf students can do is to bring live captioned materials into the classroom to spark discussions about the errors that occur. Addressing the issue openly will bring awareness to deaf students and help them develop skills and strategies for dealing with the poor quality of the captions available to them. By doing this, educators can also promote the need for deaf students, as well as hearing students, to view the news regularly. Teachers should encourage students to become knowledgeable about the world around them by showing them that viewing live news programs is an important part of incidental and intentional learning.
Suggested Strategies

Below are specific strategies that can be used in the classroom to prepare deaf students to deal with some of the most frequently occurring types of errors in real-time captioning found during this study. English teachers, in particular, could utilize such strategies in their lessons, not only as a way to prepare their students to face the challenges to real-time caption viewing, but also as a way to promote better overall reading habits. However, all educators and parents should be involved in this process.

Spelling Errors:

(1) Give students examples of sentences with a misspelled word and ask them to identify the misspelled word and then write the correct spelling in the blank provided. (Dictionary use should be encouraged.)

Ex. 1  Are you sure it is nesecary to do that?  necessary
Ex. 2  I went to bed at 10:00pm last niht.  night

(2) Give students examples of sentences that have two words together (with no space between them) and ask the students to identify that mistake and draw a line to show where the words should be separated.

Ex. 1  I want totalk to you.  to / talk
Ex. 2  Mymom is at the store.  my / mom
Word Substitution Errors:

(1) Give students examples of sentences that have a word missing (can possibly give first and/or last letter of word). Ask the students to chose the word that best fits the content of the sentence, given a choice of two similarly spelled words.

Ex. 1  *Sit b__k and relax.* book or back?

Ex. 2  *I like to w__h television after school.* watch or which?

Phonetic System Errors:

(1) Give students examples of sentences that have phonetic representations of one of the words and ask students to identify what the word should be using phonetic clues, as well as clues from the context of the sentence. Ask the students to write the correct word in the blank provided. (Dictionary use should be encouraged.)

Ex. 1  *I went outside and a moss key toe bit me!* mosquito

Ex. 2  *Open the door by pulling the hand dell.* handle

Word Added:

(1) Give students examples of sentences that have one extra word that is not suppose to be there and, therefore, does not make sense in the sentence. Ask
students to identify which word does not belong and have them test their
guess by removing the word to see if the sentence still makes sense. Once
they have identified the added word, ask then to write the word in the blank
provided.

Ex. 1  She is very a excited!  ___a___

Ex. 2  I went on a walk be today.  ___be___

Word Ending Errors:

(1) Give students examples of sentences that have a specific root word in need of
an ending that will make the word fit the context of the sentence. Provide the
students with the root word and give them two choices as to which ending
should be placed on the root word. Have students identify the correct root and
have then test their guess by using it in the sentence to see if it makes sense.

Ex. 1  I went shop at the mall yesterday.  shopping  or  shopped?

Ex. 2  I vote last week.  voting  or  voted?

Homonym Errors:

(1) Give students examples of sentences that have a blank where a word needs to
be provided and ask students to pick from a list of two homonyms. Ask
students to pick the word that best fits the context of the sentence. (Dictionary
use should be encouraged)

Ex. 1  I was searching for my glasses on the table, but when I looked the table
was _______.  bear  or  bare?
Ex. 2  I am reading a book about King Arthur and all this _______.  

knights or nights?

Conclusion

The goal of this study was to provide deaf viewers and educators with a summary of the specific types of errors that occur during real-time captioning. Not only were excessive errors detected, but there were three main types that proved to be most prevalent and in need of serious attention.

Educators need to prepare deaf students to learn through captions, despite the errors. It is also important to make deaf viewers more aware of what challenges they are likely to face in gaining access to live news programs.

Besides preparing deaf viewers to deal with caption errors, research is needed to reduce the amount of errors occurring in the future. As mention earlier, error can be the fault of the captionist or the computer system. Many times the errors that occur are out of the captionist’s hands. Signals between the television stations and the captionists are often transmitted over a telephone line that can easily pick up “noise” and other interference (Menchel, 2004). Until technology improves, there is little that can be done to avoid such problems.

Errors caused by the captionist’s lack of knowledge about the topics being presented on the news programs may be reduced by improved training and strategies that will familiarize the captionists with the material being captioned. Perhaps one solution could be that caption providers raise their standards and criteria for hiring and maintaining captionists in their companies.
Additional research is also needed to determine if similar types of errors appear in captions for television shows other than news reports. Live programs, such as sporting events, the Olympic games, talk shows and presidential addresses can also present opportunities for incidental learning.

More research is also needed on the correlation between the rate of speech by the presenter and of the caption error rate.

With an increasing number of networks providing news programs and the influence of the media on our society, it is imperative that deaf viewers have equal access to information through real-time captioning. Hopefully, future strides will be made in the area of improved access and comprehension of information through this important technology.
Bibliography


