AudiSee: An Auditory-Visual-FM System

Jean-Pierre Gagné
Université de Montréal

Introduction

For several years researchers have investigated the various factors that hinder or facilitate learning in classroom environments, especially with respect to students with a hearing loss. Everyone agrees on the fundamental communication process inherent to teaching and on the importance of providing good learning conditions in the classroom. This is why many schools rely on new technologies such as assistive listening devices (ALDs) like the well-known auditory FM transmission systems.

While these systems overcome some of the obstacles found in classrooms, many students with hearing loss still struggle. However, the recent arrival of a new technology, the audiovisual-FM system, provides added benefit to standard audio-only FM systems in that it transmits both audio and visual speech cues, thereby increasing the ability of students with a hearing loss to assimilate information.

The Classroom: An Auditory Learning Environment

The classroom is primarily a communication environment in which the teacher's task is to transfer knowledge to students in a way that enables them to understand and assimilate the information. According to Berg (1987), students spend 45% of their classroom time performing listening tasks. It is therefore vital that they understand what the teacher is saying. Unfortunately, this is not always possible, as numerous conditions impede listening activities in the classroom.

The Effect of Noise on Learning

The classroom is a noisy environment. Whereas typical speaking levels range from 55 to 65 dB (A-weighted), many classrooms have noise levels as high as 80 dB (A-weighted). These noise levels may vary according to the age of the pupils but, generally, the younger the students, the noisier the classroom (Crandell & Smaldino, 2000; Finitzo, 1988).

There are two main sources of noise: 1) infrastructures within the classroom (fans, lights, equipment) as well as outside the classroom (equipment in other classes, hallway activities, street noise, etc.), and 2) noise generated by persons within the classroom, namely other students. Together, these sources of noise can mask the voice of the teacher.

The relationship between the level of the teacher's speech and the level of surrounding noise is referred to as the Signal-to-Noise Ratio (SNR). For students, the higher the SNR, the easier speech perception becomes. A low SNR considerably hinders speech perception, especially for students with a hearing loss. It is claimed that the level of the teacher's voice should be at least 15 dB greater than the surrounding noise level (+15 dB SNR) in order for students with a hearing loss to understand what the teacher is saying (American Speech-Language-Hearing Association, 1995).

The Importance of Visual Cues in a Learning Environment

Ideal learning conditions entail not only a proper acoustic environment but also a proper visual environment. Even students with normal hearing benefit from visual cues. However, for students who have a hearing impairment, visual cues are vital. Speechreading can help these students decode the teacher's message while providing other non-verbal communication cues such as facial expressions and/or hand and body movements.

As visual cues are highly beneficial to speech perception, it is essential that students have uninterrupted access to them. Unfortunately, this is rarely possible. Often, a teacher will turn his or her back to the class, fail to articulate clearly, or speak too rapidly. All these are common occurrences in classrooms. Other obstacles, such as the distance between teacher and student, poor lighting, a teacher wearing a mustache or beard, as well as any other visual distractions can further hinder efficient speechreading (e.g., Castle, 1988; Stoker & French-St.Georges, 1984). Even when the student with a hearing loss is given preferential seating near the teacher, speechreading remains difficult and much information is lost.

New Technology: The Audiovisual-FM System

For over thirty years, students with a hearing loss have been using standard audio-only FM systems. There are two types of FM systems: 1) the single-user system, which benefits a single student with a hearing loss, and 2) the sound field system, which amplifies the teacher's voice through loudspeakers (placed at strategic locations in the classroom) and benefits the entire class. By facilitating speech perception, FM systems improve academic performances (Berg, 1987; Crandell, 1991; Crandell & Bess, 1987; Crandell & Smaldino, 2000; Jones, Berg & Viehweg, 1989).

However, there are limitations to traditional FM systems as they do not eliminate many of the learning obstacles mentioned previously. There was therefore a need to provide students with hearing loss with more complete speech-signal equipment, hence the motivation to develop an audiovisual system. Providing visual cues did seem to be the best way of improving speech perception; the question was how to provide students with uninterrupted access to visual and audio cues regardless of the distance separating the teacher from the student?

The parents of a profoundly deaf child proposed an ingenious solution. Computer engineers by trade, Marie Lapalme and Luc Ducas introduced the Audiovisual-FM system in 1997. In this system, a headset worn by the teacher is equipped with a camera and microphone. The image of the teacher's face is transmitted to a small screen on the student's desk—giving the student uninterrupted, close-up access to the teacher's face—while the voice signal is sent to the student's regular FM receiver,

thus providing simultaneous auditory and speechreading cues. *AudiSee*, as the system is named, is the first system to integrate both the voice and the facial image of the teacher.

System Description

Figure 1 illustrates the components of the *AudiSee* system and how it may be used in a classroom. The system consists of two modules. The **teacher's module** includes a headset that supports both the microphone and the camera, and a transmitter worn at the waist. Both the voice and the image of the teacher are

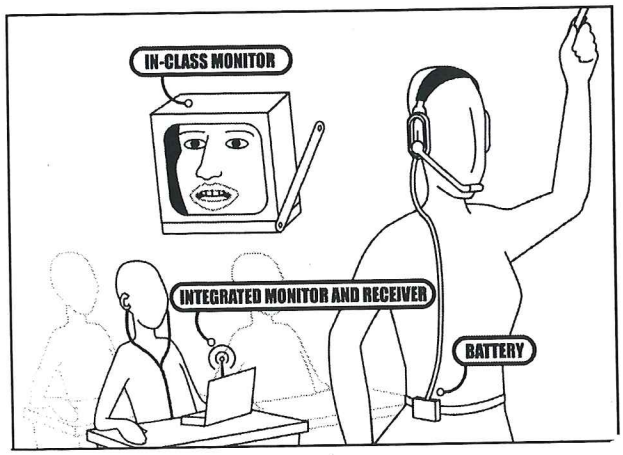

Figure 1. AudiSee System

transmitted, without wires, to the **student's module**. The image can be displayed on either a small 5-inch screen placed on the student's desk or a standard TV monitor placed in front of the class. A laptop computer can also be used.

The system is compatible with most FM systems available commercially, so the teacher needs to wear only one transmitter for both sound and image. The audio signal is transmitted directly to the student's regular, personal FM system. Combining the audio and video signals, while using a student's existing FM equipment, makes this Audiovisual-FM system very efficient.

Benefits of the *AudiSee* system

For the first time, students with a hearing loss can combine, at all times, visual and auditory cues to increase their level of understanding. Several investigators have shown the benefits in speech-perception performance that can be gained when the audio and the visual speech cues are combined (Binnie, 1974; Erber, 1974; Grant & Braida, 1991; MacLeod & Summerfield, 1990). Under poor listening conditions due the presence of background noise, a hearing loss, or both, the performances of subjects on speech perception tasks is significantly improved when they have access to the audiovisual speech signal rather than the auditory-only cues (Gagné, 1994).

Investigations desgined to evaluate the efficacy and effectiveness of the *AudiSee* system have been conducted over a period of three years. Gagné, Le Monday, Desbiens, Lapalme, and Ducas (1998) demonstrated that when the distance between a talker and a speechreader exceeds approximately 12 feet, visual-speech perception performances decreases. However, when the *AudiSee* system was used, speechreading performances remained constant even when the distance between the talker and the speechreader exceeded 24 feet. In fact, informal tests conducted with an *AudiSee* system have shown that the visual image transmitted onto the student-monitor remains undistorted up to a distance of approximately 100 feet.

Recently a field-study assessed the system's performance, as well as its benefits and drawbacks in the classroom (Gagné, Le Monday, Boisclair, Gagnon, Lapalme & Ducas, 2000). Twelve student-teacher teams used the *AudiSee* system in various classroom settings. The investigation was conducted over a period of one semester (approximately 3 months). The student-participants had various degrees of hearing impairment (from mild to severe) and they were recruited from all school levels: primary, secondary, and college. Data were collected from experimenters who observed classroom activities during different pedagogical activities. Additional information was obtained from daily-journal entrees completed by the students and the teachers as well as from individual and group interviews conducted with the participants.

The results of the investigation were conclusive. The *AudiSee* system makes speechreading readily available and more efficient, and promotes speech perception even in classrooms where lighting is not optimal. Secondary and college level students reported that the system facilitated note taking and required less concentration on their behalf. The student is thus less tired and has more energy to partake in other activities. The quality of the audio signal transmitted by the *AudiSee* system is comparable in quality to the signal provided by auditory-FM systems currently available commercially. In short, the system works and is reliable.

Two other observations made during the field study are noteworthy. First, introducing the *AudiSee* system to teenagers constituted a challenge. As with all assistive listening devices, many teenagers were reluctant to adopt the *AudiSee* system. Just like with traditional auditory FM systems, teens feared that its use would draw attention to their impairment and hinder their social integration. This is why successful implementation of the system relies on the coordinated efforts of the school staff, the teacher, and the school audiologist or speech-language pathologist. Second, many of the teachers were not keen on wearing the headset. The primary reasons for their reticence were that the headset was heavy and uncomfortable. Also, some teachers feared that the headset would undo their hair styling. Others did not like the visual reproduction of their facial features on the student- or TV monitor. Finally, some teachers reported that the headset distorted their ability to hear the students. Notwithstanding these obstacles, most of the teachers agreed to wear the headset especially when they realized the benefits it provided to the student-users. Finally, it should be mentioned that since the field study was completed (Spring, 2000), the headset worn by the teachers who took part in the investigation was completely redesigned. The current headset is significantly lighter (it weighs 5 ounces) and it is much more comfortable to wear (see Figure 2).

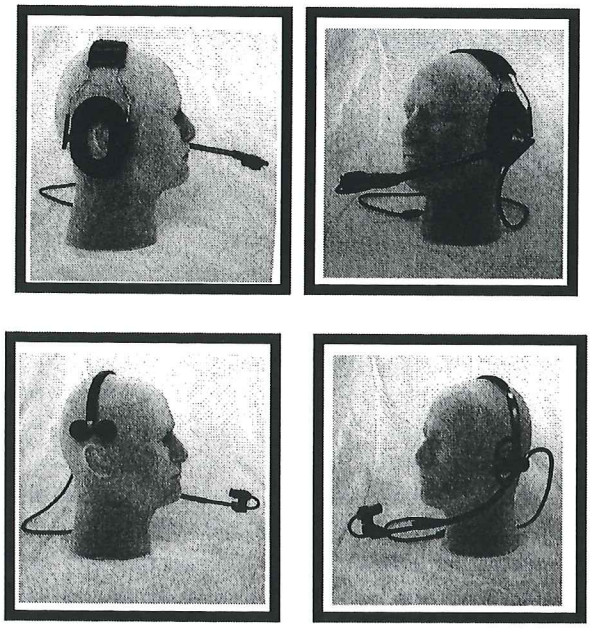

Figure 2. Photo illustrations of the AudiSee headset. The top panels display the previous version of the headset whereas the bottom panels display the current version of the headset.

Other applications

Originally designed for deaf and hard-of-hearing students, the *AudiSee* system is likely to benefit users who have communication difficulties attributable to other causes. Given that audiovisual cues enhance speech perception, anyone attending a conference or any other type of presentation where the participant is distant from the speaker could benefit from an *AudiSee* system. It is also likely that elderly individuals with a hearing loss or students who have learning disabilities not related to a peripheral hearing impairment (such as auditory processing problems or attention deficit disorder) could also benefit from this system. However, the potential benefit of the *AudiSee* system for these clienteles remains to be investigated.

Conclusion

The *AudiSee* system allows students to have uninterrupted access to the teacher's visual and auditory cues. The addition of visual cues is significant and could help students achieve a higher level of self-confidence and autonomy. In turn, this should be conducive to better academic results. Moreover, the teacher is now free to move about the class and does not need to devote as much effort to facilitating speechreading for a single individual. Finally, using the system in the classroom can increase other students' awareness of the problems linked to hearing impairment.

Additional information regarding the *AudiSee* system developed by Audisoft Technologies can be obtained at the following Web site: www.audisoft.net.

Acknowledgements

The investigations reported in this article were funded by a grant from the *Natural Sciences and Engineering Council of Canada* (NSERC) awarded to the author. Additional support was provided by a research grant awarded by the «*Office des personnes handicapées du Québec*» and by a research grant awarded by the «*Ministère de la science, de la recherche et de la technologie du Québec*». The author is grateful to all the students and teachers who took part in the field study conducted in 1999-2000.

References

American Speech-Language-Hearing Association. (1995). Position paper and guidelines for acoustics in educational environments. *Asha, 37*(Suppl.),15-19.

Berg, F.S. (1987). *Facilitating classroom listening: A handbook for teachers of normal and hard of hearing students.* San Diego, CA: College Hill Press.

Binnie, C.A. (1974). Auditory-visual intelligibility of various speech materials presented in three noise backgrounds in visual and audio-visual perception of speech. In H.B. Nielson & E. Kampp (Eds.), *Scandinavian Audiology* (Suppl) *4*, 255-80.

Castle, D. L. (1988). The oral interpreter. *The Volta Review, 90*(5), 307-13.

Crandell, C.C. (1991). The effect of classroom acoustics on children with normal hearing: Implications for intervention strategies. *Educational Audiology Monograph, 2*, 18-38.

Crandell, C.C., & Bess, F. (1987). Developmental changes in speech recognition in noise and reverberation. *Asha, 29*,170.

Crandell, C.C., & Smaldino J.J. (2000). Room acoustics for listeners with normal-hearing and hearing impairment. In M. Valente, H. Hosford-Dunn, & R.J. Roeser (Eds.), *Audiology treatment* (pp. 601-627). New York: Thieme.

Erber, N. P. (1974). The effects of angle, distance, and illumination on visual reception of speech by profoundly deaf children. *Journal of Speech and Hearing Research, 17*, 99-112.

Finitzo, T. (1988). Classroom acoustics. In R. Roeser & M. Downs (Eds.), *Auditory disorders in school children.* New York: Thieme.

Gagné, J-P. (1994). Visual and audio-visual speech perception training: Basic and applied research needs. In J.-P. Gagné & N. Tye-Murray (Eds.), Research in Audiological Rehabilitation: Current trends and future directions. *Journal of the Academy of Rehabilitative Audiology, 27*, 133-59.

Gagné, J.-P., Le Monday, K., Boisclair, A., Gagnon, L., Lapalme, M. & Ducas, L. (2000). Projet d'expérimentation du MF-Visuel: Rapport final. Research report submitted to the «Office des personnes handicapées du Québec», Montréal, Québec, Canada.

Gagné, J.-P., Le Monday, K., Desbiens, C., Lapalme, M., & Ducas, L. (1998). Evaluation of a Visual-FM system to enhance speechreading. In D. Burnham, J. Robert-Ribes & E. Vatikiotis-Bateson (Eds.), *Proceedings of AVSP'98 International conference on auditory-visual speech processing* (pp. 167-170). Terrigal-Sydney, Australia.

Grant, K.W., & Braida, L.D. (1991). Evaluating the articulation index for auditory-visual input. *Journal of the Acoustic Society of America, 89*, 2952-2960.

Jones, J.V., Berg, F.S., & Viehweg, S.H. (1989). Close, distant and sound field overhead listening in kindergarten classrooms. *Educational Audiology Monograph, 1*,15-25.

Macleod, A., & Summerfield, Q. (1990). A procedure for measuring auditory and audio-visual speech-reception thresholds for sentences in noise: Rationale, evaluation, and recommendations for use. *British Journal of Audiology, 24*, 24-43.

Stoker, R.G., & French-St. George, M. (1984). Factors influencing speechreading performance: Research findings. In W. H. Northcott (Ed.), *Oral interpreting: Principles and practices* (pp. 95-122). Baltimore: University Park Press.