College Students' Learning with C-Print's Educational Software and Automatic Speech Recognition

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Abstract

Access and communication needs, retention of information, and active learning are critical factors for deaf and hard of hearing students' (d/hh) success in the mainstreamed classroom. Speech-to-text support services with embedded educational tools such as highlighting, notetaking, and messaging can address these needs. This presentation reports results of a multi-method investigation of mainstreamed d/hh college students' use of the C-Print speech-to-text support service with embedded educational tools compared to support from interpreters and notetakers. Findings of the study include: (a) no significant differences in students' understanding of instructors between groups; (b) students frequently use the educational tools during the real-time display; and, (c) student use of C-Print notes differs from use of traditional notetaker notes in frequency and purpose. Implications of these findings are considered in the context of provision of support services for d/hh students in mainstreamed postsecondary settings.

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Today, the majority of postsecondary students who are deaf or hard of hearing (d/hh) receive their education alongside hearing classmates (Lang, 2002; National Center for Educational Statistics, 2000). In order for these students to have a successful learning experience in mainstream classes, three forms of support are important. First, students need access to classroom lectures and discussions. One way that access is provided is through a sign language interpreter and another means of access is through a real-time speech-to-text support service.

A second support for d/hh students is a mechanism that allows these students to retain information after class in order to do homework, prepare for tests, etc. D/hh students often rely on notes *taken by others*. It is common for peer or professional notetakers to handwrite the notes that are provided to mainstreamed d/hh students and students receive these notes after class (Hastings et al., 1997). Speech-to-text services also provide d/hh students a means to remember material by making available saved text that is produced during class. The saved text can be viewed in an electronic file or printed for later review.

The third form of support for d/hh student success is to find ways for students to be actively involved in classroom learning (Minskoff & Allsopp, 2003). For hearing students, the ability to take their own notes is a key way that they help themselves be actively engaged and learning, and these notes help students remember their thinking during class (Armbruster, 2000). Although d/hh students may want to only briefly divert attention from watching the teacher, or real-time display of a speech-to-text system, a support that facilitates active engagement and that helps them remember their thinking during class may be beneficial. Most computer-based speech-to-text support services do not offer students computer-based options for self-notetaking during real-time display. Dramatic changes to the software used with the C-Print speech-to-text system (C-Print, 2008) have enabled students to enhance their active learning behaviors while simultaneously using the speech-to-text support.

Objectives of this paper are:

- To describe recent findings of a study of deaf/hh college students who participated in a trial of speech-to-text support services with educational software that is designed to address access and communication, memory, and active learning goals for success in mainstream educational settings. And,
- To delineate the support needs of deaf and hard of hearing (deaf/hh) students that are critical for classroom access and communication, memory of class content, and active learning goals for success in mainstream educational settings related to speech-to-text support services.

This paper shares results of one of a series of investigations that examines the C-Print speech-to-text support service (e.g. Elliot, Foster & Stinson, 2002a & b; Elliot,

Stinson, & Coyne, 2006; Stinson, Kelly, Elliot, Liu, & Stinson, 2000; Stinson, Stinson, Elliot, & Kelly, 2004). One important way that this research is different from earlier work is that previous studies (except Elliot et al., 2006) used an earlier version of the C-Print system that had no special features to support active learning or class participation. Improvements to C-Print software that allow for active learning and class participation have provided additional opportunities for studying the experiences of d/hh students in mainstream settings. The Elliot et al. (2006) study focused on use of the C-Print system with educational tools by d/hh students in middle and high schools. In contrast, this presentation focuses on use of the system by students in postsecondary settings.

It is important independently to investigate the use of C-Print in postsecondary settings as well as in middle and secondary schools. First, student use of the educational tools to promote active learning at the postsecondary and secondary levels may be different. The faster rate of presentation of information at the postsecondary level may reduce student use of educational tools because they may judge that they do not have sufficient time to both follow the classroom discussion and use these tools. Second, the faster presentation of information at the postsecondary level could adversely affect production of text by the captionist (service provider).

The current study and the Elliot et al. (2006) study explore the use of automatic speech recognition (ASR) input as compared to typing input for the speech-to-text system. We looked at student evaluations of both systems for C-Print input, concerned that students might rate text produced with the newly developed automatic speech recognition approach as less adequate than that produced with the typing approach which

has been demonstrated to work effectively in postsecondary settings (e.g. Elliot, Stinson, McKee, Everhart, & Francis, 2001).

The research was guided by the following research goals:

(1) To determine the effects of the C-Print real-time display, educational software, and notes distributed after class upon student understanding of course material and course grades.

(2) To evaluate the benefit of the C-Print speech-to-text support service with ASR and typing approaches.

(3) To determine the extent that students used the C-Print display and educational tools, and,

(4) To determine qualitatively the manner in which students used the various tools provided by the C-Print software.

In addition to describing some of the findings of this study, this presentation will discuss the implications of speech-to-text support services with educational software for students, instructors, and support service providers in mainstream educational settings.

Methods

This presentation reports results of a 5-year, multi-method investigation of mainstreamed d/hh college students' learning with the C-Print speech-to-text support service with ASR or typing input. We will present findings from two sources: (a) a quantitative, multiple-correlational study and, (b) a qualitative observation/interview study. The quantitative study examines: the relationship between use of C-Print and course performance; the relationship between students' use of the software features and course performance; as well as, a comparison of students who used interpreter support

instead of speech-to-text support. The qualitative study focuses on how students learn with the C-Print Pro software and text display.

Design

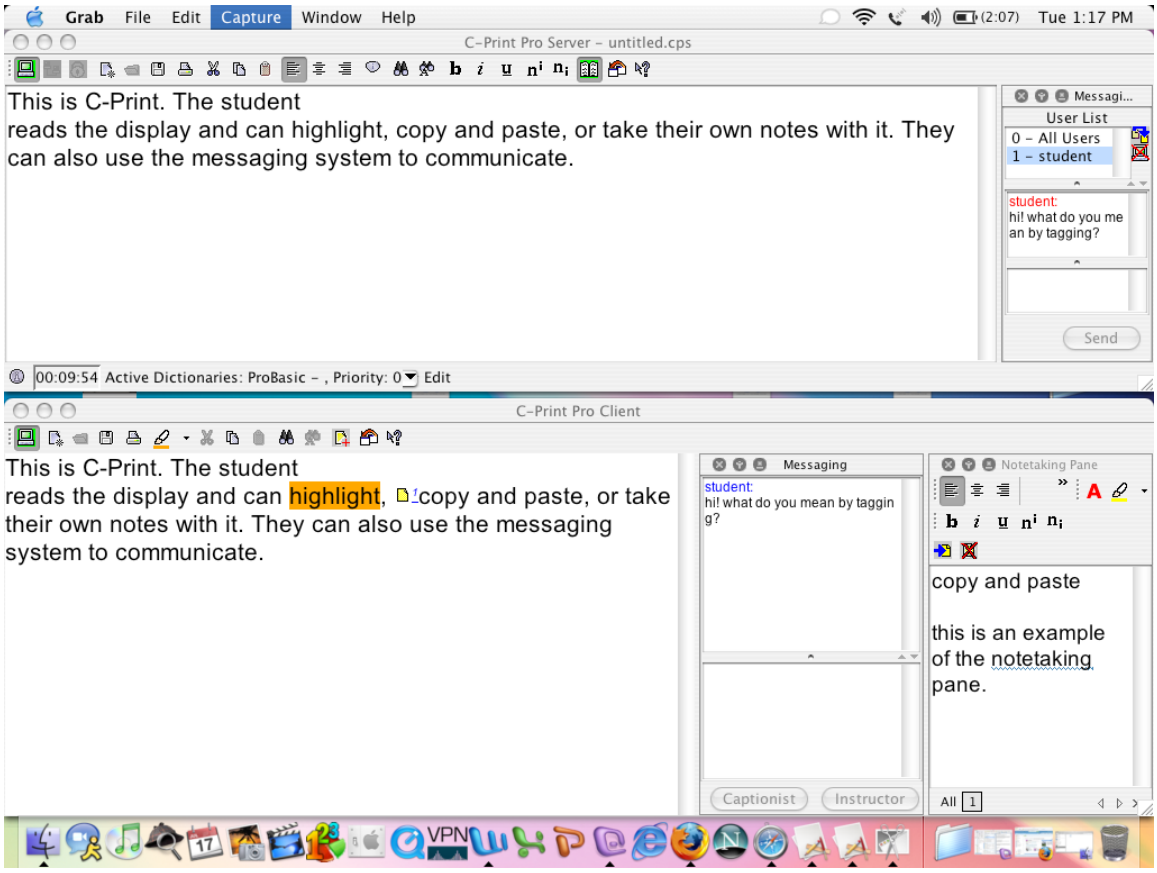
One hundred twenty d/hh mainstreamed students enrolled at Rochester Institute of Technology (RIT) and Louisiana State University (LSU) participated in this study, along with their classroom instructors and their service providers (captionists). These students, participated in a college quarter (RIT—10 week) or college semester (LSU—15 week) trial of C-Print speech-to-text support service with educational tools or with an interpreter and notetaker. Forty students received C-Print with ASR input, 40 with typing input, and 40 with interpreter/notetaker support.

Materials

For this study, the C-Print system includes the C-Print Pro® (C-Print, 2008) software that includes networking communication capabilities and educational tools and commercially available laptop computers (such as IBM Thinkpads). The networking software component sends text from the service provider's (captionist) to the student's computer, and it includes a messaging feature that allows for two-way communication between the provider and student separate from the text of the class discussion. The educational tools include an optional split screen for students to take their own notes. Students can also highlight important points in the text section or copy and paste sections of the text into their own notes (see Figure 1).

Figure 1

Examples of the C-Print captionist display (top) and student display (bottom)



In addition, the system includes the dual capacity to transcribe speech into text with: (a) automatic speech recognition (ASR); and, (b) a keyboard-based computerized word abbreviation system. To use ASR, the captionist in the classroom with the d/hh student(s) dictates into a microphone connected to a laptop computer containing the ASR software. The software converts the sounds to words that appear on the C-Print display. The captionist also can type the spoken message using the C-Print abbreviation system. Students and teachers can view the text with the software during class and at the

conclusion of class, the electronic file can be printed or saved and reviewed on a computer.

Data Sources

Quantitative data. Students completed surveys pertaining to communication preferences, motivation for success in class, and student experiences with and without C-Print (including the use of educational tools in the C-Print software and study behaviors during and after class.) Archival data from school records were collected on students' reading ability, hearing loss, and final course grades.

Qualitative data. Classroom observations and interviews were conducted with a subsample of students, randomly selected from the subject pool. Twelve observations and open-ended interviews were conducted with students from both campuses, 8 interviews were conducted with RIT students and 4 with students from LSU. Sample size for the interviews was determined based on the qualitative research rule of data saturation, or interviewing until the information one receives becomes redundant, and then allowing for additional cases for negative or disconfirming information to come to light (Bogdan & Biklen, 1998; Kuzel, 1992).

Prior to the interviews, a member of the research team visited the students' classes for one class period. Field notes were recorded during the visit regarding such topics as classroom set-up, student use of C-Print, student interaction and instructional methods. Information from these observations was used as part of the interview.

The interviews were semi-structured; a predetermined list of topics was introduced to students, but students were encouraged to pursue their own line of thinking and topics were added as they were raised by students. In addition, pertinent topics noted

during observations related to the specific students' classroom experiences were introduced. Interviews included the following topics: impact of the C-Print service on understanding and class participation by d/hh students; reactions to electronic or paper text, and descriptions of whether/how/under what conditions it is used by students; advantages and limitations of the ASR system; advantages and limitations of the abbreviation based system; impressions of features of the C-Print Pro software (e.g., the highlighting function); and, impact of the help guides provided to students.

The same member of the research team who conducted the observations also conducted the interviews. Interviews with students at LSU as well as several of the RIT interviews, took place through e-mail (Seymour, 2001). The remaining interviews were conducted face-to-face and were audiotaped. The in-person interviews lasted between 30-60 min. An interpreter was present when necessary at the interviews to (a) facilitate communication as needed and (b) voice the signing of the interviewer and respondent onto an audiotape. Verbatim, typed transcripts were generated from the audiotapes and were reviewed for accuracy by the interviewer. The e-mail interviews were saved in text documents. Field notes and interviews were read and code categories were developed based on the content analysis techniques described by Bogdan and Biklen (1998).

Participants

One hundred twenty college students who are deaf or hard of hearing participated in this study. The students were enrolled in mainstream classes on the campuses of Rochester Institute of Technology, in Rochester, NY (n=102) and Louisiana State University, in Baton Rouge, LA (n=18) and had self-identified as needing access and communication support services. Students were randomly chosen to participate in this

study based on course lists at each of the schools. The students were enrolled in a variety of courses including: Social Sciences (e.g., political science, sociology, history, psychology) (n=50), Physical Sciences (e.g., biology, chemistry, statistics, math) (n=17), Business (n=14), Art (e.g., art, photography,) (n=11), Technology & Vocational (e.g., culinary arts, medical technology) (n=11), Computer Science (n=9), Education (n=4) and Engineering (n=4). Classroom settings ranged from very large lecture halls with several hundred students to small seminars with fewer than 20 students. The students' mean pure-tone average for the better ear was 94.78 dB (*SD*=20.198).

To assess reading proficiency, we calculated a standardized z-score based on one of a number of standardized test scores from student records including: ACT English and reading subtests (ACT, 2008), California Achievement Test (CTB/McGraw-Hill, 2000), NTID reading placement test (Crandall, 1978; Johnson, 1976; Subtelny, 1982), Michigan Test of English Proficiency (English Language Institute at the University of Michigan, 2000), SAT verbal subtest (ETS, 2008b), GRE verbal reasoning subtest (ETS, 2008a), TOEFL (ETS, 2008c), and LSAT (LSAC, 2008). Among the participants, the largest number had ACT English subtest scores (n=82). If the student did not have an ACT English score, we ascertained whether they had the next most frequent test score, the ACT reading score (n=70), and so on, according to the list in the order stipulated above. Z-reading scores ranged between -1.87 and 2.06, *M*=.021, *SD*=.96.

Student characteristics were not significantly different for hearing loss among the different participant groups. However, there were significant differences in reading proficiency (f=5.307, df=2, p=.006) and preference for spoken or sign language (f=12.053, df=2, p=.000). See Table 1 for a summary of these student characteristics.

Table 1

Student Characteristics

	C-Print Typing (n=40)	C-Print ASR (n=40)	Interpreter/Notetaker (n=40)	
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p*
Hearing Loss RPTA	91.36 (23.617)	96.82 (16.723)	95.97 (19.98)	.668
Hearing Loss LPTA	92.36 (20.764)	95.84 (17.205)	96.31 (19.870)	.540
Z-Reading Proficiency	.4117011 (.87699428)	-.2762000 (.86014267)	-.0568371 (1.03220509)	.010
Communication Preference (Spoken Language/Sign Language)[a]	2.03 (1.349)	2.80 (1.40)	3.50 (1.281)	.000

Note: [a] Preference for Language 1-5, with 1=Spoken Language only, 5=Sign Language only

Results

C-Print Groups vs. Interpreter Group

With regard to input of text for C-Print (ASR or typing) versus interpreter, there were no significant differences in students' understanding of class material or the instructor. In addition, there was no significant difference in students' final course grade among the three student groups.

Student understanding of other students' comments during class did vary by condition, with students who used interpreters instead of C-Print understanding more student comments (f=4.430, df=2, p=.014).

Student surveys indicate that C-Print notes were used more often by students than traditional notetaker notes (f=5.038, df=2, p=.008). In addition, C-Print notes were used for more study purposes than were traditional notetaker notes including: making maps or

charts (f=3.9, df=2, p=.023), preparing summaries of class notes (f=4.074, df=2, p=.019), and reviewing what happened after class (f=6.096, df=2, p.003).

C-Print Software Usage

Real-time display. Students in the C-Print groups reported their use of the real-time display during class. According to student surveys, at least 82.5% of the students used the speech-to-text support service most of the time during class. 52.5% of the students switched between the interpreter or classroom teacher and the speech-to-text display. 30.7% of the students followed the display either fill in missing information (occasional glance at the screen). 16.6% of the students watched the C-Print display exclusively. Students' communication preference (spoken English or sign language) did not significantly influence students' use of the C-Print display, nor did it influence the students' use of the educational tools.

Educational tools. Students used the educational tools (highlighting, copy and paste, typing own notes) with high frequency as well. Of the 80 students in the C-Print trial groups, more than half of the students (n=42, 52.5%) used the educational tools 4 or more times during the trial, while 29 of the students (36%) used the tools with high frequency (more than 5 times).

During the interviews, students discussed their experiences using the educational tools. A number of students described how they used the software during class. Here are a few excerpts from those interviews.

> *Because every word is typed, I didn't use the transcripts to study. They were too long. I had to make my own notes but I liked this a lot. I had to listen, see and type. It helped me learn better than had I only looked at the transcripts.*

*****

I like typing my own notes because it keeps me awake. And because when I type something, I remember it better. Same of when I write something, I remember it better. But in the minor classes, if I don't have C-Print, I am literally going there and sitting there waiting for class to be over. And I can't hear the teacher, it depends on the teacher, most of the time I can't which means I am probably daydreaming or something to keep myself awake.

*****

I have used C-Print before with other class. It is a big difference! I like the C-Print that I used for this class better than the previous C-Print that I had because I couldn't participate or take notes. However, with this software, I could and take notes. It is great software. I think it is worth it.

*****

After the note-taking trial, I find it very useful and convenient. Compared to my hand note-taking in class, the C-print note-taking provides me a special software to highlight, copy, summarize, make some important points and save the notes in class than reading a long C-print notes at home. I like this software so much because it saves my time to read my own notes faster and shorter.

Of course, not all students used the educational software. Based on classroom observations and interviews, a number of situations appeared to influence software use. For example, classroom set-up and furnishings influenced use. Many college classrooms have very small student desks that were inadequate for holding a laptop computer as well as other student supplies.

Teaching methods influenced software use, too. For example, when instructors pass out note packets or use PowerPoint displays, the student may be overwhelmed with the variety of visual displays to which they must attend; Courses that are predominately discussion-oriented also leave little opportunity for student notetaking.

Finally, course content may have influenced students' use of the software as well. The version of C-Print software used for this study works well in courses that are more dependent on words as opposed to graphics or formulas. Approximately one-quarter of the students who participated in this study were enrolled in science, technology,

engineering or math (STEM) classes that rely on graphical information as well as verbal explanation. A number of these students commented in their surveys that the software did not support all of their needs because it was lacking the graphical information.

Communication tool. Included in this version of the software is an option that allows students to communicate with the service provider (captionist), much like an instant messaging program. The student can indicate whether the message is intended for the captionist or whether the message should be voiced to the instructor. Students used this feature regularly as well. Twenty-five of the eighty students in the C-Print groups (31.25%) used this feature at least 4 or more times during class. With regard to student characteristics, it should be noted that students who learned sign language later in life were more likely to use the messaging feature (r=.264, p=.03). This excerpt from a student interview explains why the student utilized the feature regularly.

> *The purpose of using the chat feature is to reduce misunderstanding between the captionist and me because we know a few ASL. The chat feature can explain to the captionist about what I ask exactly. Also, I can use it to communicate with the captionist and my teacher.*

Discussion

This study set out to describe and compare d/hh postsecondary students' course experience and performance when using one of three supports: (a) a speech-to-text support service with ASR input; (b) a speech-to-text support service with typing input; or, (c) an interpreter and notetaker. We found that there was no significant difference in understanding the instructor or in final grades based on the type of support service offered. However, there was a significant difference in d/hh students' understanding of other student comments. Students who receive interpreting services understand more of other students' comments. In addition, we found that students in the C-Print support

service groups used their C-Print notes more often than the students in the interpreter group used their notetaker notes. The C-Print notes were also used for a greater variety of study purposes than the notetaker notes. For example, C-Print notes were used more often than were notetaker notes for creating maps and charts, preparing summaries of class notes, and reviewing what happened in class.

We were also interested in students' use of the educational and communication tools embedded in the software. Despite the rapid pace of most college classes, many students did use the tools, and increased frequency of use of the software was associated with greater understanding of the instructor. Classroom circumstances, such as furnishings, instructional methods, and course content all inhibited use of these tools in certain situations.

Educational or Scientific Importance

At the beginning of this proposal, we described three critical areas that need to be addressed in providing learning opportunities for deaf/hh students in mainstream classes. Access and communication needs are often supplied by a variety of speech-to-text support services as well as interpreters. Retention of information is a second area, which is usually achieved by provision of notes to students by others, by students taking their own notes, or both. Recent enhancements to speech-to-text support services can help deaf/hh students (who were previously unable to take notes for themselves) to do so. Finally, students need to be engaged as active learners in the classroom. A speech-to-text support service that allows students to communicate and facilitates independent learning helps to accomplish that goal.

Regarding access and communication issues pertaining to this study, two findings bear particular mention. First, there was a significant difference in d/hh students' understanding of other student comments. Students who receive interpreting services understand more of other students' comments. This finding may be due to the fact that captionists often sit at the back of the classroom to minimize distraction, while interpreters are located in the front of the room. Captionists' location means that they may miss more student comments because they look at students' backs while interpreters look at students' faces. It may be helpful for captionists to consider where they sit in class and also, if they can encourage other students in the class to express themselves more clearly for the captionists' benefit.

Second, we found that students who learned sign language later in life were more apt to use the messaging feature. This finding suggests that d/hh students present a variety of communication needs and that support services need to be developed that are flexible and address the needs of students. D/hh support services are clearly not "one size fits all" or even "one size fits most."

With respect to retention of information and active learning, this study examined the extent to which students use the educational tools in the C-Print software. College students used this feature more often than middle and secondary school students as reported in Elliot et al. (2002a). The increased use of educational tools could reflect the older students' increased sophistication in using study skills and notetaking/marking strategies. Increased study strategies have been observed in earlier C-Print studies (e.g., Elliot, Foster, & Stinson, 2002b). The demands of the postsecondary environment do not appear to reduce use of this tool. However, specific classroom situations such as small

desks, particular instructional methods, or course content may detract from student use of the software tools. These findings, overall, suggest that students can use a variety of support services in postsecondary settings to support access and communication needs.

Increased use of software tools was positively associated with understanding the instructor, although not with higher final course grades. Final course grades depend on many factors, not all of which were accounted for in this study. Perhaps course grades or testing methods were not sensitive enough to detect increased student comprehension of the instructor. In addition, the method of input for producing the C-Print text (ASR or typing) does not seem to impact students' understanding of class information. However, other students' comments appear to be captured better by interpreters. It is possible that understanding the instructor alone is insufficient for class success; perhaps one needs to better understand other students' comments as well. This proposition would lead us to a support service that combines the most beneficial aspects *both* speech-to-text services and interpreting services. For example, if both support services were available, the student may use speech-to-text to understand the instructor's presentation, and the interpreter to support the class discussion. The study of the appropriateness of support service for deaf/hh students is in its infancy—findings from this study as well as future studies will enhance our understanding of the support services required for student success in mainstreamed settings.

Our third area of interest in this study was related to students' ability to use the educational and communication tools during class to support active learning. During classroom observations we gleaned that student use of the C-Print software was frequently associated with the type and variety of instructional methods employed by the

instructor. In particular, we noticed that student use of the software seemed to be less frequent when there were multiple visual demands on the student. For example, on a visit to a chemistry class, we observed use of the whiteboard, a PowerPoint display, models of chemical compounds displayed on a visualizer, and distribution of handouts, as well as the professor's verbal presentation. D/hh students face certain challenges in circumstances such as these because there is so much information coming from so many different stimuli. Whether the student needs to attend to the speech-to-text display or an interpreter, they have more visual challenges than others in the class. While the version of C-Print used in this study was limited because it could not accommodate the visual information, future versions of the software, in development now, will be able to do so with greater ease; future research will need to be done to study its effectiveness. In addition, more work needs to address the issue of educating postsecondary instructors about creating educational environments that are accessible to d/hh students. A number of useful suggestions on this topic can be found on the *Class Act* website (Project Access, 2008). The responsibility of communicating needs and useful solutions needs to be borne by a variety of individuals, namely the students, the instructors, and support service personnel to provide students with the opportunity to be successful in postsecondary education.

Research suggests that a speech-to-text support service with embedded educational tools shows promise with d/hh college students in mainstreamed settings. Students can make decisions for themselves about the relevance of information and have additional options for access and communication needs. This is a significant contribution

to developing deaf and hard of hearing students as independent learners, preparing them to become critical thinkers and empowering them to succeed.

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