

# **Telephone and Audio Conferencing: Origins, Applications and Social Behaviour**

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## **ABSTRACT**

Studies of groups and individuals using audio environments have found them best suited for workplace tasks involving information exchange, problem solving, or policy-decision making. Audio environments may have limited effectiveness with tasks where feelings of social presence, persuasion or getting to know someone better are important. This paper chronicles the history of telephone conferencing and audioconferencing in order to better understand the current uses and applications. Applications involving the Internet and virtual environments are also discussed.

## **INTRODUCTION**

According to Whittaker and O'Conaill [53], the telephone, because of its voice capability, is perceived to be the most effective communication medium to connect people separated by distance. Telephone conferencing or audioconferencing is the use of a telecommunication system (i.e. specially designed conference room or telephone unit) to allow electronic, multi-point communication between geographically dispersed individuals or groups [19, 25, 30, 42, 44]. The advantages of audio communication systems are that they are cost-effective (i.e. reduces travel costs), accessible (i.e. people can participate independent of their geographical distance) and real-time (i.e. immediate interaction not delayed by mail or email) [42]. Audio communication systems may be advantageous for group collaboration when unable to meet face-to-face.

The purpose of this paper is to present a historical background of telephone conferencing and audioconferencing in order to better understand the present environment of audio communication systems. Studies which investigated the social behaviour of users will be examined to determine which workgroup tasks audio environments may be best suited for. The sections are: chronology of the telephone; chronology of audio communication systems (i.e. audioconferencing, telephone conferencing and Internet); Social behavioural studies; Thunderwire, an audio-only case study and virtual environments.

## **SECTION 1: CHRONOLOGY OF THE TELEPHONE**

The telephone was named according to the Greek words: 'tele' which means far off and 'phone' which translates into sound or voice. When combined these words formed telephone, meaning far-speaking, and its function was to allow communication between physically-separated people [20].

On March 10<sup>th</sup> 1876, Alexander Graham Bell, initiated the first telephone call when he spoke the famous words „Mr. Watson--Come here, I want you“ [6]. Whether this was the actual text is in dispute as Mr. Bell was shouting in a microphone after spilling acid on his pants. However, Mr. Bell's assistant, Mr. Watson, heard his shouting transmitted over wire to Mr. Watson's receiver. Once they realised the significant of what had occurred, the ruined pants were forgotten. With this episode began the origins of the telephone [48].

After the initial discovery, Bell and Watson made later that year, the world's first long-distance telephone call (one-way) between Brantford and Paris, Ontario, Canada and the first long-distance telephone conversation (two-way) between Cambridgeport and Boston, Mass., USA [16, 47]. The importance of this discovery was that it provided the means for long-distance conversations that before it had only been possible through written messages sent by telegraph.

Commercial telephone service began in 1877. In 1878, the commercial exchange was created enabling women operators to connect phone calls between subscribers [20]. Major competition threatened Bell that same year as Western Union Telegraph Company using Thomas Edison transmitters and Elisha Gray receivers began to offer telephone service [51]. That same year the first UK telephone company was established [23].

In 1879, Bell founded National Bell Telephone Company and later that same year and into part of 1880, the first use of telephone numbers in Massachusetts, USA was recorded [51]. Early competitive problems existed as Western Electric Manufacturing Co, Western Union Telegraph Company and Bell were offering incompatible telephone services. [20]. In some areas, all three competed for the same customers. However, after a successful court infringement case by Bell, Western Electric became the sole supplier of Bell telephone equipment and telephones for American Bell (formerly National Bell Telephone Company). Long distance service was established in 1881 between Boston and Providence, RI, USA [51]. In 1885, American Telephone and Telegraph (AT&T) was established and began offering private telephone service the next year [47].

The telephone was not initially without problems. The invention of electric trolley cars and street lamps resulted in electrical storms that sometimes downed telephone lines. [20]. As well, poor sound quality and high long-distance fees limited access to city inhabitants who were financially successful [5].

After the Bell patent expired in 1893, local phone companies began to connect local farm families through party-lines. Usually a doctor or pharmacist would connect customers with their office or shop respectively. This was not only economically feasible but also provided a lifeline. Entrepreneurs set out establishing phone services such as in Abilene, Kansas, USA where United Telecom was established by Jacob and C.L. Brown which later became Sprint. Bell service outside of the cities, if available, was perceived as inadequate. To maximise on profits and service within the cities, service to rural areas was compromised. Bell's rural service was perceived by town residents as expensive, providing poor line quality and burdened by unfriendly management. Local town residents desired instead their own phone system rather than continuing to rely on a giant monopoly labelled 'big business' from the east. In the 1900s party lines were introduced to further decrease the cost in cities and make having a phone affordable in rural communities [45, 51].

At the beginning of the 20<sup>th</sup> century, the number of phones grew exponentially. In 1900, there were 855 900 telephones connected by Bell, in 1910, 5 883 000 and more than 15 000 000 in

1924 [47]. During the depression years of the 1930s, AT&T reduced rates and telephone subscribers returned phones to save money. Between 1931 and 1933, more than 3 million subscribers gave up their phone service [45, 51].

The origin of telephone conferencing can be traced back to these rural party-lines of the early 1900s, an extension phone linking three families that provided the capacity for simultaneous conversations. Disadvantages included poor sound quality, consistently occupied phone lines and lack of privacy as individuals could listen in without detection [27]. In one Canadian town, inhabitants wanted Gaelic banned during telephone conversations because as native English-speakers they couldn't understand the foreign language when eaves-dropping [9]. In addition, privacy and security concerns made party-lines impractical for business.

During the 1940s, as a result of WWII, military-related research became the primary focus of the Bell telephone laboratory. In 1948, the 30 000 000th telephone was installed in the Bell system in the United States [51].

Technological advances in the 1950's included direct-dial service replacing the „number-please“ operators, the world's first hands-free Speakerphone and the first transatlantic cable being laid between Canada and Scotland, heralding the age of international companies and global communication [4, 47]. But it was not until 1966 that the first commercial electronic central office was able to provide customers with memory options such as third party conferencing [47].

## **SECTION 2: CHRONOLOGY OF AUDIO COMMUNICATION SYSTEMS**

The desire to reduce energy during the 'energy crisis' of the 1970s may also have contributed to the search for a cheaper alternate to the costs of transportation. It has been estimated that an automobile running continuously uses a similar amount of energy as a telephone exchange (25 kW for auto vs. 6-100kW for a telephone exchange). In addition, 0.03% of the national energy in the UK was used for telecommunication vs. 18.4% for transportation [44].

Additional problems that may have hindered widespread acceptance of group audio systems in the 1970s were the length of time necessary to set up (between one-two hours) and the restriction on the number of participants. Limitations existed because of the cumulative background noise generated by each additional member. To overcome difficulties such as group members being unable to simultaneously collaborate on documents, use of the fax machine was suggested. [44].

Speaker identification, has been identified as a possible problem with audio systems even in small groups [37]. Exceptions were when distinct discrepancies existed between members such as gender or accent [37, 44]. The Remote Meeting Table attempted to address this concern by having a person's name light up at the remote group's meeting table which enabled everyone to be aware of the speaker's identity [30,49]. Short [44] questions the effectiveness of the light, wondering if it is a good replacement for physical presence, or if it actually was a distraction.

At the end of the 1970's, telephone copper wire began to be replaced by fibre optic wires. This led to the first fibre optic system in downtown Chicago and resulted in a variety of new telecommunication options (i.e. voice, data and video) available to local businesses [3].

In the early 1980, BT introduced Rendezvous service in the UK. Similar to other phone companies, it was operator-based with conference calls needing advance bookings. The participants would contact the operator who would ensure everyone was properly connected for the conference call [23]. In 1981, the IBM desktop personal computer was introduced [47]. Since the late 1960s, early 1970s there had been perceptions of North American cities becoming more crowded, leading people to migrate from the cities to the suburbs. This trend continued in the 1980s with increasing numbers of employees remaining linked with employers through telecommunications (i.e. phone, computer and fax machine) and resulted in the concept of telecommuting.

In the 1990's telephone conferencing has continued to increase in its popularity as a preferred form of communication. For companies with budget constraints, telephone conferencing reduces expenses associated with travel and enables employees choosing flexitime or telecommuting to maintaining a 'sense of presence' during meetings [see 34]. Audioconferencing accounts for approximately 75% of the United Kingdom communications market and it is perceived successful because of the low-cost overhead when set up by the British Telecom telephone company [41]. Two different types of telephone conferencing providers are the phone companies (i.e. AT&T) and companies specialising in telecommunication equipment (i.e. Polycom).

### **Current Telecommunication System Use**

There are a variety of conferencing systems that currently exist: audioconferencing; audiographic conferencing; and desktop conferencing. The differences are: audioconferencing provides audio communication to link participants over the telephone; audiographic conferencing combines audioconferencing and dataconferencing using the Internet to share data for collaboration between participants; and desktop conferencing uses a desktop computer to link participants through the Internet to other PCs or telephones[42].

Conference calls can be divided into two types: regular basis calls and ad hoc basis calls. Regular basis calls include monthly progress report meetings and ad hoc basis calls are used during a company crisis such as sabotage [23]. Phone companies primarily focus on operator assisted calls in which participants dial an operator who connects everyone, and a special customer handled calls where individual members are linked by calling an assigned reserved number during a specific time period. Uses of these features include: job interviews, planning company strategies and resolving emergencies. Special features available are: polling of members, question and answer (i.e. chair decides when queued members speak), and taping of conversations [7, 2].

In the United States, Sprint operates a Sprint Conference Line system that began in 1990 with only a limited number of customers. Since then over one million conference calls have been completed. Features available include audiotaping, subconferencing (i.e. breaking into subgroups), lecture-only mode, and question and answer queuing. Presently, there are more than 100 000 basic customers and 280 corporate accounts (businesses committed to monthly use) [35].

In Germany, an ISDN network system has been in operation since 1989. During the 1960's and 1970's telephone conferencing was manual involving an operator. In 1989, an ISDN network system became operational that made 3 way party calls possible and now up to 10 way party calls are possible. Since 1997 it is believed that 1 300 000 telephone conferencing customers exist [24].

British Telecom (BT) is presenting designing a Conference Call Instant system (audioconferencing system) that when implemented should include features such as: conference recording, dial-in conference joining and speech recognition, common viewing of a document page (i.e. placing it on a WWW which the chair would continually update) and providing the capacity to share and view documents electronically [23].

### **Telecommunication Equipment**

Polycom, which has a co-marketing agreement with AT&T conferencing services and its audio products, is a manufacture of video, data and audioconferencing equipment. They perceive themselves as a world leader in group conferencing needs for both group conferencing rooms and office equipment. In the past six years since their SoundStation conference phone was originally introduced for an office or small-to-medium sized conference room, new SoundStation products have been created for large conference rooms (i.e. up to 25 participants in a room) [40]. In addition, Internet telephony is also available.

Products offered by Polycon include Soundpoint, a speaker attached to the phone providing hands-free, two-way conversations for the office; SoundStation, a conference phone used by 95/100 Fortune 100 companies with telephone keypad, speaker, and microphone capacity for the office or small conference room; and a SoundStation system for up to 25 participants in a medium or large conference room that is equipped with keypad, internal microphones and capacity for external microphones. According to Polycon [40], the sound quality provided is a clarity superior to speaker phones common during the early days of telephone conferencing.

### **Internet Conferencing**

In recent years, telephone conferencing has found a new form of telecommunications, the Internet, capitalising on reduced rates and advances in telephone communication such as ISDN (Integrated services digital network). This method of telephone conferencing has been called virtual conferencing or Internet telephony [see 47 for a comprehensive list of available companies].

British Telecom with its Conference Call Presenter conferencing system uses the Internet to transit images or documents to other participants during an audio conference. Through the use of a browser combined with presentation slides from Microsoft PowerPoint, one is able to speak while visually presenting slides to the other participants via the Internet [8].

Lucent Technologies was formed in 1996 out of AT&T during diversification. They create products such as: 'Internet Telephony Server' which converts speech to compressed IP signals for voice transmission; 'OneMeeting' Internet conference software which allows communication with up to 6 participants; and 'elemedia' which provides hundreds of simultaneous conversations independent of communication platform (i.e. Internet telephony software, regular phone or Microsoft NetMeeting) [33].

VocalTec, a new Internet telephony company, has a promising future with the release of Internet products such as its VocalTec Conference server. Unique features include speaker arbitration where participants speak on a first-come-first-served basis and 'privileged user' where a person has special powers to become the current speaker whenever desiring to speak [50].

One of the problems hindering Internet telephony is the poor sound quality. Once this is modified, this area of group communication should grow because the price of sending faxes

or telephone calls over the Internet is a fraction of the current costs charged by telephone companies such as Deutsche Telekom or Bell. In the future, global communication will increase as optic fibres allow more freely the possibility of group conferencing via the Internet and telephone.

### **SECTION 3: SOCIAL BEHAVIOURAL STUDIES**

In 1963, the Institute for Defense Analyses (IDA) in Washington D.C. after developing the 'hot-line' from the White House to the Kremlin (a direct connection for emergency communication), decided that it should be possible for more than 2 people to communicate simultaneously. This came to be known as the first studies on teleconferencing [30]. In their negotiation studies in which participants role-played members of a military alliance who were externally threatened, two results should be noted: individuals preferred the depersonalised effect of the telephone to face-to-face contact and after a brief trial with a television reported no significant advantage in being able to see their opponent [30].

Research was conducted during the 1960's and 1970's to examine the communication effectiveness of telephone conferencing and compare results with face-to-face or video conferencing. Early problems such as sound quality were minimised with acoustical treatment and open-microphone systems. Problems of protocol were solved with an appointed chairperson. Auditory systems introduced included speaker phones and speakers embedded into a desk or tabletop unit [30]. In-house audio conferences systems became more common as companies (i.e. Bank of America, General Electric) attempted to reduce travel time and costs [30].

Social behavioural studies of audio and telephone conferencing systems have determined which types of tasks audio environments may be most effective for. These are: gathering factual information [12], problem-solving [30, 44, 54], information exchange and asking questions [30], group discussion [37], group collaboration [30], information seeking [30, 44, 54] and policy-decision making [54]. Additional advantages include the ability to reduce the duration of meetings [17]. A factor that seems to be significant as to whether an audio system is preferred depends on the meeting task activity for which the medium would be used [44]. The tasks for which audio-only is ineffective or has reduced effectiveness include: degree of social presence [11], getting to know a stranger or acquaintance better [44, 49], persuasion, bargaining or forming coalitions [44]. A more in-depth analysis will now take place.

#### *High Effectiveness*

Champness [12] sampled 112 civil servants' opinion on two kinds of video systems, face-to-face and an audio system as to the degree of suitability for interpersonal relations (keeping group morale), factual information (issuing orders), interpersonal conflict (persuasion) and chatting (general conversation). Although the results showed video superior to audio on activities involving interpersonal relations and interpersonal conflict, no differences based on type of medium were found for tasks requiring factual information.

One's awareness of the physical separation between participants effects one's feelings within the environment. Short et al [44] describes this as social presence. Social presence is based on a variety of cues used to access the relative distance between participants. The personal relationship felt during group interaction is relevant to the degree of social presence felt. Even though audio-only environments eliminate cues such as: facial expression, eye-contact, gesture, posture, proximity and physical appearance, Short et al. [44] doesn't perceive the elimination of these cues as having a significant effect on the outcome of group tasks which

are insensitive to the type of medium used (i.e. face-to-face, audio) for interaction such as problem solving or exchanging information.

Champness [11] studied 72 managerial civil servants who had three conversations (face-to-face, closed-circuit television and an audio system) in pairs after which they rated their experience of the medium used. Their hypothesis on social presence stated that users perceive a telecommunication medium as having varying degrees of social presence and that users avoid using a communication medium that require a higher degree of social presence than perceived possible with that medium. Media with a high degree of social presence is judged to be sociable. Consistent with hypothesis predictions, face-to-face was perceived to be most sociable with audio being the least.

The Communication Studies Group of London found that bargaining and negotiation tasks were most sensitive to the type of communication medium with problem-solving and information exchange tasks being least sensitive. An Office Communication Survey of office meetings concluded that: the importance of visual cues in face-to-face meetings was overstated and audio-only conferencing systems could accommodate 26-52% of all meetings without adversely effecting the outcome of the meeting. This was because they believe that most meetings involve either information seeking (48%), giving information to keep everyone informed (48%), or problem solving (48%) tasks [30]. The overall conclusion that can be drawn is that audioconferencing or telephone conferencing systems are an effective medium for group collaboration and conversation.

Various studies have found that for certain tasks, video-mediated communication has marginal effectiveness or is no more effective than audio-only communication [see 19, 21, 44]. Other studies have concluded that a voice communication channel to be an essential element of any communication system [38]. While discussing the usefulness of audioconferencing for distance education, Neal [37] perceives audioconferencing being best suited for situations that involve full group collaboration.

In a study of two audioconferencing systems, one in-house (University of Quebec) and a Remote Meeting Table from the U.K., participants reported feelings of uneasiness and a perception that one's privacy could not be guaranteed. The authors cite this as a consistent concern of all teleconferencing systems [30, 49]. However, respondents believed that using audioconferencing in their meetings would create a more friendly, more aggressive and less business-like environment than during face-to-face sessions [30]. In fact, audioconferencing may work best with low-level person-oriented tasks such as the exchange of information and asking questions [30].

Short [43] asked 144 users of face-to-face, audio systems and video systems for comments about the experience with the different mediums and the frequency of the comments was reported. One comment that should be noted is that of a user of a Bell Canada teleconference system:

„The advantage of audio conferencing is that we wouldn't have to sit up straight, stare at the camera and look presentable when we speak: we could take it easy. Also there would not be the fear of the camera suddenly focusing on you when you are not ready...that is embarrassing [p118].“

Audio conferencing also has a positive effect on reducing the duration of the meeting. Craig and Jull [17] reported that when two group of managers alternated between face-to-face and audio conferencing meetings, the audio conferencing meetings were 40% shorter in both groups. The authors attribute this to a reduction in the amount of social conversation during

the meeting.

In 1978, a detailed survey of permanently installed teleconferencing sites in North America reported the existence of fourteen audio sites. Johansen and Bullen [31] believed in 1984 that the numbers had increased significantly with seventy-five companies with permanent installed audio sites. Johnansen and Charles [32] reviewed the data from an extensive survey conducted by the Institute for the Future [IFTF] in 1982 on 317 respondents from eighteen companies and government organisations throughout the United States. Based on the responses, they believed that audio and text are essential features for a multimedia system either in combination or alone and that the best option is an integrated system for communication.

A Connell [15] project called DACOM clustered meetings according to function and purpose and when focusing only on meeting task concluded that for those meeting that could possibly be transferred from face-to face interaction, the majority would be transferred to an audio-only communication medium. The comparative numbers were face-to-face (30.4%), video (2.9%), audio (38.1%) and allocation not possible (28.6%).

#### *Limited or Reduced Effectiveness*

The American New Rural Society Project conducted a study reported by Christine [14]. Twenty business executives after a demonstration of an audio conferencing system reported that a visual picture of the other individual speaking was only necessary when they were not familiar with each other.

Christie [14] grouped 36 businessmen into sets of 6 using five types of communication medium. Their attitudes towards each medium was then assessed. When comparing social presence of a speakerphone, a high fidelity speakerphone, closed-circuit television, face-to-face and a multichannel audio system, the results showed that face-to-face had the highest degree of social presence based on a factor score (0.7) followed by video (0.6), multichannel audio (-0.01), high fidelity speakerphone (-0.5) and speakerphone (-0.7).

Two in-house audioconferencing systems: (University of Quebec) and a Remote Meeting Table from the U.K were rated as most unsatisfactory for getting to know someone [49]. Short [44] agrees finding that tasks which involve a personal relationship with the other person are effected by the type of medium used because it is perceived that face-to-face provides the best opportunity for the development of a relationship with the other participants.

Tasks where the medium has an influence on the task include bargaining, persuasion, forming coalitions and getting to know a stranger; as face-to-face is perceived to have a higher level of presence [44]. The perception from Short [44] is that with audio communication one loses the personal relationship that is generated between participants during face-to-face communication so audio is perceived as less effective. Privacy is a concern with participants as Champness [13] reported that participants in three person groups perceived audio-only conversation under laboratory conditions as less private than face-to-face.

## **SECTION 4: THUNDERWIRE: CASE STUDY**

Hindus et al. [28] used a media space system called Thunderwire, which is an audio-only communication system designed similarly to a telephone conference call system [1] in a field setting in order to investigate how potential users of such a system would interact with each other as well as perceive the system. Thunderwire was designed in order to allow interaction



between a small group of participants located throughout two buildings. All messages were public, a fluid system facilitated easy connection and disconnection, an audible click indicated someone had entered or left the system (but not who), and the audio was of a high-quality [1]. Over a two month period the nine group members, who knew each other previously, communicated through the system. Participants sat in cubicles while working, wore headsets and spoke into desktop microphones [28].

### **Social Conventions**

Social conventions relevant to group members within this shared environment were: announcing when someone logged on or off; logging off for personal distractions (i.e. telephone call) and projecting cues that announced one's inattentiveness or desire not to communicate. The issues most important to the participants were: addressing background noise; knowing who was currently on the system; knowing when someone was lurking; and minimising invasions of privacy [1]. Social norms formed and developed based on cues that are present during face-to-face interaction. This occurred throughout the duration of the system use. For example, participants created signals for the other members so that members present were aware of each others degree of attentiveness to the conversation.

One social norm that was found to exist was the convention of announcing oneself when logging on and logging off the system [1]. The system design did not announce the identity of individuals as they joined and left the group. When one signed on/off there was an audible click at which time according to social norms, the new member would announce oneself or if leaving, say goodbye. When there was not a immediate greeting from a new member that logged on, someone would ask who was on. This method allowed participants to keep track of members present. Members also updated new participants as to who was presently on or who had logged off previously. These social norms were regularly followed [1, 28].

Individuals who received or initiated telephone calls were suppose to leave the system until the call was complete as everyone was privy to the telephone call. Usually this norm was ignored. Hindus et al [28] believe this behaviour mirrors similar norms within physical environments where one usually carries on a conversation when others are present in the same room listening in. Social conventions exist such that it may actually be considered rude to excuse oneself in order to have more privacy [1, 28]. That leads to an interesting question. Is it proper etiquette to disconnect from an audioconferencing system when interrupted by someone at the door or on the telephone?

Group members believed it to be important to let other members know when one was temporarily absent or distracted [28]. Signals existed in order to symbolise one's lack of attentiveness or preoccupation in a socially acceptable manner. For example, pauses or short sounds expressed very slowly symbolised one's inattentiveness, allowing one to maintain a system presence with a minimal level of telepresence. [1, 28]. Telepresence is described as physically dispersed participants perceiving themselves as occupying a shared social space [26]. Slowing letting a conversation wind down which is cited as occurring during face-to-face office conversations [see 52] signalled partial inattentiveness [28]. Members would express their desire to end unwanted conversation by falsely blaming equipment breakdown(i.e. defective headphones) as the reason for terminating conversation [28].

Hindus et al [28] believe that the creation and existence of social conventions by the participants of the Thunderwire system indicates that the users perceive the virtual environment as a social space. They believe that these social norms regulated social behaviour within the work environment and as such indicate a significant level of telepresence as users

constructed a 'sense of place'[see 34] within the Thunderwire space.

### **Important Features for an Audio Communication System**

Ackerman et al. [1] perceive certain characteristics of the Thunderwire system as necessary for any type of audio-only conference system. These are constant open-audio mikes to facilitate long-term communication [18] and make interaction more fluid [22]; good quality full-duplex audio without a lag in voice transmission, which is important for remote collaboration [39] and fluid use that allows ease of use of accessing and leaving the system, which facilitates frequent conversations and mimics interactions in the workplace [52].

Additional features that could be added to audioconferencing systems to enhance the overall conference quality include 'voice activity detectors' that perform a microphone muting function and indicate the current speaker. Colours or tones could also be used to get attention or for voting purposes[23]. For office-based audio systems such as Thunderwire which are not linked to a telephone, it is important to have an automatic method to turn off the microphone when receiving phone calls. Knowing who is speaking is important and well as the ability to have private conversations [28].

## **SECTION 5: VIRTUAL ENVIRONMENTS**

Virtual conferencing is a new area of research being explored by some Telecommunication companies such as British Telecom. Its benefits are being able to represent participants as graphical representations (i.e. avatars) in a computer-generated shared environment [36]. Gestures, body language directed at other participants, and turn-taking cues necessary for the natural flow of conversation between speaker and listener are available options. Three fundamental features that must be used according to Mortlock et al. [36] when designing a virtual conference system are: avatars that exist in real time to allow instantaneous gestures and movements; personalised avatars that allow instant recognition by participants; and non-intrusive control of the avatars to maximise concentration on the goals and task of the meeting.

Neal (1997), while combining an audio-conferencing system and Virtual Places, a 2D graphical virtual environment, found positive responses when creating a virtual classroom for a distance education class discussion. Avatars added more humour and provided a greater degree of communication as gestures and emotions such as waving and smiling became part of the conversation. Experiences within the virtual world were also perceived to create an enhanced sense of community between the classmates.

## **CONCLUSION**

Audio environments such as telephone and audio conferencing systems will continue to be effective during remote group collaboration. What is important for the users of these systems is to ensure that the group task is best suited for an audio environment. In addition, it is important that groups feel a 'sense of presence' of being together in the same media space [34] even when separated by physical distance.

## REFERENCES

1. Ackerman, M.S., Hindus, D., Mainwaring, S.D., Starr, B. (1997). Hanging on the 'wire: A field study of an audio-only media space. *ACM Transactions on Computer-Human Interaction*, 4, 1, 39-66.
2. American Telephone and Telegraph, *The Telephone*. <http://www.att.com>.
3. American Telephone and Telegraph, *AT&T Milestones: Optical fibre communications*. <http://www.att.com>.
4. American Telephone and Telegraph, *AT&T Milestones: Transatlantic Cable*. <http://www.att.com>.
5. Baldner, J.G. *The Telephone: Impact and Expansion*. <http://www.beloit.edu/~amerdem/students/baldner.html>.
6. Bell, A.G. Experiments made by A. Graham Bell, (Unpublished Notebook) Vol. I, Box 258, *Bell Family Papers*, Library of Congress, 40-41. <http://jefferson.village.virginia.edu/~meg3c/id/AGB/V1p40.html>.
7. Bell, *Advantage Teleconferencing*. <http://www.bell.ca>.
8. British Telecom. *BT Conferencing*. <http://www.visual.bt.com>.
9. Bruce Municipal Telephone System. *The Company and its long local history*. <http://www.bmts.com/company.htm>.
10. Butters, Gerry (Spring 1997). *Straight talk about the other public network*. In Network Edge. <http://www.lucent.com/netsys/news/news97.html>
11. Champness, B.G. (1972a). *Attitudes Towards Person-Person Communications Media*. Unpublished Communications Studies Group paper no. E/72011/CH.
12. Champness, B.G. (1972b). *The Perceived Adequacy of Four Communications Systems for a Variety of Tasks*. Unpublished Communications Studies Group paper no. E/72245/CH.
13. Champness, B.G. (1972c). *Feelings Towards Media in Group Situations*. Communication Studies Group paper no. E/72160/CH.
14. Christie, B. (1973). *Appendix M*. In P.C. Goldmark *et al.* The 1972/73 New Rural Society Project. Research report available from Fairfield University, Connecticut.
15. Connell, S. (1974). *The 1973 Office Communications Survey*. Communications Studies Group paper no. p/74067/CN.
16. Consultative committee on the implications of telecommunications for Canadian sovereignty. (1979). *Telecommunications and Canada*. Canadian Government.
17. Craig, J., and Jull, G. (1974). *Teleconferencing Studies: Behavioural Research and Technological Implications*. Paper read at 7th International Symposium on Human Factors in Telecommunications, Montreal.
18. Dourish, P. Adler, A., Bellotti, V., and Henderson, A. (1996). Your place or mine? Learning from long-term use of audio-video communication. *Computer Supported Cooperative Work*, 5, 1, 33-62.
19. Edigo, C. (1988). Videoconferencing as a technology to support group work: A review of its failure. In *Proceedings of CHI '88*, ACM, N.Y., 13-24.
20. Flammger, Dawne M, *A History of the Telephone*. <http://www.geog.buffalo.edu/Geo666/flammger/tele2.html>
21. Gale, S. (1991). Adding audio and video to an office environment. in Bowers, J.M. and Benford, S.D. (Eds.). *Studies in Computer Supported Cooperative Work*, Elsevier: Holland, 49-62.
22. Gaver, W.W. (1993). Synthesizing auditory icons. In *Proceedings of the ACM INTERCHI '93 Conference on Human Factors in Computing Systems*. ACM, New York, 228-235.
23. Gibson, D.L., Pauley, D., and Willis, L. (1997). Unattended audioconferencing. *BT Technology Journal*, 14 (4), 26-32.

24. Gleissert, J. (April 1998). personal email correspondence; personal telephone call.
25. Global Company, The. *Sites across world*.  
[http://http2.brunel.ac.uk:8080/+emmcim/1995/people/stuart\\_holliday/cim\\_ass2.htm](http://http2.brunel.ac.uk:8080/+emmcim/1995/people/stuart_holliday/cim_ass2.htm)
26. Greenberg, S. and Chang, E. (1990). Computer support for real time collaborative work. *Congressus Numerantium*, 75, 247-262. First published in *Proceedings of the Conference on Numerical Mathematics and Computing*, Sept 28-30, Winnipeg, Manitoba, 1989.
27. Guinee, K.A. *Journey through the history of information technology*.  
<http://www.cs.princeton.edu/~kguinee/thesis.html>
28. Hindus, D., Ackerman, M.S. Mainwaring, S. and Starr, B. (1996). Thunderwire: A field study of an audio-only media space. In *Proceedings of CHI '96*, ACM, N.Y., 238-247.
29. Hollier, M.P. Rimell, A.N. and Burraston, D. (1997). Spatial audio technology for telepresence. *BT Technology Journal*, 15(4), 33-41.
30. Hough, R.W. (1977). *Teleconferencing Systems: A State-of-the-Art Survey and Preliminary Analysis*. National Science Foundation.
31. Johansen, R. and Bullen, C. (1984). What to expect from teleconferencing?, in Johansen, R. (Ed.) *Teleconferencing and Beyond: Communications in the Office of the Future*. Data Communications: New York
32. Johansen, R. and Charles, J. (1984). What users say about teleconferencing, and beyond to expect from teleconferencing?, in Johansen, R. (Ed.) *Teleconferencing and Beyond: Communications in the Office of the Future*. Data Communications: New York
33. Lucent Technology. <http://www.lucent.com>
34. Mane, A. (1997). *Group Space: The Role of Video in Multipoint Videoconferencing and its Implications for Design*. In K. E. Finn, A.J. Sellen, S.B. Wilbur (Eds.). *Video-mediated Communication*. New Jersey: Lawrence Erlbaum.
35. Martin, P.D. (April 1998). *audio conference information (sprint)*. personal email correspondence.
36. Mortlock, A. Machin, D. McConnell, S. and Sheppard, P (1997). Virtual conferencing. *BT Conferencing Journal*, 14, 120-129.
37. Neal, L. (1997). Virtual Classrooms and Communities. in Hayne, S.C. and Prinz, W. (Eds.). *Proceedings of ACM GROUP '97*, ACM: New York, 81-90.
38. Ochsman, R.B. and Chapanis, A. (1974). The effects of 10 communication modes on the behavior of teams during co-operative problem-solving. *International Journal of Man-Machine Studies*, 6, 579-619.
39. Olson, J.S., Olson, G.M., and Meader, D.K. (1995). What mix of video and audio is useful for small groups doing remote real-time design work? In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'95)*. ACM, New York, 362-368.
40. Polycom, *Company Information*. <http://www.polycom.com>
41. Parke, I. (1997). The evolution of conferencing. *BT Technology Journal*, 15, 19-25.
42. Russ, M. (1997). Desktop conversations – the future of multimedia conferencing. *BT Technology Journal*, 14, 42-50.
43. Short, J.A. (1973b). *The Effects of Medium of Communication on Persuasion, Bargaining and Perceptions of the Other*. Unpublished Communications Studies Group paper no. E/73100/SH.
44. Short, J., Williams, E. & Christie, B. (1976). *The social psychology of telecommunications*. Bath: Pitman Press.
45. Sprint. *History of the World*. <http://www.sprint.com>
46. Sprint (1998). *Sprint Products and Services*. Sprint Proprietary. handbook
47. Telecom Information Resources on the Internet  
<http://china.si.umich.edu/telecom/Internet-telephony.html>

48. Telfonmuseet, *The history of the telephone...*,  
<http://www.telfonmuseet.dk/uk/museum.htm>
49. Thomas, H.B. and Williams, E. (1995). *The University of Quebec Audio Conferencing System: An Analysis of Users' Attitudes*, Communications Studies Group, University College: London
50. VocalTec Communications Ltd. <http://www.vocaltec.com>
51. Webb & Associates, *Telecommunications History Time Line*,  
<http://www.webbconsulr.com/timeline.html>
52. Whittaker, S., D. Frohlich and O. Dalz-Jones (1995). Informal workplace communication: What is it like and how might we support it? In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'95)*. ACM, New York, 369-376.
53. Whittaker, S. and O'Conaill, B. (1997). *The Role of Vision in Face-to-Face and Mediated Communication*. In K.E. Finn, A.J. Sellen, S.B. Wilbur (Eds.), *Video-Mediated Communication*. NJ: Lawrence Erlbaum, 23-51.
54. Williams, E. (1974). *A Summary of the Present State of Knowledge Regarding the Effectiveness of the Substitution of Face-to-face Meetings by Telecommunicated Meetings: Type Allocation Revisited*. Unpublished Communications Studies Group paper no. P/74294/WL.