Chapter Three

Research Method

Discussion of the research method commences with a summary of the participant recruitment procedure in which demographic characteristics of the study participants are defined. An explanation of the research design leads to a description of the data collection instruments that includes an account of the study equipment and procedures. The ensuing analysis of sound design characteristics of the selected IMMI programs is followed by discussion of the development of the Sound Activity Profiles (SAPs). Finally, the data analysis procedures employed in the investigation are scrutinised.

The Study Participants

The subjects in the current study responded to a request for volunteers to participate in an investigation of the role of interactive multimedia in music education. The call for participants, which is shown in Appendix A, was distributed to a population of Bachelor of Music Education students who were enrolled at an Australian conservatorium of music in the second, third, or fourth academic year of their course. The request for volunteers emphasised that selection was not dependent upon the participant's level of computer expertise. Volunteers with little or no previous computer experience were encouraged to participate, along with others who had more highly developed computer skills. All those who volunteered were offered a place in the study. As an incentive to encourage participation, two CD-ROM discs were offered as prizes. The prizes were drawn by ballot at the completion of the study sessions.

Twenty-two volunteers agreed to participate in the investigation which was conducted over a two week period in February 1996. The data for two participants was incomplete due to
an equipment failure. Therefore, the study cohort consisted of 20 subjects: 14 females and 6 males. The mean age of the participants was 21.4 years.

Research Design

The design of this exploratory study draws upon two research models, namely, the case study and the relationship study. Burns (1997) observes that "the case study is used to gain in-depth understanding replete with meaning for the subject, focusing on process rather than outcome, on discovery rather than confirmation" (p. 365). He reports that the main information gathering techniques employed in case studies are observation, interviewing, and document analysis. According to Burns, "a case study should focus on a bounded subject/unit that is either very representational or extremely atypical" (p. 364). The "bounded subjects" of the present case study are the individual participants who took part in the research. The IMMI programs used in the study are likewise "bounded units" that function as the principal independent variables of the investigation. A rationale for the selection of the IMMI programs is provided in a subsequent section of this chapter.

While the IMMI programs employed in this research have an educational emphasis, their application in the study was not manipulated to directly evaluate their instructional effectiveness. This approach is consistent with the recommendations of Gordon (1986) who observes that

most research studies in music education are designed to determine and to compare what students have learned. Rarely, if ever, are research studies in music education designed to discover how students learn what they learn. Typically, emphasis is on using the criterion measure to assess the product and not the process of learning. That is unfortunate. It should be of greater benefit to the music educator to know how students learn when they learn than to know what information students are capable of learning when they are given different types of instruction under different conditions. (p. 31)
Consequently, the present study does not directly assess learning nor does it compare the instructional outcomes of an experimental group with those of a control group. All subjects received the same treatment, that is, every participant engaged in one twenty minute session with each of two selected IMMI programs. Therefore, the investigation is essentially a behavioural case study of participant interactions with the audio components of the IMMI programs, which focuses on interaction as a process of learning in an IMMI setting. Such an approach is advocated by Horney (1993b) who argues that interactive multimedia research would be more effective if researchers would first pay more attention to fundamental descriptions of [participant] activities and the context in which these activities take place before abstracting these actions into strategies. A close examination of just what [participants] do and when they do it will lead to new developments in hypertext software and in the rhetoric of hypertext structures. (p.269)

The variables under investigation in the present study relate to the events and interactions that occur between participants and the IMMI programs they use. Session sound activity is documented using videotape recordings and is subsequently analysed through visual and aural assessments of participant interactions with the audio elements of the IMMI programs. Questionnaires and follow-up interviews are administered to confirm and further explain participants’ behaviours and their opinions of the events that occur in the study sessions. Hence, as Burns recommends, the case study analysis draws upon a triangulated database of information obtained from observations, questionnaires, and interviews to create a "thick description of the phenomena" (Gall et al.:1996) in which participant interactions with the audio components of the selected IMMI programs are elucidated.

The advantages of such triangulation in data collection are emphasised by Cohen and Manion (1996) who maintain that triangular techniques endeavour to "...explain more
fully, the richness and complexity of human behaviour by studying it from more than one standpoint and, in so doing, by making use of both quantitative and qualitative data" (p. 233). Burns (1997) confirms that "the use of multiple sources is the major strength of the case study approach...multiple sources allow for triangulation through converging lines of inquiry, improving the reliability and validity of the data and findings" (p. 374).

A subsidiary goal of the investigation is to discover if relationships exist between participant characteristics, such as prior computing experience, and their interactions with the audio components of IMMI. This aspect of the investigation draws upon a co-relational model that is characterised by Cohen and Manion (1996) as a research method concerned with identifying the antecedents of a present condition. As its name suggests, it involves the collection of two sets of data, one of which will be retrospective, with a view to determining the relationship between them... in effect, researchers ask themselves what factors seem to be associated with certain occurrences, or conditions, or aspects of behaviour. (p. 146)

In the present investigation, "retrospective" data is obtained from a survey of participants’ previous computing experience. This "antecedent" information about prior computer usage is correlated with data obtained from the observational analysis of IMMI session sound activity to investigate possible relationships.

Cohen and Manion (1996) further identify the co-relational model as an *ex post facto* design and emphasise its value as an exploratory tool in fields where prior research is limited and where the relationships between variables are not well understood. *Ex post facto* investigations can give a sense of direction in a new field of research and provide a "fruitful source of hypotheses that can subsequently be tested by the more rigorous experimental method" (p. 153). Gall et al. (1996) likewise attest to the suitability of co-relational methods in exploratory research and maintain that such an approach is
especially useful in areas where little or no previous research has been done. According to Gall et al., one of the principal advantages of such relationship studies is that they permit the researcher to investigate the associations between several variables simultaneously. Tuckman (1994) agrees that "co-relational studies serve a useful purpose in determining relationships among measures and suggesting possible causality" (p. 161). He points out that while co-relational studies in themselves can not adequately establish causal relationships between variables they are a useful first step.

Current limitations in the understanding of how participants interact with sound in computerised instruction and the limited scope of existing IMMI research suggest that co-relational designs may prove beneficial in helping to establish links between key variables in these domains. For instance, the co-relational investigation of associations between participants' prior computing experience and their IMMI session sound activity may yield valuable insights into the effects of varying levels of computer expertise on IMMI music listening behaviours. Likewise, relationships between participant ratings of the IMMI programs and their session sound activity could be productively explored using a co-relational model. In the present study, the use of co-relational techniques to explore such relationships is intended to complement the case study approach that is at the core of the investigation.

Data Collection
Videotape recordings of the IMMI sessions, pre-session and post-session questionnaires, and follow-up interviews are the principal data gathering tools of this study. Information obtained from an analysis of the IMMI session recordings is used as a basis for the development of researcher-designed Sound Activity Profiles (SAPs) that offer a comprehensive description of participant sound usage in each of the study sessions. The two questionnaires gather background information about participant characteristics and
survey subject responses to the study sessions. Follow-up interviews document and clarify participant perceptions of IMMI session sound activity.

While the study design rests in case study and co-relational models, the development and implementation of data collection procedures draws upon previous studies of both music listening behaviour and participant interactions with the media components of interactive multimedia instruction. For example, early studies by Cotter and Toombs (1966), Cotter and Spradlin (1971), Greer, Dorrow, & Randall (1974), and Greer (1978) using analogue recording equipment provide a model for the direct assessment of music listening behaviours. Greer employed the *Operant Music Listening Recorder*, an instrument developed by Cotter to measure the amount of time subjects spend listening to self-selected channels of music. Greer's aim was to determine music listening preferences from an objective standpoint, based on direct and precise behavioural measures. As Hargreaves (1986) points out, reliable information cannot as readily be obtained using self-reporting measures such as participant interviews, because what subjects say about their musical preferences and their actual listening behaviour often varies considerably. Therefore, the present investigation employs direct and precise measures of listening behaviour, in the form of a computer-assisted observational analysis of session sound activity, in an attempt to provide an accurate foundation for the objective assessment of IMMI music listening behaviours. Comparisons between participant self-reporting and objective measures of IMMI music listening behaviour are also undertaken to assess the accuracy of participant perceptions of IMMI session sound activity.

During the design and development of the current data collection instruments, consideration was given to the procedures adopted in previous studies of participant interaction with the media components in interactive multimedia. Researchers have frequently used computerised automatic data collection techniques to document "audit trails" (records of the sequence of computer keystrokes) which can subsequently be
analysed to produce behaviour profiles for a group of interactive multimedia users (Bowers and Tsai: 1990, Schwier and Misanchuck: 1990, Beasley: 1992, Beasley and Vila: 1992, Misanchuck and Schwier: 1992, Horney: 1993a, 1993b, Berz: 1995, Jones and Berger; 1995, Beasley and Waugh: 1997). These exploratory studies have often investigated participant interactions with small "non-commercial" interactive multimedia programs that were designed by the researchers themselves.

While automated data capture through the use of audit trails delivers accurate and comprehensive information, it can present difficulties when investigating commercial interactive multimedia resources as software modification is often necessary to fully implement automated data collection. The modification of commercial software raises both logistical and legal difficulties which may constrain the research effort. An approach to data collection that circumvents the need for software modification has been adopted by investigators who use observational techniques, typically with the assistance of videotape recordings of computer screen activity, to document participant interaction with the media components of interactive multimedia. Leinhardt and McCormick (1996) attest to the advantages of using video recordings as they "allow the researcher to capture behavioural observations in a manner that enhances reliability of coding procedures and facilitates archiving and reanalysis of raw data" (p. 571). They report that the use of videotape recording in educational research has "dramatically improved" the capability for capturing subtle nuances in participant behaviours and note that videotape recording can facilitate "an extremely fine-grained level" of analysis of every component of an educational interaction. A study of children’s interactions with interactive multimedia programs by Plowman (1994) is typical of investigations that employ videotape as the principal data collection tool. Plowman used videotape to document both computer screen activity and the dialogue that occurred between children as they worked in small groups with an interactive multimedia program. Subsequent observational analysis of the videotape
recordings allowed Plowman to compare behavioural aspects of the children’s interactions with the multimedia programs.

While both automated and videotape data collection procedures are commonly employed in the investigation of participant interactions with interactive multimedia, most of the aforementioned studies have concentrated exclusively on visual elements. In contrast, the present investigation focuses on participant interactions with the audio components of interactive multimedia. Videotape recordings of the study sessions capture both sound and corresponding computer screen activity. When audio and visual records are analysed and reconciled it is possible to elucidate participant interactions with the audio components of IMMI and thus to characterise music listening behaviours. When the analysis of session sound activity is combined with questionnaire and interview data on participant characteristics and their attitudes towards the study sessions, latent relationships between session sound activity and participant attributes can be explored.

The following discussion describes the design and development of the data collection instruments of the present investigation and the procedures that governed their application in the study. The description reflects the two phases of the investigation: in the initial phase of the study, data was obtained from Session Video Recordings and two Questionnaires, while in the second phase, Follow-up Interviews were conducted.

**Session Video Recordings**

Videotape was the principal data gathering tool of the investigation. Each study session was recorded on videotape to provide comprehensive documentation of both computer screen activity and computer-delivered sound that would expedite subsequent analysis and cross-referencing. Video recording of screen activity facilitated the analysis of participant interactions with on-screen objects such as sound icons, while the audio track from each videotape recording was subsequently transferred to computer for analysis using digital
audio recording technology (Sound Designer: 1987). The Sound Designer analysis procedure is described in a subsequent section of this chapter.

To minimise the possibility that the videotape recording process might influence participant behaviour during the study sessions, cameras and microphones were not used (Leinhardt and McCormick: 1996). Instead, the recording was achieved through the use of the Apple Presentation System (APS). The APS can be used unobtrusively to transfer computer screen activity and computer delivered sounds to a videotape recorder. Whilst subjects were informed that their session would be documented, the recording technology was not apparent to the participant. As the schematic diagram of the study equipment in Figure 3.1 indicates, a screen was used to mask the recording equipment.

Figure 3.1 Schematic Diagram of the Study Equipment Setup

![Schematic Diagram of the Study Equipment Setup](image-url)
In order to deliver the best possible audio quality from the IMMI programs, the built-in sound capabilities of the Macintosh computer were rendered inoperative and high-fidelity sound reinforcement equipment was employed. A list of the equipment used in the study sessions appears in Appendix C.

**Questionnaires**

Data collected from the questionnaires was intended to complement information obtained from the observational analysis of IMMI session sound activity. Prototype questionnaires were developed by the researcher based on an assessment of related studies of sound use in computerised instruction by researchers such as Barron and Kysilka (1993) and Barron and Atkins (1994). Reports on the design and evaluation of instructional software by Blease (1986), Doll (1987), Hannafin and Peck (1988), Karat (1988), Allesi and Trollip (1991), Reeves (1992), Tessmer (1993), and McAteer and Shaw (1994) provided a further specific focus for the development of the questionnaire items.

Questionnaire One, which is shown in Appendix D, was administered immediately prior to the study sessions and sought demographic information relating to the study participants. It also surveyed the extent of participants' previous computer usage, their self-assessed level of computer proficiency, and their attitudes towards the use of computers in music education. The questions that related to previous computer use employed a "closed" structure which required participants to respond on Likert-type scales. A principal benefit of the Likert scale is that it allows respondents to quantify the relative value of objects and events relating to a given statement or question. The use of Likert scales in the assessment of attitudes, opinions, and participant characteristics is widely advocated (Abeles et al.: 1984, Oppenheim: 1992, Tuckman: 1994, Gall et al.: 1996, Burns: 1997). The design of the items used to assess participants' previous use of various types of computer software was influenced by the approach of Gardner, Discenza, and Dukes (1993) who measured the computer experience of subjects with a questionnaire that included several self-report
items which related to playing computer games, using word-processing software, data
analysis, writing computer programs and so forth. Responses to the self-report items were
aggregated to provide a composite "total computer experience" index. A similar approach
was adopted in the current study to measure the extent of participants’ previous computer
software usage.

Questionnaire Two, which is shown in Appendix E, was administered immediately after
each study session and focused on participants' experiences of the IMMI program,
particularly their attitudes towards session sound activity. The questionnaire consisted of
both "open-ended" questions that requested short written responses, and "closed" items
which required responses on a Likert scale. A principal advantage of open-ended
questions is that they place minimal restraint on respondents "facilitating a richness and
intensity of response" (Burns:1997:473). The open-ended and closed format items in
Questionnaire Two were intended to function as complementary data gathering devices.

A panel of experts with knowledge in the fields of questionnaire design, interactive
multimedia evaluation, and instructional design reviewed the prototype questionnaires with
the aim of enhancing their reliability and validity. Both questionnaires received a rigorous
critical evaluation based on expert analysis. This approach to questionnaire design is
consistent with the recommendations of Wiersma (1995) who maintains that the
continuing feedback provided by experts throughout the development process often leads
to a marked refinement of questionnaires. Questionnaires that had been modified
according to the recommendations of the expert panel were trialed on a group of
participants with similar characteristics to the population from which the study sample was
to be drawn. Responses from the pilot questionnaires were subsequently analysed and
further refinements to the question wording were made. The combined use of expert
review and pilot testing substantially enhanced the robustness of the study questionnaires.
The Session Procedure

The study sessions were held in a soundproof studio which allowed extraneous noise and interruptions to the sessions to be minimised. Upon arrival for individual sessions, participants were greeted by a supervisor and requested to read the proforma Participant Information Sheet (shown in Appendix B). The proforma outlined the session procedure and instructed participants to "explore" the selected IMMI programs, then detail their reactions to each program by completing a questionnaire. A non-specific session objective was chosen with the aim of allowing the inherent characteristics of the IMMI programs to operate without externally imposed instructional objectives. Having read the Participant Information Sheet, the subject was then asked to complete Questionnaire One. Following completion of Questionnaire One, the participant sat at the computer, where the supervisor checked that he or she was comfortable and satisfied with the placement of the computer keyboard and mouse. When the supervisor had set the timing and video recording devices in motion, the session began. At the end of the first twenty minute session, the participant completed a post-session questionnaire. Following this activity, the subject was again seated at the computer for a session with the second IMMI program. When the second IMMI session concluded, the participant completed another post-session questionnaire relating to that particular session. Upon completion of the second post-session questionnaire, the session ended and the supervisor thanked the participant for being involved in the investigation.

Supervisors were employed during the sessions as a means of minimising potential researcher bias. As standardised instructions were given in the Participant Information Sheet, conversation between participants and supervisors before the session was kept to a minimum. Supervisors were requested to avoid offering advice to the participants unless technical assistance was critical to the continuation of the session. During the sessions, supervisors left the study room. Subjects were informed that the supervisor would be
present in an adjoining room, but were asked to request assistance only if continuing the session became impossible.

To minimise the potential for bias as a result of novelty effects, tiredness, or from participants making comparisons between the two IMMI programs, the order in which the programs were delivered to the participants was alternated. Burns (1997) recommends this system of counterbalancing in the presentation of independent variables as a means of controlling for bias that may arise out of presentation order.

Follow-up Interviews
Sound Designer analyses of IMMI session sound activity revealed substantial variations in the extent of participant interactions with Music, Voice, and Silence. With the aim of identifying reasons for the observed variations, follow-up interviews were conducted with selected participants. The principal goal of these interviews was to encourage participants to identify and explain attitudes, behaviours, and cognitive processes which may have influenced their interactions with IMMI audio components. In particular, as substantial periods of Silence had occurred in many sessions, the interviewer sought to establish in what activities participants were engaged during these periods of Silence.

Participant selection for the follow-up interviews was undertaken in accordance with a purposive sampling procedure identified by Patton (1990:169) who suggests that "extreme or deviant case sampling" can be used to provide an understanding of more typical cases. Wiersma (1995) maintains that "the logic of a purposeful sample is based on a sample of information-rich cases that are studied in depth. There is no assumption that all members of the population are equivalent data sources, but those selected are believed to be information-rich cases" (p. 298). He reports that extreme case sampling is "a selection process that includes units so that differences on specified characteristics are maximised…" while “… typical case sampling takes the “middle road”, selecting units
that are considered typical of the phenomenon under study" (p. 300). Burns (1997) and Gall et al. (1996) confirm that both "extreme" and "typical" cases should be included as they complement one another, and each serves important and different purposes in qualitative research. By making comparisons between "extreme" and "typical" cases it is possible to determine the consistency or lack of consistency in the occurrence and character of an observed phenomena.

In the present investigation, extreme and typical cases were chosen on the basis of the results of a statistical analysis of data derived from the observational analysis of session sound activity. The four subjects selected for follow-up interview were as follows: one participant who registered the lowest amount of Silence in a study session, one participant who registered the highest amount of Silence in a study session, and two participants who registered an occurrence of Silence that was nearest the group mean.

As several months had elapsed since the study sessions, the researcher decided to employ a "stimulated recall" interviewing technique described by King and Tuckwell (1983). Stimulated recall involves the use of an original stimulus to prompt the subject's memory of an event. In the follow-up interviews, recall was aroused by screening a five minute segment from the videotape of a participant’s original study session. Immediately after the screening of the relevant segment, the subject was interviewed by the researcher in the original study setting. Burns (1997) recommends the use of a "focused interview in which a respondent is interviewed for about one hour on a specific topic, often to corroborate facts already gleaned from other sources. The questions are usually open-ended with a conversational tone" (p. 372). To minimise constraints on subject responses and to encourage forthright answers, the follow-up interview questions (shown in Appendix I) were framed in the open-ended style as suggested by Phelps (1980) and Gething (1995). Each of the follow-up interviews, which lasted for approximately one hour, was recorded on audio tape for subsequent transcription and analysis.
The IMMI Programs
As participant interaction with IMMI audio components is the principal concern of the current investigation, this examination of the IMMI programs used in the study will focus on the design and implementation of sound. While issues pertaining to the programs' visual components need to be addressed when considering their sound design, coverage of the visual elements is intended to facilitate understanding of how sound is implemented, rather than to provide an exhaustive analysis of the visual content of the programs. A discussion of reasons for the selection of the IMMI programs is followed by an analysis of the selected IMMI programs in which audio quality, program structure, and navigation features are examined in relation to the design and implementation of sound.

Selection of the IMMI Programs
The investigation examines participant interactions with two IMMI programs, namely, *Mozart Dissonant Quartet* (1991) and *Microsoft Musical Instruments* (1993) hereinafter referred to as MDQ and MMI respectively. These programs were initially considered for inclusion in the study due to their widespread market penetration, which was confirmed by their consistent appearance on the top-seller lists in trade publications such as *CD-ROM Professional* and *MacWorld*. However, widespread commercial acceptance was not the sole criteria for their selection. It was important that the selected programs should exemplify trends in contemporary IMMI software design. Critical reports by Berger (1993), Mainzer (1993), Nordgren (1994), Martin (1994), Singer (1994), and Farrington (1995) support the researcher’s contention that at the outset of the present investigation, the selected programs represented benchmarks in IMMI software design. The selected IMMI programs are representative of two approaches to software design that were commonly employed in early IMMI programs. The MMI program is essentially an encyclopedia of musical instruments that is enhanced with short audio excerpts and interactive multimedia links between related information. The MDQ program is typical of a class of IMMI software developed by companies such as Voyager and
Warner New Media that adopts a "tutorial" approach in presenting a musicological analysis of a composition linked to a CD recording of the work (Renwick and Walker: 1992, Berz: 1995, Nielsen: 1995). It is important to acknowledge that substantial differences in the design characteristics of the two IMMI programs mean that users are likely to interact with the audio components of each program in markedly different ways. For instance, sustained listening is limited by the universally brief duration of MMI Music examples, while MDQ users have access to more lengthy Music examples, which allow them to listen for extended periods. As such differences need to be considered in interpreting the results of the present study, further analysis of these differences now follows.

Comparison of Audio Quality in the Selected IMMI Programs

The IMMI programs that were used in the study are delivered on CD-ROM. CD-ROMs are capable of storing approximately 660 MB of digitised information which can take the form of images, sound, text, and so forth. Rumsey (1996) provides an explanation of memory requirements for the storage of digital audio at various recording resolutions. Digital audio data requires a considerable amount of storage capacity, and when recorded at standard CD audio quality (44.10 kHz, 16 bit, Stereo), a compact disc can store approximately 74 minutes of audio data. Lower recording resolutions (for example, 22.25 kHz, 8 bit, Mono), which deliver a mediocre sound quality, require considerably less storage space and can be appropriate where conflicting storage needs arise.

In addition to digital audio data, visual images and programming information must be stored on the CD-ROM disc. Image quality and size are proportional to memory requirements and high quality images require a considerable amount of storage space. Thus, image and sound quality need to be considered not only from the perspective of the artistic and instructional requirements of the context in which they are to be used, but also in relation to the available storage space. As the use of high quality sound may require
compromise on image quality or vice versa, program authors must decide how best to use the available memory space and what level of sound and image quality will suffice. Data compression techniques have been developed to minimise the amount of digital information that needs to be stored, but they frequently result in some loss of image or sound quality (Patterson and Melcher: 1998). Neuenfeldt (1997) reports that "fitting hundreds of samples of sound and music on a CD-ROM requires some compromise on sound quality...the level of compression necessary to accomplish this task, sometimes up to ten times, results in CD-ROMs having the approximate quality of radio" (p.61). While this lowering of sound quality is not obvious to the casual listener, experts "notice immediately that certain frequencies have been attenuated" (Neuenfeldt: 1997:61).

The amount of storage space devoted to images and sound differs substantially between the selected IMMI programs. For example, MDQ uses 4.1 MB of disc space for images and programming information. This relatively low allocation occurs primarily as a result of the MDQ program’s exclusive use of black and white images which occupy a very small amount of disc space. Thus, sufficient space remains on the MDQ disc to accommodate a CD quality audio recording of Mozart’s *Dissonant Quartet*. In addition to the complete quartet recording, the program offers narration, vocal responses are used in *The Mozart Game*, and short music excerpts are used for specific instructional purposes. Availability of the various audio components is summarised in Table 3.1.

| Table 3.1  Mozart Dissonant Quartet  - Summary of Sound Availability |
|------------------------|------------------|------------------------|
| **Music** | **Voice** |
| **Type** | **Time** | **Type** | **Time** |
| Quartet Recording | 27:53 | Narration | 24:10 |
| Music Examples | 20:18 | Game Responses | 1:00 |
| TOTAL MUSIC | 48:11 | TOTAL VOICE | 25:10 |
Analysis of MDQ audio components indicates that the program provides access to a total of 73 minutes of sound, comprising 48 minutes of Music and 25 minutes of Voice. Participants can listen to the entire 28 minutes of the quartet recording without interruption, and it is likewise possible to listen to 24 minutes of the narrative that accompanies the visual presentation in Mozart’s World without interruption.

In contrast to the relatively modest amount of disc space devoted to visual material for the MDQ program, MMI uses 138.92 MB of disc space for images and programming information. The use of a larger proportion of disc space for visual information reflects the MMI program's emphasis on colour graphics. The length of individual music examples and the number of examples required to fulfil programming needs also has an influence on the overall amount of memory required. Neuenfeldt (1997) reports that in view of the need for a balance between memory requirements and functional adequacy, the audio production team at Microsoft often restrict the music examples they use to a duration of between 30 and 90 seconds. In the case of MMI, such restrictions were needed to allow for the storage of at least 1500 music examples relating to more than 200 musical instruments (Berger: 1993). To accommodate so many excerpts, a reduction in sound quality (22.25 kHz, 8 bit, Mono) was required. An examination of the MMI disc indicates that audio components occupy 381.15 MB, while total data storage on the disc is 520.07 MB, which is approximately 130 MB less than its maximum capacity.

A comparison of the audio recording resolution used for each of the IMMI programs may help to illustrate differences in the allocation of CD-ROM disc space in relation to audio quality. As the summary in Table 3.2 indicates, the relationship between sound quality and data storage requirements is dictated by three key factors: Sampling Rate, Sampling
Resolution and the choice of either Mono or Stereo sound. Each factor has a direct influence upon the Memory Required per Minute of recording time.

Table 3.2 Comparison of Audio Recording Resolutions and Memory Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Microsoft Musical Instruments</th>
<th>Mozart Dissonant Quartet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Rate</td>
<td>22.25 kHz</td>
<td>44.10 kHz</td>
</tr>
<tr>
<td>Sampling Resolution</td>
<td>16 Bit</td>
<td>16 Bit</td>
</tr>
<tr>
<td>Mono/Stereo</td>
<td>Mono</td>
<td>Stereo</td>
</tr>
<tr>
<td>Memory Required per Minute</td>
<td>2.60 MB</td>
<td>10.33 MB</td>
</tr>
</tbody>
</table>

Note. kHz = samples per second, MB = megabytes

Sampling Rate refers to the number of times per second that the recording process captures the signal being recorded. Higher sampling rates produce superior quality recordings. Conversely, as Heid (1993) reports, lower sampling rates result in a "distorted recording that doesn't faithfully convey all the frequencies present in the original sound" (p. 443). While the MDQ recordings use the standard CD sampling rate of 44.10 kHz, the MMI recordings employ a sampling rate of 22.25 kHz. The reduced sampling rate of the MMI recordings is approximately half that used in MDQ, which leads to some attenuation of frequency response.

Sampling Resolution determines the precision with which the recording process captures variations in the dynamic range of the original sound. In this respect, the MDQ and MMI programs are equal as both employ a 16 bit sampling resolution.

Mono and Stereo refer to the process of recording or replaying sound in one or two channels respectively. Since twice as much information must be stored, the memory...
requirements for Stereo sound recording are double that of Mono recordings. Stereo separation adds a dimensional space to the recording and provides a more realistic sound than that of Mono recording. According to Neuenfeldt (1997), in order to make parsimonious use of the available data storage space, the Microsoft program designers (the team that developed MMI) adopted a policy of delivering sound in Mono. Consequently, an essential difference between the selected IMMI programs is that MMI provides Mono sound, while MDQ offers Stereo sound.

The Memory Required per Minute of recording time is determined by the interaction of the three aforementioned factors. The summary shown above in Table 3.2 indicates that the MMI audio recordings required 2.60 MB of memory per minute. This contrasts markedly with the 10.33 MB of memory per minute that is required for the MDQ recording. Thus, while the MDQ recording is of a substantially higher quality, its data storage requirements exceed those of the MMI recording by a ratio of almost five to one.

Another factor which may influence the quality of recorded sound is the fidelity of its original source. While many of MMI's music examples were recorded specifically for the program, a substantial number were drawn from a broad range of previously recorded material. As the fidelity of the original sound sources was inconsistent and frequently beyond the direct control of the programs' authors, the quality of MMI audio recordings is likewise variable. In contrast, the primary sound source in the MDQ program is a high fidelity digital audio recording of Mozart’s *Dissonant Quartet* that was made under consistent and controlled conditions. All the additional MDQ sound excerpts appear to have been recorded specifically for the program under the similar controlled conditions. Consistency in the recording process, the higher sampling rate, and the stereo recording techniques employed in the MDQ recordings resulted in sound quality that is substantially superior to that of the MMI recordings. It is important to emphasise, however, that the MMI program designers made an informed decision to allocate disc
space in such a way that sound quality was acceptable, while allowing for the provision of colour graphics.

Mozart Dissonant Quartet - Program Structure and Sound Design

The components of the MDQ program were assembled using a software authoring program called HyperCard (1987). HyperCard stores and organises the required information on a series of "cards" which can be linked by the software designer into semantically relevant structures (Wilson: 1991). The MDQ program contains 790 cards and employs an hierarchical structure that includes eight complementary sections, namely, (1) A Pocket Guide, (2) The Instruments, (3) Mozart's World, (4) Quartet Listening, (5) A Close Reading, (6) More Reading, (7) Glossary, (8) The Mozart Game.

When operating the MDQ program, participants move to the information of their choice by using a mouse to select options from one of the on-screen menus, or by clicking on "hotspots" or "buttons" on the computer screen that provide direct pathways between linked concepts. The MDQ program also provides a Navigation Palette, similar to the one shown in Figure 3.2, at the bottom of each screen.

Figure 3.2  MDQ - Navigation Palette

The MDQ Navigation Palette not only provides access to program navigation tools such as the table of Contents, but also offers control over the playback of the audio recording, which is often strategically linked to visual components of the program. For example, when the Play Through option is selected, the program plays the quartet recording and associated pages of visual information are paced to match to the progress of the audio
recording. Selecting Play This Card limits audio playback to the section of music that is associated with the information on the screen at that particular time. The Resume button operates in a similar manner to the pause control of a CD player. By clicking on this button, users can interrupt or reactivate playback of the audio recording. While users can exert a considerable amount of control over the presence of sound by using the controls on the Navigation Palette, the MDQ program occasionally initiates the playback of musical excerpts automatically. For example, the program automatically provides a musical accompaniment for the animated sequences that introduce sections such as The Instruments and Mozart's World. Users can, however, interrupt this musical accompaniment by clicking with the mouse.

The sound design of the MDQ program can be illustrated further in an examination of how the audio components are implemented in the following sections of the program: A Pocket Guide, Quartet Listening, A Close Reading, Glossary, and The Mozart Game. For example, A Pocket Guide, shown in Figure 3.3, provides a diagrammatic overview of the formal structure of Mozart's Dissonant Quartet.

Figure 3.3 MDQ - A Pocket Guide
Note. The Navigation Palette has been omitted to facilitate the current display. Users can listen to specific segments of the quartet in any sequence that they choose by clicking on text in the diagram that relates to the section they want to hear. The program can also be set to play through the entire work without interruption. As the quartet plays, the relevant section of the diagram becomes highlighted allowing users to follow the progress of the performance in relation to the structure of the composition.

The MDQ user guide states that "Quartet Listening uses musical examples to illustrate the inner workings of Mozart's music" (Winter:1991:7). The example shown in Figure 3.4 illustrates a typical Quartet Listening page where the instrumental parts of the quartet can be heard individually and in various combinations. In this way, users can listen to how the various instrumental parts contribute to the complete quartet sound.

Figure 3.4 MDQ - Quartet Listening
Finally, the coda of the slow movement demonstrates how fluid—even irrelevant—the boundary between theme and accompaniment had become. You may bring in (and remove) the instruments one at a time. All the voices are important, but each voice portrays a distinctive character and makes a distinctive contribution. This is musical democracy at work.

In a similar manner to *A Pocket Guide*, the section of the program entitled *A Close Reading* provides a structural diagram of a particular movement of the quartet. According to the user’s manual *A Close Reading* provides a "running commentary to the entire work" (Winter: 1991: 7). Figure 3.5 shows a page that describes the opening section of the quartet. On the right of the screen, a summary of the formal structure of the movement is given and the section that is currently sounding is highlighted. As listeners advance through the movement their progress is indicated on the diagram. A textual description of the work can be viewed either with or without the music playing. Listeners can move directly to other sections of the movement by clicking in the appropriate place on the structural diagram.

Figure 3.5 MDQ - *A Close Reading*
A Close Reading

MOVEMENT 1
Adagio [Very Slow]

Beginning with somber pulsations in the cello, the slow introduction stacks up dark dissonances in viola and violins that lead to a first crescendo.

Note: The Navigation Palette has been omitted to facilitate the current display.

A Quartet Glossary is available throughout the program. It provides definitions and musical examples that illustrate and explain terms used in the musicological analysis of the work. Activating the Glossary option from the Navigation Palette causes the program to underline terms that are defined in the Quartet Glossary when they appear in the on-screen text. Underlined text provides a link to a definition of the term. Figure 3.6 shows a typical Quartet Glossary page which offers an explanation of the term "Appoggiato". In this case, music examples illustrate the concept and by clicking on the appropriate button, users can hear a music excerpt played either with or without appoggiato.

Figure 3.6 MDQ - A Quartet Glossary
Figure 3.7 shows how *The Mozart Game* uses music examples to test participants’ knowledge of the *Dissonant Quartet* and the events surrounding its composition.

Participants listen to the *Question Passage* as many times as they wish and then register an answer by selecting one of the listed alternatives. Answers are assessed by the computer according to pre-programmed algorithms and feedback is provided in the form of *Wolfgang's Reply*. Wolfgang’s often humorous responses are spoken and also appear as text on the screen. Progress to the next question is contingent upon the participant entering the correct response. However, where an incorrect answer is given, participants can listen to the passage again before offering another response.

Figure 3.7 MDQ - *The Mozart Game*
The present examination of the design and implementation of sound in MDQ suggests that the program’s author placed a strong emphasis on music listening. The program encourages participants to interact with its audio components by offering a considerable amount of control over the playback of sounds through on-screen controls such as those found in the Navigation Palette. Sounds are sometimes automatically activated to underscore an animated sequence of visual events, but listeners are free to interrupt sounds which they find intrusive. Frequently, however, participants need to actively select sounds by clicking on the appropriate on-screen button. As all recorded sound takes full advantage of the digital audio reproduction capabilities of compact disc, the uniformly high quality of sound provided in MDQ further enhances its aural appeal.

Microsoft Musical Instruments - Program Structure and Sound Design

The information contained in the MMI program is organised in a hierarchical structure of menus and sub-menus. In addition to their structural function, these graphical menus provide access to the program content. Users can click on the pictures to access
information and listen to sounds by clicking on "speaker" icons which initiate audio
replay. A Navigation Palette, which is located at the top of each screen, provides another
means of accessing the program's information. A diagram of the MMI Navigation Palette
appears in Figure 3.8. Unlike the MDQ Navigation Palette, the MMI Navigation Palette
does not provide direct control over sound or immediate access to music examples.
Nonetheless, users can move to pages that contain sound icons by selecting one of its
options.

Figure 3.8  MMI - Navigation Palette

<table>
<thead>
<tr>
<th>Contents</th>
<th>Index</th>
<th>Back</th>
<th>Next</th>
<th>Random</th>
</tr>
</thead>
</table>

Clicking on the Contents option causes the program to display to the main Table of
Contents page. The Index option provides an alphabetical list of all of the musical
instruments that are featured in the program and direct access to a page devoted to each
instrument. Clicking the Back option prompts the program to scroll in reverse order
through all pages that have previously been visited during the current session. Selecting
the Next option causes the program to display program pages in a sequential order that
relates to the hierarchical structure of the Table of Contents. The Random option places
the program in a demonstration mode where pages are displayed in random order and
sounds are automatically activated.

Each time the MMI program starts, the Table of Contents appears which offers four
options, namely, Families of Instruments, Instruments of the World, Musical Ensembles,
and A-Z of Instruments. For example, when users choose Families of Instruments from
the Table of Contents, they may select The Woodwind family page shown in Figure 3.9,
which illustrates how related instruments are grouped for easy access. Similar pages exist
for other families of instruments and by clicking on the picture of an instrumental group
such as *Recorders*, users can move directly to a page which shows the various types of recorder and provides access to further pages that are devoted to each specific instrument.

Figure 3.9  MMI - *The Woodwind Family*

The *Instruments of the World* section of the program organises instruments according to the geographical areas from which they originate. For example, Figure 3.10 shows the *Central and South America* page. Participants can examine musical instruments from the perspective of their geographical origins. Sound icons provide access to short musical excerpts of between two and three seconds in duration that may encourage the listener to
explore a particular instrument in more detail. If participants want further information about a particular instrument they can access it by clicking on the appropriate picture.

Figure 3.10  MMI – Central and South America

The Musical Ensembles section depicts instruments in the context of the various ensembles in which they may participate. Figure 3.11 shows the Wind Bands page which lists examples of types of wind ensembles. Users can move to a page devoted to a particular type of wind ensemble by clicking on one of the options at the bottom of the screen. For example, the Wind Bands page offers links to pages that are devoted to the Marching Band and the Concert Band. Similar pages are provided for other types of musical ensemble.
To complement the menu structures that group related instruments according to families, geographical areas, and types of ensemble, musical instruments are also listed in the A-Z of Instruments. Users can scroll through pages that list the musical instruments alphabetically and which provide short audio examples of each instrument. Participants can move directly to a page devoted to a specific musical instrument by clicking on the appropriate picture. Figure 3.12 shows a typical A-Z of Instruments page.
Sound design in the MMI program can be further illustrated in an examination of how sound is implemented in pages devoted to instrumental groups and specific instruments. "Speaker" sound icons are located in varying places on the page according to the dictates of the screen layout. Pages that show groups of instruments often have multiple sound icons that provide access to brief audio samples of the instruments in a particular category. For example, Figure 3.13 shows the layout of the *Recorder and Related Instruments* page which is representative of many other MMI pages that show groups of instruments. By clicking on the speaker icon next to the name of an instrument, participants can hear a short "sound bite" of that instrument. By clicking on the picture of the instrument they can move to a page devoted to that specific instrument.

Figure 3.13  MMI – *The Recorder and Related Instruments*
The Recorder page shown in Figure 3.14 is representative of pages that are devoted to specific instruments. Specific instrument pages usually contain two sound icons, one of which provides access to a music example that is typically between 15 and 30 seconds in duration. The second icon allows users to hear a recorded voice pronounce the name of the instrument. In addition to the sound icons, pages devoted to specific instruments provide a detailed photograph with hypertext links to related information, which may contain further audio examples, and a textual description of the instrument. Links to additional information are often provided from a menu at the bottom of the screen.

Figure 3.14   MMI – Recorder
For example, a hypertext link to further information occurs with the text "Mouthpiece" as shown on the Recorder page in Figure 3.14. Clicking on the highlighted text causes the program to superimpose further information about the recorder mouthpiece as shown in Figure 3.15. The additional information usually provides more detail about a specific aspect of the instrument. In this case the mouthpiece is shown and sound examples are provided that allow the user to hear the recorder being played as a complete instrument and with the mouthpiece only.

Figure 3.15  MMI - Recorder Mouthpiece
Icons at the bottom of the screen sometimes offer access to a Sound Box which can be superimposed over the main instrument page. The recorder Sound Box is shown in Figure 3.16. While in the Sound Box, users can request the program to play individual notes within the range of an instrument. Another option allows participants to hear the complete range of the instrument. If the instrument is capable of producing special effects, such as double tonguing or multiphonics, further examples are often available for audition in the Sound Box. Music examples which place the instrument in the context of a variety of ensemble settings can also be accessed through the Sound Box. The recorder, for example, can be heard in an Orchestral or Chamber Music setting.
Another audio feature that is often provided is the option for users to "play" some of the musical instruments. The pictures of some of the instruments feature hotspots so that as the cursor passes over them, participants can click and "play" that part of the instrument. While basic, this option provides users with a novel way of interacting with the musical instruments. For example, the Two-Tone Block shown in Figure 3.17 can be "played" by moving the cursor from one end to the other and clicking to produce a differing pitch. Similar interactive playback facilities exist for other instruments.
Analysis of the design and implementation of sound in MMI indicates that the program provides a comprehensive range of music examples that encompass the broad range of featured instruments. Participants are offered adequate control over sound with on-screen sound icons. Automatic activation of audio examples is limited to the provision of a musical accompaniment for the title sequence when the program is first launched and when the program is placed in a "Random" demonstration mode. Most MMI pages offer at least one music example and many provide a pronunciation of the name of a musical instrument. The MMI music examples are universally brief, with the shorter sound "bites" lasting for between 2 and 3 seconds, while the longer music examples last for between 15 and 30 seconds. The sound quality of the MMI program has been attenuated to conserve...
disc space so that colour graphics and more than 1500 audio examples could be used. Limitations in the quality of the MMI sound recordings are especially evident when high fidelity sound reinforcement equipment is used for playback and where high playback volumes occur.

Data Analysis
The data analysis procedures of the present investigation are examined in relation to the dependent variables of the study, namely, (1) session sound activity as determined from an observational analysis of participant interactions with IMMI audio components, (2) the opinions and attitudes of participants as established from responses to the questionnaires, (3) an evaluation of participant interactions with IMMI audio components as determined by a reconciliation of computer screen activity with the corresponding sound track from the session video recordings, and (4) participant responses in the follow-up interviews. The discussion that follows outlines the procedures employed in the analysis of these dependent measures.

Analysis of Session Sound Activity – Sound Activity Profiles
To examine participant interactions with the audio components of the selected IMMI programs, the soundtrack from the videotape recording of each study session was digitally transferred to a Macintosh computer for analysis using Sound Designer (1987). Sound Designer is a digital audio recording technology that can display sound activity in a comprehensive and detailed manner. An overview of the capabilities of Sound Designer is provided by Yavelov (1992). The program is capable of producing graphs of sound activity that can facilitate the analysis of participant interactions with IMMI audio components. For example, Figure 3.18 shows Sound Designer graphs of audio activity during the first twelve minutes of two IMMI sessions. The graphs provide an overview of session audio activity which suggests that the occurrence of sound in Subject One’s session was more consistent than in Subject Two’s session. Sound Designer graphs that
depict IMMI audio activity provide a foundation for the Sound Activity Profiles which appear in the Results chapter of this thesis to characterise participant interactions with IMMI audio components.

Figure 3.18  Sound Designer Audio Activity Graphs

![Subject 1 - Microsoft Musical Instruments](image1)

![Subject 2 - Microsoft Musical Instruments](image2)

Note. The horizontal axis = session time, the vertical axis = sound measured in decibels.

While the overview of audio activity that Sound Designer provides is fundamental to the current analysis, the program’s capacity to facilitate a more detailed examination of audio activity is similarly crucial. The resolution of Sound Designer graphs can be varied widely, allowing sound activity to be represented in millisecond intervals if required. By adjusting the resolution to an appropriate level, Sound Designer graphs can be used to isolate and examine discrete segments of sound within an audio recording. For example, Figure 3.19
depicts a short segment of an audio recording with the display resolution in one second increments.

Figure 3.19  Detailed Audio Activity Graph

<table>
<thead>
<tr>
<th>Subject 3 - Microsoft Musical Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Audio Activity Graph" /></td>
</tr>
</tbody>
</table>

Note. The horizontal axis = session time, the vertical axis = sound measured in decibels.

The graph documents IMMI sound activity during a period of approximately three and a half seconds in which two audio events occur. In this case, the same sound occurred twice in quick succession. By facilitating such precise visual and aural comparison of sound activity, Sound Designer analysis can produce comprehensive and detailed documentation of the length and frequency of occurrence of segments of the audio components of Music, Voice, and Silence. In the current analysis, discrete segments of these audio components were labelled as distinct Audio Events. As each Audio Event can be identified, classified, and listed as a separate entity, it is possible to calculate the length and the number of occurrences of each category of Audio Event that occurs during an IMMI session.

As suggested by Tuckman (1994) and Gall et al. (1996), correlational procedures were used to determine the reliability of the Sound Designer analysis. The researcher’s coding and analysis of IMMI Audio Events were subjected to a test–retest protocol similar to that described by Athanasou (1997). After more than six months had elapsed from the time of
the initial Sound Designer analysis, the researcher re-assessed randomly selected segments from the study session recordings. Two parameters were specified for re-coding in the retest analysis, namely, the number of Music examples and the Amount of Music that occurred in each session. Results of the retest analysis were correlated with corresponding results from the researcher’s original analysis. As Table 3.3 indicates, the reliability of the researcher’s assessments was uniformly high on both parameters for each of the selected IMMI programs.

Table 3.3  Test – Retest Reliability of Audio Activity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Mozart Dissonant Quartet</th>
<th>Microsoft Musical Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of Music</td>
<td>r = .99</td>
<td>r = .99</td>
</tr>
<tr>
<td>Number of Music Examples</td>
<td>r = .98</td>
<td>r = .99</td>
</tr>
</tbody>
</table>

Statistical Analysis of Session Sound Activity and Questionnaire Data
Quantification of the duration and frequency of Audio Events using Sound Designer analysis provided a basis for the calculation of summary statistics relating to the occurrence of the audio components of Music, Voice, and Silence during the study sessions. Standard descriptive statistics such as the Mean and Standard Deviation are used to compare session sound activity. Summary statistics are likewise incorporated into the Sound Activity Profiles to complement the graphical representations of session sound activity.

Summary statistics were calculated for participant responses to the demographic items in Questionnaire One, while Pearson’s product-moment correlation analysis was employed
to investigate relationships between participants’ previous computer experience and the extent of participant interaction with IMMI audio components. In addition to summary statistics, the analysis of responses to the Likert-scale items in Questionnaire Two employed the student’s $t$-test to compare participant reactions to each of the IMMI programs. Differences in participant responses to the IMMI programs were considered significant at the $p < .05$ level. All statistical calculations were computed using StatView 4.5 (1994), while graphs relating to the results of the statistical analyses were prepared by the researcher using StatView and Microsoft Excel 5 (1996).

Reconciliation of Audio and Video Recordings of the Study Sessions

With the aim of corroborating and expanding upon the Sound Designer analysis of session sound activity and its associated summary statistics which were based exclusively on an analysis of the audio track of the session videotape recordings, the visual record of computer screen activity in each study session was reconciled with the corresponding audio recording. A principal concern of this further analysis was to determine the level of participant interruption of Music examples, while a related objective was to look for patterns in participants’ sound usage. Visual records of computer screen activity, including mouse activation of on-screen sound icons, were reconciled with session audio recordings to characterise participant activation and interruption of IMMI Audio Events more precisely.

A Likert-scale evaluation instrument, shown in Appendix H, was developed by the researcher for use in the analysis. The reliability of the analysis protocol was established in test sessions which involved the comparison of assessment responses from a team of seven judges, including the researcher. Judges viewed five-minute segments of the video recordings of selected study sessions and were requested to monitor computer screen activity in relation to its associated sounds. At the conclusion of each example, judges
were required to assess aspects of session sound activity using the seven item Likert-scale evaluation instrument.

Based on the recommendation of Tuckman (1994) who suggests that data from at least twenty percent of participants would need to be examined in any test to establish inter-judge reliability, the recordings of four study sessions were selected for use in the judge testing sessions. The selection of session recordings for use in the judge testing procedure was based on summary statistics derived from the Sound Designer analysis of session sound activity. Two participants whose Music usage in the sessions represented outlying values were chosen, along with two participants whose Music usage was representative of the group mean.

The Likert-scale inventory employed in the assessment procedure yielded data at an ordinal level of measurement. To establish inter-judge reliability in circumstances where subject numbers are small and data are collected at an ordinal level of measurement, Tuckman (1994) recommends the use of two non-parametric tests, namely, (1) Kendall’s Coefficient of Concordance and (2) Spearman’s Rank Order Correlation. Using procedures similar to those described by Hayes (1973), the Kendall test of inter-judge reliability was computed at $W = .75 \ (n = 7, \ df = 27, \ p < .000)$, while the Spearman measure of inter-judge reliability was determined to be $r_s = .88 \ (n = 28, \ p = .000)$. As reliability coefficients of between .70 and .90 are considered appropriate by Tuckman (1994) and Burns (1997), inter-judge reliability in the testing sessions was considered to be high. In view of the demonstrated consistency between the researcher’s judgments and those of other judges, and to expedite the investigation, further analysis and the reconciliation of audio and video recordings of session sound activity was undertaken by the researcher alone using the Likert-scale evaluation instrument.
Qualitative Analysis of Follow-up Interview Responses

Audio tape recordings of the follow-up interviews were transcribed and a qualitative analysis of participant responses was undertaken using a "lexical searching" technique similar to that described by Weaver and Atkinson (1994). The analysis involved a computerised search for "keywords" in the text of the interview transcripts. The selection of the keyword search terms was based in part on issues arising from the research reported in the Review of Related Literature and upon the results of a preliminary inspection of the interview transcripts by the researcher. The analysis procedure was facilitated by the use of a computer program entitled NUD*IST (1995), which was employed in the keyword searching of the interview transcripts (Weitzman and Miles: 1995).

The dynamic and emergent character of qualitative analysis usually involves the tentative selection of categories which are progressively refined (Bliss, Monk, and Ogborn: 1983). In the present analysis, keyword searching identified themes in the data that were distilled by the researcher until robust categories emerged. Common themes that emerged as the analysis progressed were subsequently used as a framework for presentation of the results. The final categories, which relate primarily to participant usage of IMMI audio components in the study sessions, are as follows: (1) Silence, (2) Control of Sound, (3) Quality of Sound, (4) Simultaneous Presentation of Information in Differing Sensory Modalities, (5) Instructional Advantages of IMMI, (6) Sound Design, and (7) Sound Use and Session Goals. The discussion of the results of the analysis is accompanied by summary tables that contain representative quotes drawn from interview responses.