College Students' Perceptions of the C-Print Speech-to-Text Transcription System

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C-Print is a real-time speech-to-text transcription system used as a support service with deaf students in mainstreamed classes. Questionnaires were administered to 36 college students in 32 courses in which the C-Print system was used in addition to interpreting and note taking. Twenty-two of these students were also interviewed. Questionnaire items included student ratings of lecture comprehension. Student ratings indicated good comprehension with C-Print, and the mean rating was significantly higher than that for understanding of the interpreter. Students also rated the hard copy printout provided by C-Print as helpful, and they reported that they used these notes more frequently than the handwritten notes from a paid student note taker. Interview results were consistent with those for the questionnaire. Questionnaire and interview responses regarding use of C-Print as the only support service indicated that this arrangement would be acceptable to many students, but not to others. Communication characteristics were related to responses to the questionnaire. Students who were relatively proficient in reading and writing English, and in speech-reading, responded more favorably to C-Print.

Within the past few decades, schools have witnessed a dramatic increase in the number of deaf and hard-of-hearing students educated alongside hearing students at both secondary and postsecondary levels (Moores, 1992; Rawlings, Karchmer, & DeCaro, 1988; Schild-

roth & Hotto, 1994). A major concern for these students is the adequacy of classroom communication, and the communication difficulties of deaf students in mainstream classes are well documented (Osguthorpe, Long, & Ellsworth, 1980; Stinson, Liu, Saur, & Long, 1996). Even when an interpreter and additional support services are provided, students still experience communication difficulties, such as understanding the teacher and participating in class discussions and activities (Kluwin & Stinson, 1993). For example, one problem is the ability to understand hearing classmates. Many hard-of-hearing students and some deaf students use Frequency Modulation (FM) systems to supplement their lipreading of the teacher. Usually the teacher wears the FM microphone. When the students' hearing aids are switched to receive the FM input, they generally cannot hear their classmates' comments.

In response to these difficulties, and also in response to the recognized value of printed information, alternative means of support for mainstreamed deaf and hard-of-hearing students have been developed in the form of real-time speech-to-text transcription systems (Stuckless & Carrol, 1994). The first to be developed was a stenographic-based system in which the code produced by the stenographer was converted by computer into a real-time display of English text (Stinson, Stuckless, Henderson, & Miller, 1988). More recently, with the development of laptop computers, computer-assisted note taking has also been used as a support. In these systems, the support person types on

a standard keyboard (Cuddihy, Fisher, Gordon, & Shumaker, 1994; James & Hammersley, 1994; Stinson & Stuckless, 1998; Youdelman & Messerly, 1996). One of these systems has been called C-Print in recognition of the system's display of print ("C" sounds like "see") and the computer basis of the system. In the past 15 years, the use of these systems to support students has increased steadily (Stinson et al., 1999).

It is important to evaluate these systems to determine their educational effectiveness and also their limitations. We report here a study of college students' perceptions of C-Print as a support service. This study addressed four factors related to the use of C-Print: (1) the real-time text display, (2) the hard copy printout of the text provided to students after class (C-Print notes), (3) the effectiveness of the C-Print system without other support services, and (4) individual differences in student responses to C-Print. We first provide a description of the C-Print system before discussing these four factors.

Description of C-Print

As with other computer-assisted note-taking systems, C-Print uses standard laptop computers and word processing software. However, C-Print uses additional technology and training, which permits captionists to more fully capture the lecture. Captionists are trained to use phonetics-based abbreviation software that allows for the transformation of an abbreviation into a full word on the computer screen. In addition, captionists learn strategies for listening actively, for eliminating redundancies, for identifying important points, and for condensing and organizing information (Stinson & McKee, 2000). In comparison to stenography training (usually 2–3 years), C-Print training is relatively short (about 6 weeks). Furthermore, equipment costs for C-Print ($3,500) are less than those for stenographers ($7,000), as is the salary requirement for the captionist (approximately $18 vs. $100 per hour for stenographers) (National Court Reporters Foundation, 1995; Stinson et al., 1999).

The captionist, using a computerized abbreviation system, types the words of the teacher and students as they are being spoken. The system provides a real-time display that the student can read on a laptop computer or television monitor. The text display for the message appears approximately 3 seconds after the words are spoken and remains on the screen for approximately 1 minute. This provides students far more time to consider these words than if they were using an interpreter or lipreading a speaker. In addition, the text files are saved and may be edited after class. These edited notes can be used by students, tutors, and instructors after class by reading them on a monitor or from a printed copy. The system cannot provide word-for-word transcription because it cannot keep up with the speed of speech (approximately 150 words per minute). However, the system does provide for capturing almost all of the meaning of the lecture (Stinson, McKee, & Elliot, 2000). Although the stenographer's notes are verbatim and more detailed, C-Print notes contain the important information in a more condensed format. Consequently, C-Print reduces the number of pages of notes. Students seem to find these C-Print notes easy to study because they feel that the notes contain detailed information about class proceedings and course content (Elliot, Foster, Stinson, & Colwell, 1998).

Real-Time Text Display

The amount of classroom discourse that the C-Print system captures was investigated in an analysis that compared six transcripts produced by a C-Print captionist with verbatim transcripts of teachers' lectures. This comparison found that the mean percentage of idea units captured by the C-Print captionist was 65% and that the mean percentage of important idea units (as rated by three judges) captured by C-Print was 83% (Stinson & McKee, 2000). These findings can be contrasted to those for a stenographic system. Real-time stenographic systems capture virtually every word spoken by the teacher (Stinson et al., 1988).

These findings raise the question of the extent to which students would regard the information provided by C-Print in the classroom as easy to understand and comprehensive. A previous investigation by Stinson et al. (1988) evaluated the use of a steno-based support service in the classroom. Questionnaires were administered to 121 deaf and hard-of-hearing students at the National Technical Institute for the Deaf (NTID) served by the steno-based service. Students reported

that they understood significantly more lecture information with the steno system than with the interpreter. The first question of this study was whether students would respond favorably to the real-time text display of information provided by C-Print.

Hard Copy Printout of C-Print Text as Notes

A major concern of deaf and hard-of-hearing college students is that they have high quality notes for study after class. If the student relies on interpreting services, lipreading the teacher, or a real-time text display, it is often difficult to simultaneously focus on this information and on taking good notes (Hastings et al., 1997). In view of this difficulty, educators, such as Saur (1992), have stated that note taking, when a designated person in the class takes notes, is an essential support for most deaf and hard-of-hearing college students. These notes provide a permanent record that the student can review after class in order to remember the relevant information (Saur, 1992). Note taking is the most frequently used support service for deaf and hard-of-hearing students (Lewis, Farris, & Greene, 1994).

Despite the popularity of note taking, Hastings et al. (1997) and Saur (1992) describe several limitations, including variations in the quality of notes. For example, notes from student volunteers may exclude important information because the student taking notes already knows the information or does not value its importance. Paid note takers may produce better notes. However, all handwritten notes have limitations. They may be messy or disorganized and must include considerable summarization, because note takers cannot write nearly as rapidly as professors can talk.

Text produced by a real-time transcription system in class and distributed to students as a computer text file or as a printout are essentially a verbatim copy of what was said in class. This printout is likely to be considerably more detailed than handwritten notes when a computer-assisted note-taking system, such as C-Print, is used. Previous research on real-time transcription systems suggests that students prefer notes generated by real-time systems rather than handwritten notes. For example, Stinson et al. (1988) found that students perceived the printout produced by the real-time graphic display steno system as more helpful than notes provided by paid student note takers. The second question for this study was how students perceive the printout produced with the C-Print system.

C-Print Without Other Support Services

Although a speech-to-text system is most economical when it is the only support service in a given course, it may be used in addition to other support services, such as interpreting. The Stinson et al. (1988) study included a question about preference among various support services including interpreting, steno system display on TV, note taking, steno system printout, and tutoring. Results indicated that students had a favorable opinion of the steno system relative to other support services. Overall, 62% of the students selected either the real-time display or the printout of the text as their most preferred support service, whereas 36% selected either note taking or interpreting as the single most preferred system. The frequent choices of these two services provided by the steno system suggested that the system could sometimes be used without the support of an interpreter or note taker. Students were not, however, asked directly whether they perceived that system as an appropriate support service if they used it without other support services. The third question of this study was whether students perceived this practice as appropriate.

Individual Differences in Perceptions of C-Print

Given the variations in communication preferences and learning styles of deaf and hard-of-hearing students, they likely will also offer differing favorable or unfavorable responses to specific support services, including C-Print (Kluwin & Stinson, 1993; Lang, Stinson, Kavanaugh, Liu, & Basile, 1998). For example, because C-Print provides printed English, students who are relatively proficient readers may respond more favorably than those who are less proficient. Stinson et al. (1988) considered communication preference and educational background of students who used a steno system and their preferences for interpreting, steno system display, note taking, steno system notes, and tutoring support services. The authors reported individual differences in preferences for various support

services. Students who came from mainstream high school programs and who were relatively proficient in reading, writing, and speech-reading tended to prefer the steno system. On the other hand, students who came from residential or day schools for the deaf, who were relatively proficient in manual reception, but who were less proficient in auditory discrimination, speech-reading, and speech production, were likely to prefer an interpreter.

These results suggest that individual differences in student characteristics would also relate to students' favorable ratings of C-Print. The fourth question of this study was whether student characteristics were related to the ratings of C-Print.

Method

To examine college students' perceptions of the C-Print service, we employed a multimethod research strategy, an approach that has been gaining acceptance in educational research (Garrison, 1986; Howe, 1988). Use of multimethod design enables researchers to develop a deeper understanding than the use of only one methodology (Eisenhart & Borko, 1993; Howe, 1988; Howe & Eisenhart, 1990; Lagemann & Shulman, 1999). To this end, this study collected questionnaire and qualitative interview data and also used information on background and communication characteristics from NTID student records.

Participants

The participants for the questionnaire component of the study were 36 deaf or hard-of-hearing college students (17 women, 19 men). They received the C-Print support service in one of their mainstream courses at the Rochester Institute of Technology between spring quarter 1994 and fall quarter 1996. Students received the C-Print service for all class sessions in the 10-week term. All students who received the services were asked to complete questionnaires and participate in interviews. Virtually all the students who answered the questionnaire had attended mainstream high school programs (32) as opposed to separate day or residential secondary schools (4). The mean pure-tone average for the better ear was 95.12 (SD = 14.32). The students'

overall grade point average was 2.85 (SD = .57) on a 4-point scale. All students who apply to NTID or receive support through NTID are asked to complete the Language Background Questionnaire (LBQ) developed at NTID and containing items related to self-perceived skill levels in several modalities (Metz, Caccamise, & Gustafson, 1997). The mean score on the LBQ item providing a self-rating of sign proficiency was 2.83 (SD = 1.11), where 1 = poor skills and 4 = high-level skills, indicating relatively good sign proficiency. Twenty-two students participated in the in-depth interview component of the study. All of these students, except one, also responded to the questionnaire described above.

Courses

Eight students served by C-Print were in business courses; 28 in liberal arts courses. Examples of courses covered by C-Print included "Foundations of Sociology" and "Social Psychology" in the College of Liberal Arts and "Financial Accounting" in the College of Business. The courses were taught by 4 different faculty members in the College of Business and 12 different faculty members in the College of Liberal Arts.

Twenty-seven of the students were in courses identified by the C-Print captionist as primarily lecture-oriented, five in discussion-oriented courses, and four in a course that had approximately equal amounts of lecture and discussion. All students had trained note takers and tutors in their courses, and all but two students had interpreting services as well as C-Print. These two students agreed to use C-Print instead of an interpreter.

Materials and Procedures

The materials and procedures for collecting the three sets of data include the following.

Questionnaire. The questionnaire included items relating to (1) the use and understanding of the real-time display, (2) the use and assistance provided by the C-Print hard copy notes, and (3) the use of C-Print as the only support service. These questionnaire items are presented in Appendix 1. All items except for one were

fixed-alternative questions. Questionnaires were distributed by the C-Print captionist during a class session near the end of the term. Students completed the questionnaire independently, returned it to an office at NTID, and received $3 for their time.

Interviews. The purpose of the in-depth interview was to extend our understanding of how students perceived the effectiveness of the C-Print system and how they used it to aid learning in the mainstream classroom. Some of the information solicited during the interviews addressed the same issues as the questions included in the questionnaire (see Appendix 2). However, the interviews were open-ended and participants were encouraged to pursue their own line of reasoning. This resulted in elaboration that was not possible within the constraints of our questionnaire. The interviews lasted 30 minutes to 1 hour. Students received $10 for their participation. Interviews were conducted by two members of the research team who were proficient in sign communication (Everhart, Stinson). The students' communication skills varied. Most of the students used sign communication with or without speech, and the interviewer used sign communication and speech. A voice interpreter repeated the interviewer's and respondent's sign and voice communication into an audiotape recorder. A few students preferred to use spoken English. If these students had intelligible speech, their responses were spoken directly into the tape recorder. If their speech was judged unintelligble, the interpreter voiced the responses. Interviews were later transcribed verbatim for analysis.

Student records. Students gave the researchers permission to access their records, which are maintained in a database at NTID. Data from five tests of communication proficiency were used for this study: (1) reading comprehension subtest of the California Achievement Test ($M = 10.77$, $SD = 1.07$), (2) Michigan Test of English Proficiency ($M = 81.76$, $SD = 12.63$), (3) NTID Test of Speechreading with Sound ($M = 68.60$, $SD = 33.55$), (4) NTID Test of Speechreading Without Sound ($M = 46.90$, $SD = 22.45$), and (5) NTID Test of Simultaneous Communication Reception ($M = 84.00$, $SD = 14.28$). The first two tests are standardized achievement tests. The California Achievement

Test is now called the TerraNova CAT and is distributed by CTB McGraw-Hill (2000). The Michigan Test of English Proficiency is a retired component of the Michigan English Proficiency Battery distributed by the English Language Institute at the University of Michigan (2000). The last three tests listed above were developed at NTID and are used for student advising and course placement in communication courses (see Crandall, 1978; Johnson, 1976; Subtelny, 1982). For the two speech-reading tests, students viewed a videotape of a person saying sentences (with and without sound) and then wrote out the sentences. For the simultaneous communication reception test, students viewed a videotape of a person signing and saying sentences and were then required to write out the sentences. More detailed descriptions of the tests, the scoring, and examples of test items can be found in Johnson (1976), Crandall (1978), and Subtelny (1982).

Analysis

Questionnaire. Data were summarized using descriptive statistics (e.g., frequency distributions) and standard inferential statistics (chi-square, paired t tests).

Interviews. Verbatim transcribed interviews were analyzed using content analysis techniques described by Bogdan and Biklen (1992). The transcripts were coded into three categories: (1) use and understanding of the C-Print real-time display, (2) use and assistance provided by the C-Print hard copy notes, and (3) appropriateness of C-Print as the only support service.

C-Print index and student records. To examine the relationship between perceptions of C-Print and communication characteristics of individual students, we created an index of the extent to which students responded favorably to C-Print. Scores were combined for three questions: (1) "How helpful is C-Print without the notetaker?" (range of scores: 2–4), (2) "What percentage of the lecture was understood with C-Print?" (range: 50–100), and, (3) "How much did C-Print notes help with the course?" (range: 2–4). To give responses to these questions equal weight in the index, we applied a z-score transformation to individual students' responses to each question. We then created a

C-Print "index" for each student by adding together the three z-scores for that student. This index was correlated with scores on the five communication skills tests described above.

Results

The results for both the questionnaire study and the interview study will be summarized together where appropriate. Not all students answered all questions on the questionnaire, and due to the nature of the open-ended interview, not all students interviewed answered the same questions during the interview. The results are organized according to the study's four main topics: (1) use and understanding of the C-Print real-time text display, (2) use and assistance provided by the C-Print hard copy notes, (3) appropriateness of C-Print as a stand-alone support service, and (4) relations between perceptions of C-Print and student communication characteristics.

C-Print Real-Time Display

Students were asked how much of the lecture they understood from watching the C-Print display. Students felt that C-Print made it easy to understand the teacher. Sixteen out of 25 questionnaire respondents stated that they understood between 90% and 100% of the lecture with C-Print. A majority of the interviewed students indicated that they understood almost all the lecture. According to interview responses, students felt that C-Print facilitated comprehension of the classroom discourse. For some students, C-Print significantly improved their comprehension of classroom dialogues. One student described his experience this way:

> Well, I would say that it helps a lot. And it surprised me because I never realized how much information was provided in class. Before I always thought that the teacher did not provide enough information and it was boring, but when I was using the C-Print it seemed more interesting. It makes me feel like I have been missing something in the past. Like I missed the last few years.

When producing text in real-time in the classroom, the C-Print captionist condenses what is being said. In view of this, students were questioned specifically about whether the C-Print text contained an acceptable amount of information and captured the important points in the lecture. Most students agreed that C-Print fulfilled this function. All 31 students who answered the questionnaire item pertaining to this issue agreed that the C-Print text produced by the captionist included the important points of the lecture (χ^2 [1] = 31, $p < .001$).

Students were also interviewed about the extent to which the captionist captured all the information, and the interviewer specifically pointed out that sometimes the C-Print captionist needed to summarize in order to capture the information. A few students were surprised to learn this given the quantity of text displayed. Some students felt that the information was so complete that it had a verbatim-like quality. One student commented: (for a course served by C-Print alone) "I would understand everything that is going on in that classroom at 100% because everything would be recorded." Another student responded

> Yes, I accept that it is summarized. I can hardly tell if it is summarized. It looks like she is just typing every single word that the teacher is saying. I can hardly tell that she is summarizing. When I look at the interpreter, I can tell that they are summarizing. So I can see the difference.

Some students did, however, indicate an awareness that some information was missing. In particular, several students noted that the segments of the text display that contained other students' comments could sometimes have been more complete. Students recognized that professors sometimes spoke too quickly for their comments to be typed verbatim. In addition, it was mentioned that C-Print was not capturing graphs, formulae, or other visual information. Students commented that there were times when verbatim transcription was preferable. For example, one student expressed a desire to have verbatim transcription of other students' comments or important messages from the professor:

Student: And most important things that the teacher says that it is important to know this word or sen-

tence then the person really needs to type that down, it really needs to show up on the screen those important words.

Interviewer: So if the professor says, "This is important to know" you want that exact sentence typed in? Because you want to know that the professor said it was important, right?

Student: If the professor says something important you really want to know that, you really want to have those exact words on there or for an announcement like it is time for a test time, for final exams, you want that specific information is really important. I don't want to show up at the wrong place at the wrong time or something like that. That would be upsetting.

In regard to students' participation in class, we were interested in knowing whether students could tell, from the C-Print display, when the professor was asking a question of the entire class or a specific person. The majority of students who were interviewed said they could tell. Several commented that a question mark appeared in the text display. Others commented that they noticed a dialogue occurring between teacher and student in the display. One student, however, commented that she was not able to detect a question posed to the class by watching the display because C-Print does not use intonation to distinguish statements from questions. Other students did not pick up on questions because of the lag time associated with the real-time display. As mentioned previously, in those cases, students may have realized that a question was asked, but by the time they read the display, the time for answering the question had passed.

We also asked students how they would feel using C-Print to relay their questions to the teacher or comments to the group. For example, interviewers suggested to students that they might type a question that the C-Print captionist could voice for them, or the comments might be displayed for all to read on a TV monitor. Several students thought this strategy would work, but others were less certain, as this approach would be quite different from the current practice of having an interpreter voice their signed message.

Students were asked to consider their comprehension of class lectures with C-Print, as compared with an interpreter. The analysis of the questionnaire re-

sponses revealed that students assigned significantly higher ratings for percentage of the lecture understood with C-Print than with interpreting (paired t test, $t = -2.43$, $p < .025$). The mean percentage of lecture information understood with C-Print was 84.8 ($SD = 16.5$); for interpreting, it was 69.9 ($SD = 28.4$).

Examination of the interview data indicated that a few students felt both services were comparable. Many more students stated that they felt they understood more with C-Print. However, reasons for better comprehension of the lecture with C-Print varied by student. First, some students had limited proficiency in American Sign Language (ASL), and, thus, the interpreters were difficult to understand. Second, the interpreters' skills varied and sometimes the interpreters missed information. Third, several students commented that they felt interpreters sometimes omitted information because they condensed the message in translating it to ASL. Fourth, several students thought C-Print included more of the actual vocabulary used by the professor and that this was beneficial for test preparation and learning the course material. In regard to the issue of the extent to which C-Print and interpreters modify what the teacher says, one student commented:

When I watch the interpreter and the teacher, I know that the interpreter is changing what the teacher is saying a lot, and I don't like that because I feel I am losing a lot. Most of the time I will ignore the interpreter and pay attention to the teacher. Some interpreters I have had a few times, and I know if they are good or not. So it depends on the interpreter.

Fifth, some students stated that they perceived the information provided by C-Print as simply more complete than that provided by an interpreter. As one student said, "I am a fifth year student. I have experienced many interpreters, and I know that I missed a lot of information. I have seen them do it. And I know that on the C-Print that all the information is there."

On the other hand, students indicated during the interviews that they recognized the limitations of having the C-Print real-time display in class, as opposed to an interpreter. Some students favored the message provided by the interpreter and thought they learned

more by watching the interpreter because the interpreter captured more of the classroom activity than did C-Print. One student described her feelings this way:

> I would like to add that why I only looked at the in classroom thing for only five minutes, because the interpreter has expression and I have a better sense of what is happening in class. From the C-Print it is just kind of blank. There is nothing there. People are laughing and I don't know it, people are moving, things are happening in class and I can't realize it. And so I only watched the in class thing, the display, for five minutes.

Interpreters add a more personal touch. With an interpreter, the students watch an individual conveying the message, rather than reading text. Also, for a student without intelligible speech, participation in class may be more difficult when only the C-Print service is provided. As one student commented,

> The only problem I would see is if I don't have an interpreter—what if the student has a question? How would they ask? Or maybe the student could type the question and it appears on the screen . . . and the teacher can see the screen, and then they know what the question is.

During the interviews, students were asked to consider in which class settings C-Print was most helpful and in which settings an interpreter would be most helpful. Several students felt that C-Print would be most helpful in lecture-only classes. Some students appreciated C-Print in their discussion-based classes as well, because the C-Print notes provided a transcript of the discussion. Other students supported the idea of an interpreter for discussion-based classes. Clearly, there is no one solution to this dilemma.

As evidenced here, for certain students and in certain circumstances, one service may be more useful than another. Students expressed the opinion that C-Print and interpreting services are complementary. For example, currently, interpreters seem to better capture group discussion, whereas C-Print notes seem to better help students remember that discussion later.

C-Print Notes

An important component of the C-Print system is the hard copy printout of the C-Print text, called the C-Print notes, that is distributed to students after class. The students in the study were asked for their perceptions (1) regarding the C-Print notes relative to the handwritten notes of student note takers, (2) their use of the C-Print notes, and (3) the advantages or disadvantages of the C-Print notes.

On the questionnaire, students rated how helpful they found the C-Print notes. Due to the small number of subjects, the four rating categories were collapsed into three for analysis purposes: "helps little or none," "helps enough," and "helps very much." Almost all students (33 out of 36) rated the C-Print notes as helping enough or very much (χ^2 [2] = 15.17, $p < .01$). Twenty-four out of 34 students responded that they used the C-Print notes more than the notes from the note taker. This difference in frequency was statistically significant (χ^2 [1] = 5.76, $p < .02$). Students were hard-pressed to identify disadvantages of the C-Print notes. The few students who did criticize the notes were concerned with the length of the transcript and the amount of time needed to read the notes, the quantity of paper used for printing notes, and the lack of illustrations or other graphic information.

In the interviews, students were asked about how often they would read a set of C-Print notes. Some students did not integrate reading C-Print notes into their regular study routines. As one student remarked, "It is going to take time for us to fully adapt to C-Print." Other students made the transition to C-Print notes more easily and read the notes regularly. They reviewed the notes between 1 and 3 times for each class session.

We also asked students about specific ways that they used the C-Print notes. For the 36 students who responded to the questionnaire, 29 reported skimming the notes. Sixteen of these students reported noting unfamiliar vocabulary and ideas, and 10 reported using the notes to create their own outline. Fourteen students reported "other" uses of the notes, such as reading.

Similarly, in the interviews, students reported using the C-Print notes for study in a variety of ways: (1) skimming the text, (2) reading and rereading the text, (3) noting special vocabulary, and (4) making an additional set of personal notes. One student reported using the following strategies in studying notes:

> I just read them to see if I know the information. And I know that, know that, fine, no problem. And

then I get to something I have not seen before, then I mark it, I mark it up. And then I continue reading, and then I go over it again to figure out what they are talking about, and try to understand everything that is going on. And then like words I never saw before or heard before, I underline. And then I write an explanation about what it means. And I use that for tests. Yes, it helps a lot. It has really pulled my grades up a lot.

These results suggest that students' study techniques might be best characterized on a continuum from passive to active approaches, based on the degree to which they manipulated the notes to fit their needs. The more passive approaches for using the C–Print notes involved only reading them. For example, several students looked at the notes only on occasion and just skimmed the notes. Many students said that they read them more thoroughly. Still other students compared C–Print notes with note taker's notes, the textbook, or their recollections of class lecture and discussion. C–Print notes were also used as an additional reference to prepare for tests and class projects.

The more active approaches for using the C–Print notes went beyond a rereading of the notes. These approaches involved reorganization of the material, identification of key points, or the writing of one's own thoughts. For example, many students said that they would read over their C–Print notes and write additional notes or questions for the professor on the margins. Several other students used the C–Print notes as the basis for writing their own notes or outline for the course.

C–Print Without Other Support Services

We asked students for their opinions regarding the use of C–Print without other support services. Students rated how helpful they thought the C–Print system would be in a hypothetical classroom situation without an interpreter or note taker present. Due to the small number of subjects, the four rating categories were collapsed into two: "help little or none" and "help enough or very much." A higher number of students (24) rated the C–Print system as helping enough or very much, as compared to the number of students (2) who rated the system as helping little or none (χ^2 [1] = 7.92, $p < .02$).

During the interviews, students were presented two hypothetical scenarios. Students were asked to think about the acceptability of using C–Print in the classroom without an interpreter, but with a note taker, or on a "stand-alone" basis, without either an interpreter or note taker. Many students felt comfortable with the thought of no interpreter. About half of the students also felt comfortable about using C–Print without a note taker, as well as without an interpreter. Several students expressed confidence that they would understand everything if they had to rely exclusively on C–Print.

Some students indicated that they could get along with only the C–Print service because it provides complete information regarding what was discussed in class, as the following quotation reveals:

You said one situation is you have a note taker and you have an interpreter. The other situation is that you have C–Print only, right. I would prefer the C–Print only. Yes, I would get all the information, and with an interpreter I may miss some information, and the note taker may miss some information or may only do summaries. With C–Print I am getting everything, and I can see it on the TV screen or on the laptop, and I can summarize it myself if I want to.

In contrast, a few students felt that C–Print alone was not a viable option. One student said that if he were confronted with the prospect of C–Print as a stand-alone service, he would drop the course. One concern that students raised was how they would ask questions without the aid of an interpreter.

Relationship Between Perceptions of C–Print and Communication Characteristics

This study also examined the relationship between perceptions of C–Print and communication characteristics of individual students. To examine this relationship, we correlated the index of extent that students perceived C–Print favorably with scores on five communication skills tests and three background measures (see Method section for descriptions). Table 1 presents the intercorrelations between these eight measures and the index of favorableness toward C–Print.

Relatively favorable responses to C–Print were as-

Table 1 Intercorrelations of the index of C-Print favorableness with communication skill tests and background measures

Tests and measures	n	r with C-Print index
1. Reading Comprehension Subtest, California Achievement Test	30	−.05
2. Michigan Test of English Proficiency	29	.51*
3. NTID Test of Speechreading with Sound	30	.57*
4. NTID Test of Speechreading without Sound	30	.59*
5. NTID Test of Simultaneous Communication	26	−.07
6. Puretone average	33	.23
7. Language Background Questionnaire item related to sign proficiency	30	.13
8. College grade point average	36	−.22

*$p < .01$.

sociated, at a statistically significant level, with higher scores on the Michigan Test of English Proficiency, with higher scores on the NTID Test of Speech Reading with Sound, and with higher scores on the NTID Test of Speech Reading without Sound. As shown in Table 1, the C-Print index did not correlate significantly with the other communication skill tests or background measures. Thus, preference for C-Print appears to be associated with being skilled in English and skilled in receiving spoken (e.g., English) communication.

Discussion

The results of this study indicate that many of the deaf and hard-of-hearing college students responded favorably to the form of information delivery provided by the C-Print speech-to-text transcription system. Students perceived the system as providing complete information that captured all, or almost all, the important points and details communicated in a college classroom. They also indicated that the C-Print real-time display enabled them to achieve a high level of comprehension of lecture material. Despite this level of comprehension, students did criticize certain aspects of the C-Print display—namely, lag time, captionist's

difficulty in capturing other students' comments, and C-Print's inability to capture visual material, such as illustrations or mathematical formulae.

One factor in the favorable response to C-Print may be the permanence of the information on the display and in the printout. For the real-time display on the laptop that is presented during class, each row of words remains on the screen for approximately a minute. This provides students far more time to consider these words than if they were using an interpreter or lipreading a speaker. After class, students can further review the material in exactly the same wording and in much greater detail than notes from a note taker.

In general, students responded favorably to the C-Print notes. Many commented on the clarity and detail of the notes. Students recognized the benefits of the notes to themselves and to others in class. C-Print notes appear to be a versatile study tool. Students read, highlighted, and wrote on these notes. C-Print notes helped students to recall class proceedings, and students used them to study for tests and to write papers. Only a few students criticized the notes for their length and lack of graphic information.

Students generally thought that C-Print enhanced their educational experience. Some students felt that they were more confident about learning and that they could perform better when the C-Print service was provided.

The results of this study are similar to those of a study conducted during the 1980s at NTID with a steno system (Stinson et al., 1988). In the previous study and this one, deaf students assigned higher ratings of understanding to the transcription system (C-Print or steno) than to interpreting. In addition, for both studies, more students responded favorably to the hard copy text than to notes from a note taker. Why might students find the printout more helpful? Comments during interviews for this study, as well as anecdotal remarks during the previous study, suggest that the detail of the printout permits clarification of what was not understood during the lecture. Furthermore, although the content of notes varies among note takers, the C-Print printout is as near the original message as possible and preserves its meaning. The results from this study suggest that students rated C-Print about as favorably as students had rated the steno system in the

previous study. C-Print, however, is generally the more cost-effective of the two systems. Due to the shorter training time of C-Print, approximately 6 weeks, many persons can be trained and placed in classrooms as support professionals at a reasonable cost. Equipment costs are also low.

Educational programs are frequently interested in using C-Print as the only support service because this approach is less costly than including it as an additional service along with others. Student responses indicated that use of C-Print as the only service would probably be acceptable to some students, but that it would not be to others.

Results pertaining to individual differences in questionnaire responses were consistent with the interview data. These results indicated that not all students reacted more favorably to C-Print than to interpreting or note taking. This pattern of relationships between communication background and preferences and response to C-Print was consistent with the previous research with a steno system (Stinson et al., 1988). For both the previous study and this study, students who were relatively proficient in reading and writing English, and in speechreading, responded more favorably to the speech-to-text system. The generally favorable response to C-Print came from a population of deaf and hard-of-hearing students with unusually high reading proficiency; less proficient readers may prefer an interpreter. A study under way with high school students, who are less proficient readers than those in this study, is addressing this question.

One limitation of this study is that C-Print was used only in certain types of classes, primarily lecture-oriented courses in business or liberal arts. For certain instructional situations, such as laboratories, the system may be inappropriate (Haydu & Patterson, 1990). In addition, a little more than half of the students served by C-Print completed questionnaires or interviews. It is possible that students who participated in the study had more favorable attitudes about the system than those who did not participate. Also, the questionnaire sample was small.

Research to develop a more comprehensive understanding of the benefits and limitations of educational technologies, such as C-Print, must use a variety of methodologies and must evaluate the technology with various groups and in different settings. This study used quantitative and qualitative methodologies. Other studies are needed to obtain additional objective data. These include investigation of the effect of C-Print on memory for lectures and of the system's influence on educational achievement. Such studies are currently under way.

This study contributes to the accumulating evidence that indicates that a speech-to-text transcription system, such as C-Print, is an effective way of increasing accessibility to information in the mainstream classroom for deaf and hard-of-hearing students. Evidence also supports the perspective that it is desirable to match support services to the needs and preferences of individual students, given considerations of cost and availability. In making recommendations regarding support services to deaf or hard-of-hearing students, support service professionals can use information such as the finding that proficiency in English appears to be a good predictor of the perceived benefit obtained from C-Print. This does not imply that a student's predicament and preference should not be taken into account. However, it does imply that a student's preference is not the only factor that should be considered in selecting an appropriate support service.

Appendix 1

Questionnaire Items Used in the Study

Items	Response Options
Which do you use more?	Circle answer: (a) Notes from note taker; (b) C-Print notes
How do you use the C-Print notes to study?	Can circle more than one response: (a) Skim the notes and highlight important information; (b) Make an outline from the information; (c) Note unfamiliar vocabulary and ideas; (d) Other? (write in)
How much do the C-Print notes help you with this course?	Circle one: (a) C-Print notes do *not* help at all; (b) C-Print notes help me a little; (c) C-Print notes help me enough; (d) C-Print notes help me very much
Often the C-Print operator has to summarize information. Is that acceptable to you? Do you feel you are getting the important points?	(Open-ended question; responses coded)
How much of the lecture can you understand from watching the interpreter?	Circle answer: (a) 100%, (b) 90%, (c) 80%, (d) 70%, (e) 60%, (f) 50%, (g) 40%, (h) 30%, (i) 20%, (j) 10%, (k) 0%
How much of the lecture can you understand from watching the C-Print display (TV or laptop)?	Circle answer: (a) 100%, (b) 90%, (c) 80%, (d) 70%, (e) 60%, (f) 50%, (g) 40%, (h) 30%, (i) 20%, (j) 10%, (k) 0%
If there is an interpreter, but no note taker is available, how helpful would the C-Print system be?	Circle answer: (a) C-Print does *not* help at all; (b) C-Print helps a little; (c) C-Print helps enough; (d) C-Print helps very much
If *no* interpreter and *no* note taker are available, how helpful would the C-Print system be?	Circle answer: (a) C-Print does *not* help at all; (b) C-Print helps a little; (c) C-Print helps enough; (d) C-Print helps very much

Appendix 2

Interview Questions

I. Real-time Display

1) How much of the lecture can you understand watching the display?
2) Do you have any problems with the display itself or with watching the display?
3) When watching the display, do you know when the teacher is asking a question and wants an answer?

II. Text "Condensing"

1) The captionist has to "condense" (summarize) information often in class. Is that acceptable to you? Do you feel you're getting the important points?
2) Do you think any information has been missing from the display?

III. C-Print Notes

1) What are the advantages and disadvantages of the C-Print notes?
2) Please tell us what you do with the C-Print notes from the time you get them to the time you are finished with them.

3) How do you use the C-Print notes to study (e.g., skim the notes and highlight important information; make an outline from the information; note unfamiliar vocabulary and ideas; other ways)?

IV. Adequacy of the C-Print System

1) If there was an interpreter, but no note taker was available, how adequate would the C-Print system be?

2) If there was a note taker, but no interpreter was available, how adequate would the C-Print system be?

3) If no interpreter or note taker was available, how adequate would the C-Print system be?

V. General Questions

1) For you, what is the best thing about C-Print?

References

Bogdan, R. C., & Biklen, S. K. (1992). *Qualitative research for education: An introduction to theory and methods* (2nd ed.). Boston: Allyn and Bacon.

Crandall, K. (1978). Reading and writing skills and the hearing-impaired adolescent. *Volta Review, 80,* 319–332.

CTB/McGraw-Hill. (2000). *TerraNova CAT.* Available: http://ctb.com

Cuddihy, A., Fisher, B., Gordon, R., & Schumaker, E. (1994, April). C-Note: A computerized notetaking system for hearing-impaired students in mainstream post-secondary education. *Information and Technology for the Disabled, 1,* 2.

Eisenhart, M., & Borko, H. (1993). *Designing classroom research: Themes, issues, and struggles.* Boston: Allyn and Bacon.

Elliot, L., Foster, S., Stinson, M., & Colwell, J. (1998, April). *Perceptions of learning with a speech-to-print system.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

English Language Institute at the University of Michigan. (2000). *Michigan Test of English Proficiency.* Available: http://www.lsa.umich.edu/eli/testpub.htm

Garrison, J. (1986). Some principles of postpositivistic philosophy of science. *Educational Researcher, 15*(9), 12–18.

Hastings, D., Brecklein, K., Cermak, S., Reynolds, R., Rosen, H., & Wilson, J. (1997). *Notetaking for deaf and hard-of-hearing students: A report of the National Task Force on Quality of Services in the Postsecondary Education of Deaf and Hard of Hearing Students.* Rochester, NY: Northeast Technical Assistance Center, Rochester Institute of Technology.

Haydu, M. L., & Patterson, K. (1990, October*). The captioned classroom: Applications for the hearing impaired-adolescent.* Paper presented at the Fourth National Conference of the Habilitation and Rehabilitation of Hearing-Impaired Adolescents. Omaha, NE.

Howe, K. (1988). Against the quantitative-qualitative incompati-

bility thesis (or, dogmas die hard). *Educational Researcher, 17*(8), 10–16.

Howe, K., & Eisenhart, M. (1990). Standards for qualitative and quantitative research: A prolegomenon. *Educational Researcher, 19,* 2–9.

James, V., & Hammersley, M. (1993). Notebook computers as note-takers for handicapped students. *British Journal of Educational Technology, 24,* 63–64.

Johnson, D. (1976). Communication characteristics of a young hearing-impaired adult population: Techniques for evaluating their communication skills. *American Annals of the Deaf, 121,* 409–424.

Kluwin, T. N., & Stinson, M. S. (1993). *Deaf students in local public high schools: Background, experiences, and outcomes.* Springfield, IL: Charles C. Thomas.

Lagemann, E. C., & Shulman, L. S. (Eds.). (1999). *Issues in education research.* San Francisco: Jossey-Bass.

Lang, H., Stinson, M., Kavanagh, F., Liu, Y., & Basile, M. L. (1998). Learning styles of deaf college students and teaching emphases of their instructors. *Journal of Deaf Studies and Deaf Education, 4,* 16–27.

Lewis, L., Farris, E., & Greene, B. National Center for Educational Statistics. (1994). *Deaf and hard of hearing students in postsecondary education.* (NCES 94–394). Washington, DC: U.S. Government Printing Office.

Metz, D., Caccamise, F., & Gustafson, M. (1997). Criterion validity of the Language Background Questionnaire: A self-assessment instrument. *Journal of Communication Disorders, 30*(1), 23–32.

Moores, D. F. (1992). An historical perspective on school placement. In T. N. Kluwin, D. F. Moores, & M. G. Gaustad (Eds.), *Toward effective public school programs for deaf students: Context, process, and outcomes* (pp. 7–29). New York: Teachers College Press.

National Court Reporters Foundation. (1995). *Realtime in the educational setting.* Vienna, VA: Author.

Osguthorpe, R. T., Long, G. L., and Ellsworth, R. G. (1980). The effects of reviewing class notes for deaf and hearing students. *American Annals of the Deaf, 125*(5), 554–558.

Rawlings, B. A., Karchmer, M., & DeCaro, J. (1988). *College and career programs for deaf students.* Washington, DC: Gallaudet College.

Saur, R. (1992). Resources for deaf students in the mainstreamed classroom. In S. B. Foster & G. G. Walter (Eds.), *Deaf students in postsecondary education* (pp. 96–113). New York: Routledge.

Schildroth, A. N., & Hotto, S. A. (1994). Deaf students and full inclusion: Who wants to be excluded? In R. Johnson & O. Cohen (Eds.), *Implications and complications for deaf students of the full inclusion movement* (pp. 7–30). Washington, DC: Gallaudet Research Institute.

Stinson, M., Eisenberg, S., Horn, C., Larson, J., Leavitt, H., & Stuckless, R. (1999). *Real-time speech-to-text services: A report of the National Task Force on Quality of Sevices in the Postsecondary Education of Deaf and Hard of Hearing Students.* Rochester, NY: Northeast Technical Assistance Center, Rochester Institute of Technology.

Stinson, M., Liu, Y., Saur, R., & Long, G. (1996). Deaf college students' perceptions of communication in mainstream classes. *Journal of Deaf Studies and Deaf Education, 1,* 40–51.

Stinson, M., & McKee, B. (Eds.). (2000). *Development and evaluation of a computer-aided speech-to-print transcription system.* Rochester, NY: National Technical Institute for the Deaf.

Stinson, M., McKee, B., & Elliot, L. (2000). Development and implementation of the C-Print speech-to-text support service. In H. Strauss and J. Albertini (Eds.), *Festschrift zum 70 Geburtstag* (pp. 133–150). Heidelberg: Necker Verlag.

Stinson, M., & Stuckless, E. R. (1998). Recent developments in speech-to-print transcription systems for deaf students. In A.Weisel (Ed.), *Issues unresolved: New perspectives on language and deaf education* (pp. 126–132). Washington, DC: Gallaudet University Press.

Stinson, M., Stuckless, R., Henderson, J. B., & Miller, L. (1988). Perceptions of hearing-impaired college students toward real-time speech-to-print: RTGD and other support services. *Volta Review, 90,* 336–348.

Stuckless, E. R., & Carroll, J. (1994). National priorities on educational applications of technology for deaf and hard-of-hearing students. *American Annals of the Deaf, 139,* 62–63.

Subtelny, J. (1982). Speech assessment of the adolescent with impaired hearing. In D. Sims, G. Walter, and R. Whitehead (Eds.), *Deafness and communication: Assessment and training* (pp. 155–176). Baltimore: Williams and Wilkins.

Youdelman, K., & Messerly, C. (1996). Computer-assisted note-taking for mainstreamed hearing-impaired students. *Volta Review, 98*(4), 191–199.