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Hear3D: A Study Of Spatial Sounds Effect On Language Learning

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I certify that this dissertation which I now submit for examination for the award of MSc in Computing (Advanced Software Development), is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the test of my work.

This dissertation was prepared according to the regulations for postgraduate study of the Dublin Institute of Technology and has not been submitted in whole or part for an award in any other Institute or University.

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1   ABSTRACT

Spatial sound is the manipulation of audio to add the illusion of position to the source of the sound, i.e. making sounds seem to originate from behind you or from different points around a room. Headphones must be used to achieve the optimum level of 3D sound. At any time over half a billion people are learning languages with the aide of audio which is why and the study of the effect or potential effects that the spatial sounds have on language learning is particularly interesting. If the application of spatial sounds to educational audio clips could be shown to have a positive effect by, for example, improving the knowledge retention of the listener it could provide an interesting insight into future language learning course development. Equally, if the effect had a negative effect on the listener's learning capacity it could also provide guidelines for the creation of high quality educational audio content.

For the purposes of this dissertation Hear3D an application that enables 3D audio to be combined with language learning content was developed. A group of participants (users of Hear3D) applied individually chosen 3D positions to French language learning content in the form of a pre-developed language-learning module. The script was read by a French language teaching professional and, upon completion of the module (8-12 minutes approximately), the students' comprehension and knowledge retention was assessed through the use of a questionnaire. A second control group (non-users of Hear3D) also, completed the same module and were tested in the same manner. The results for the two groups were then compared in order to measure any impact of Hear3D on the users comprehension and knowledge retention. The results of this experiment showed that there was a positive effect on the Hear3D users knowledge retention and that this area merit further research.

Key words: *Spatial Sounds, 3D audio, Language Learning, Hear3D*

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLE

1. INTRODUCTION

1.1 Introduction To Hear3D

Currently millions of people are using audio as an aid to the learning of a second language, with companies such as Rosetta Stone selling over 60 million dollars in language learning audio based material in the second quarter of 2012 alone (2012, Rosetta Stone). Any research into the area of knowledge retention for language learning and the development of relevant systems/applications could be of great benefit. Not only could software assist in aiding the learning of new languages it could also potentially build future language learning material based on results from participants choices of sound sources. If it can be shown that a correlation does exist between the preferences in relation to sound source location and the ability to retain information, the potential for further research into psychoacoustic preferences would be indicated and the further refinement of audio applications should follow.

This research project focuses on the possible beneficial effects that spatial sounds could have on learning, particularly in the area of language learning. The project also attempts to build a picture of the user preferences of the different age groups with regard to audio positional preferences.

The experiment involved the development of a short French language-learning module including a general introduction, a short grammar section and an interactive listen and repeat section, which was developed and recorded with the assistance of a French language teaching professional.

This audio was then manipulated to the users preference using the Hear3D software; this was accomplished through the use of OpenAL and Java to add a 3D sound effect that added the illusion of position to the educational content. This was the core element of the Hear3D software which was then used to test the effect of spatial sounds on participants. A questionnaire was then built around the learning module, with one questionnaire being distributed to the 3D sound participants and another to the control group.

These questionnaires involved the testing of all participants in order to extract any effects that the audio processing had on the participants, with a focus on the effect that the spatialised audio had with regard knowledge retention, comprehension and interactive learning. The results of these questionnaires were then correlated to evaluate what impact the audio effects had on participants compared to the control group.

From the results pool, the effectiveness of the 3D sounds was evaluated and compared in order to measure their effectiveness and discuss areas of interest that emerged-especially the sections of the audio clip, where the spatialised sounds seem to provide a benefit to knowledge retention and comprehension. A picture was also built around different age groups' preferences with regards the location of the sound source for the educational content.

1.2 Background

The learning of a second language can, more often than not, be a tedious and time-consuming process. Most people in Ireland, for example, have experienced some form of second and third language learning in the educational system. Although there are no exact figures in circulation, estimations have been made as to how many people are learning a second language worldwide. It is predicted that Roughly 2.4 billion people (35% of the worlds population) have learned or are currently learning a second language (Beare, 2010). Figure 1 gives a breakdown as to what languages are being learnt.
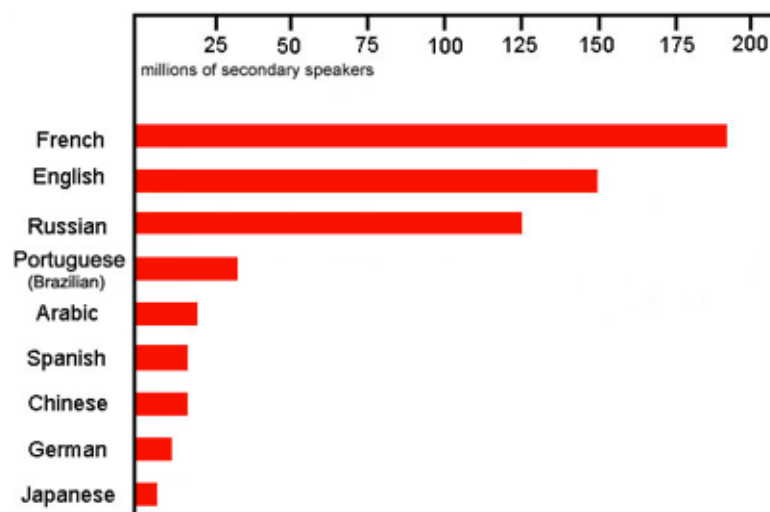
Figure 1.1: An Estimation Of Worldwide Second Language Learning

Although this may not a 100% accurate picture, due to the difficulty in documenting the wide variety of ways in which people are learning, it is safe to say that there are many people learning second languages. It is also safe to say that languages are studied for a multitude of reasons. With such a staggering number of people attempting to learn a secondary language anything that could be done to simplify or enhance this process of acquiring a second language and therefore increase the ease at which a student can learn would represent a huge potential for further study and software development   (with associated economic opportunities). This project attempts to identify the potential of audio in this regard.

This project discusses and draws together many areas of research in order to build a picture of where this study might be based placed within the literature strands. The four main areas of research of which this research is associated with are e-Learning, Language Learning, Spatial Sounds and Psychoacoustics. Through developing an understanding of these four areas it becomes easier to understand, evaluate and discuss this project.

e-Learning is defined as:

"The delivery of content via electronic media, such as the internet, video, interactive TV and CD-ROM. e-Learning encompasses all learning undertaken, whether formal or informal, through electronic delivery." (HEFCE, 2009)

This is an important background topic for this project as a picture of where Hear3D fits into modern e-Learning systems will be developed. Also, how such systems are assessed will be discussed in order to form a basis for the evaluation of Hear3D.

Language Learning or Second Language Learning is defined as:

"learning and acquisition of a second language once the mother tongue or first language acquisition is established." (Singhal, 2011)

The theory behind language learning and its history is also an important background topic to discuss in order to develop the project background. It also allows for the establishment of criteria for the development of the language learning content required for the experiment.

Spatial sound is defined as:

"the illusion of sound positioned anywhere in a sphere surrounding the listener: all points right, left, to the rear, above, below, or in front of the listener."

(Edifier, 2005)

The primary area of importance to the background of this project is spatial sounds, it is important to discuss this area to fully develop the thinking behind project. Factors effecting the efficiency of spatial sounds will also be discussed to form an understanding of what makes a good spatial sounds system.

Psychoacoustics is defined as:

"a branch of science dealing with the perception of sound, the sensations produced by sounds and the problems of communication" (CSA, 2008)

The final background discussion will be focused on the psychology of sound perception, it is important to develop this area in order to fully understand and appreciate the possible reasons for the results of the experiment.

Through combining a background study of these topics a basis for the understanding of the project material can be built for further discussion.

1.3 Research problem

3D audio is a form of audio modification which alters sounds to give them a sense of localisation i.e. sounds seem to move around a room. This experiment sets out to investigate if this audio effect contains the potential to be used as a tool to increase the capabilities of students to absorb information from educational content in the form of audio. This research was achieved through the implementation of an experiment involving a group of control participants and a group of experiment participants which utilised an application that was specifically designed for the experiment - Hear3D. These results were then compared and contrasted to build a discussion based on the results and the presented literature review.

The following are the 3 core research questions that are to be addressed:

What (if any) effect do spatial sounds have on language learning content when presented in an interactive environment?
What (if any) correlation emerges with regards to participants' audio positional preference?
For what reasons do participants choose their locations in the localised sound space?

These research questions poised some difficult problems to the analysis of the dissertation, firstly, a large literature review was required in order to maximise the efficiency at which the results could be discussed. Potential reasons as to the results had to be developed in a clear and appropriate fashion. The research questions also created a great challenge with the analysis of user preferences as often users of the software knew in their own minds why they chose certain locations but were often unable to formally express that opinion without some degree of discussion.

1.4 Intellectual challenge

The intellectual challenges of this project span many areas:

Audio Recording
The hardware setup and recording for the creation of the educational content provides a challenge as specialised computer hardware is required.

Audio Mastering
The mastering of the audio content involves many elements such as the adding of tones to signal user feedback and the removal of unwanted sounds and pauses.

Script Development
The development of the language script also provides a challenge as thought must be put into what questions are going to be asked in the questionnaires and the creation of questions in order to optimize the testing process.

Java Programming
The programming of the Hear3D application was a major part of the intellectual challenge as it involved the use of modern libraries (Java3D) which are not incredibly well documented and are still at a relatively early stage of development.

Background Research
The background literature review was also a time consuming and difficult challenge due to the limited studies involving spatial sounds currently on offer.

Conducting Experiment (Questionnaires & Software)
The conduction of the experiment also proved a challenge for some common research problems, such as the sourcing of participants and some software issues.

The challenges in developing this project were quite diverse and interesting, from the vocal recordings with hardware, to then mastering the audio with software and then custom application development using Java. All the tasks are quiet varied which will hopefully allow for interesting and fruitful discussion in later chapters.

1.5 Research objectives

The objective of this research is to identify the effects that soundscapes can have on learning when applied to language learning material. Through the use of questionnaires and audio clips, both with and without the spatialised sound effect applied, results will be drawn from the effects that the individually customised 3D spatialisation had on the participants ability to remember various aspects of the clips, as well as to what degree that the answers differ between the trial group and the control group.

The techniques that will be needed to create this experiment will mainly be Java programming as that will be the environment in which the effect will be applied to the educational audio. Through the users interaction with the software their choice of sound position will be identified and applied to the educational content in order to personalise the experience. This will also build demographics of preference with respect to spatial positioning preference.

This set of sound sources will then be compared in order to evaluate their effectiveness on the participants, and to determine if any one sound source has a dominant effect on the communication of the language learning material.

The following tasks must be completed to achieve these objectives:

- *Develop a language learning module*
- *Apply the sound source set-ups to the language module (Programming)*
- *Develop the module into an intuitive questionnaire (10 - 15 minutes)*
- *Measure the effect of the module through the results of questionnaires.*
- *Identify types of sound positional preferences*
- *Assess the effectiveness of the spatialised sounds on the knowledge retention by the participants, as well as any other impact that may have been observed during testing.*

1.6 Research methodology

Both primary and secondary research was performed for this project.

The primary research involved the testing of participants with the Hear3D software and questionnaires, the testing of the control group with the unaltered standard language module audio and the development of the language module script and audio.

The secondary research involved a literature review focused on the four main topics of the dissertation - e-Learning, spatial sounds, language learning and psychoacoustics.

The following resources were required to complete the project.
- Access to a French language teaching specialist - essential to audio content
- Access to a control group - essential to experiment
- Access to test participants - essential to experiment
- Personal computer and internet access - essential to all aspects of dissertation
- Access to library resources - both printed and electronic for research purposes

This project has two primary areas of evaluation - the assessment of questionnaire results and the analysis of the participants audio positional preferences.

The questionnaires were circulated firstly to the control group, then the control group questionnaire results were compiled in order to develop a baseline for comparison with the software test participants i.e. Hear3D users. Questionnaires were the primary medium for evaluating the effectiveness of the Hear3D system and particular focus was placed on evaluating the software effect on knowledge retention, comprehension, motivation and anxiety. The Hear3D effect on knowledge retention was assessed through the comparison of correct and incorrect answers chosen by the two groups. Details regarding comprehension were gathered through a variety of questions which were purposefully developed in order for the answers to sound similar. For example a question could read "the word for pen is?", and the series of answers could be 1) Stylo 2) Stylet 3) Styliste. By creating some question/answers in this fashion i.e. where the answers are phonetically similar there was an opportunity to test participants in a deeper fashion than the standard analysis of right and wrong answers.

The Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR) was adopted as a framework for evaluating the level of French language proficiency achieved. The CEFR ranges in level from A1 (Basic User) to C2 (Advanced User). Hear3D could assist users in achieving the first proficiency level.

The secondary area of evaluation is the analysis of user audio positional preferences. This component of the project can be assessed through breaking down participants' positional choices using different characteristics, such as, age and gender. These breakdowns can be plotted in diagrams in order to visualise a wide demographic of users preference and interpret the results much more efficiently. The evaluation also attempts to put forward reasoning's behind the results based upon the literature review.

1.7 Resources

There were two main branches of resources that were required for the development of this dissertation, which were namely, technical and non-technical.
Technical:

- Personal Laptop
- Internet Connection
- Microsoft Word
- Java Development Environment
- Audio Recording Equipment

Non-Technical:

- Language Professional
- Questionnaire and experiment participants

1.8 Scope and limitations

There are multiple components involved in correctly defining the scope of this project, firstly the scope of the educational content, secondly the scope of the Java development and thirdly defining the scope for the conducting of the experiment.

Educational Content

Although this content should be developed to as high a standard as possible and adhere to a framework for language learning material, it was not the primary area of discussion, this is due to it being the vessel for the spatial sounds capabilities and not the other way around.

Java Development

The scope of the Java development needed to be clearly defined with backup plans developed to avoid the occurrence of scope creep. At its initial requirement stage Hear3D was to allow for the customisation of audio content based on the users preference which is to be gathered from the software, then based on this preference educational content should be relayed to the user based on their interaction with the software.

Experiment

Research was conducted to decide the correct size for the experiment participants groups, this was done to have a clearly designed and efficient scope to the size of the experiment.

These combined factors allowed for a scope to be outlined for the primary aspects of the research undertaken and the creation of what deliverables are to presented at the end of this research process.

- Literature review based on the relevant background topics
- Development of experiment, which comprises of:
    o Development and delivery of French language module
    o Development and testing of deliverable software – Hear3D
    o Development and circulation of questionnaires to two groups of participants (control group vs. test group)
- Discussion and conclusion based on the results of all the above.

1.9 Organisation of the dissertation

Chapter two is the first of four chapters of literature review, with the first chapter focusing on e-Learning. In this chapter, various approaches to e-Learning are discussed before moving to e-Learning for language learning and then to design elements of e-Learning systems before finally concluding the chapter with a discussion of evaluation criteria for e-Learning systems and common pitfalls to be avoided during the development of such systems.

Chapter three is a discussion on digital signal processing and spatial sounds, with an overview of the subject being given before drilling down to the discussion of spatial sounds. This discussion will then be expanded to discuss current work with spatial sounds and their application to real world systems and environments.

Chapter four focuses on language learning. Firstly, a history of the various techniques of language teaching will be discussed. The techniques that involve the use of audio will be evaluated before an analysis of the principles of language learning is outlined. The chapter ends with a discussion on the measurement of language learning and language skill acquisition.

Chapter five examines the psychology behind hearing (psychoacoustics) and its impact and relevance is to the Hear3D experiment.

Chapter six represents the core area of discussion - a detailed analysis of all tasks that were undertaken will be outlined at length in this chapter. The challenges this audio development, script development, application development and the conduct of the experiment presented will all be examined in this chapter.

In the final chapter seven an analysis of the experiment results will be given, the contribution to the body of knowledge will also be given in the final chapter and areas for further research are indicated.

2. E-LEARNING

2.1 Introduction To e-Learning

e-Learning refers to the use of technology in any form as an aide to learning. Its origins lie in a study conducted by Stanford University in the 1960s where computers were used to teach elementary students reading and math (Nicholson, 2007). e-Learning has come a long way since the 1960s and is currently a $48 billion market (European Commission, 2008). Most learning institutes have incorporated some form of e- learning into their programmes. Web courses is now, for example, one of the many tools available to DIT students, and allows students to upload homework, view lecture notes and contact lecturers.

Institutes such as the Open University enable students to earn a degree without having to physically attend at the college - all material is covered through e-Learning systems that rely heavily on social networking tools for communication between students and lecturers. High-end graphic design software is, also, used to create instructional DVDs. This form of education illustrates some of the ways in which recent developments in technology are already being used to further enhance e-Learning systems through the use of most forms of social networks, use of Skype to contact tutors for help on a certain question or to post a blog outlining the parts of course students find difficult to understand.

e-Learning has also been rising to prominence with its ability for electronic assessment (e-assessment), where sophisticated new systems allow for online assessment through the use of multiple choice testing (Biernbaum, et al., 2006). In addition, such systems can point students to gaps in their knowledge that the system has established from the students' correct and incorrect answers. Similar systems are now in place in Ireland for the driver theory test.

e-Learning systems can be broken down into 3 core system designs as defined by the OECD (OECD, 2005) which are as follows:

Web-Supplemented

Supplemented courses are focused on classroom learning but aides are available online e.g. course notes, links to email addresses and links to other online resources.

Web-Dependent

Web-Dependent courses require "the use of the internet for key elements of the programme". These elements range from online project work to collaboration boards. The classroom time is not significantly less than the web-supplemented approach.

Mixed Mode

Mixed mode is a combination of the Web-Supplemented and Web-Dependent approaches, but "e-Learning elements begin to replace classroom time". These elements are similar to the first two approaches above with a mixture of online assessment, project work and discussion.

2.2 e-Learning Content And Delivery

When developing an e-Learning system it is important to consider the approach to content delivery in order to maximize the effectiveness of the content. The four primary approaches to educational content tailoring, are outlined below.

Computer-based training (CBT)

CBT is a form of self-paced learning accessible on your computer or handheld device through a download or CD-ROM (Kasten, Stefan, Wolfgang and Bernhard, 1998). This means that CBTs are available without the Internet being a core requirement in order to study, but the assessment sections of these courses generally require Internet access as a prerequisite. CBTs educational content are typically laid out in a similar fashion to a school or college text book with each individual topic getting its own chapter. There are specific advantages to this approach over the traditional approach as information can be conveyed to the student in more interesting manner with the use of animations, videos and audio. However, there are disadvantages associated with

such systems as problems can arise due to a lack of human interaction, which can provide motivational issues for the student.

Computer-based learning (CBL)

CBL is the use of computers as a key component of the educational experience. Although this may allude to just the use of computers in a class, it is generally more known for the use of computers within a structured course with the computers being used for a teaching purpose. This means that rather than the computers just being there for some tertiary teaching requirements, they are the essential core to the primary focus of the course.

Technology-enhanced learning (TEL)

TEL describes the enhancement of any learning or learning activity through the use of technology. This is an incredibly broad design area allowing for many avenues on content or learning development. An example of the diversity of TEL can be found in the Games And Learning Alliance (GALA) where games are used and developed as learning aides.

Computer-supported collaborative learning (CSCL)

In more recent times CSCL is discussed as the most promising approach to e-Learning with the use of cutting edge communication and information technology. Most of the recent advancements in CSCL have fallen under the heading of e-Learning 2.0, but the concepts developed within CSCL have existed much longer. CSCL's focus is on the encouragement of students to work together and collaborate in order to complete learning tasks. Wiki's, Blogs and Google Docs are examples of mediums for CSCL. By creating a collaborative arena for learning a learning community is developed which encourages students to learn more and to learn from each other and, through the use of web 2.0 tools, the collaboration can be enhanced further allowing for students and teachers to discuss ideas, hold meetings and pursue course topics online.

Hear3D could fall under the heading of TEL since Java technology is being used to enhance a relatively old language teaching technique in order to increase the students ability to comprehend the content, However it might be more appropriate to classify Hear3D as a learning object.

A learning object as defined by the (LTSC, 2002) is "any entity, digital or non-digital, that may be used for learning, education and training". The main difference between a learning object and the approaches discussed above is that learning objects are not based around the traditional hour or so classroom routine, instead they provide bite-size reusable tools and lessons. A set of characteristics have been outlined in order to identify the four key components of learning objects (Cisco Systems, 2000) which are:

Reusability

This means that the learning object can be used across multiple systems under different circumstances. In the case of Hear3D this would be valid as the software could be used for other languages and offers a certain degree of reuse.

Aggregation

This is core to learning objects its premise is to allow a learning object/objects to be built into a collection in order to form a bigger system such as an entire course. This also applies to Hear3D as multiple lessons could be run through the software for the creation of a language course.

Self-Contained

This characteristic can be considered the mantra of learning objects in that they work on their own without the need for any other form or content - particularly relevant to Hear3D as no other educational content is required.

Time

As discussed above, the time involved in utilizing a learning object is much smaller than the average e-Learning approach. This is the primary focus of a learning object and Hear3D conforms with this characteristic.

It is important to discuss Hear3D's position within the realm of e-Learning in order to clarify what its purpose is and in what form and way it will attempt to convey its educational content.

2.3 e-Learning For Language Learning

Since the advent of e-Learning systems there have been many examples of combining e-Learning and language learning. One such system was developed by the Stanford Learning Lab through the use of Mobile Phones (Brown, 2001). Sanford students were able to take quizzes, translate words, practice new words and save vocabulary to their notebook all from their mobile phone.

What the developers found was that although the technology was not perfect, the system did in-fact increase motivation due the ease of access to the content. Language learning has also been combined with the medium of phone SMS in order to teach students Japanese (Thornton and Houser 2005). In this case the lecturer texted the student 3 times a day with a short lesson in vocabulary and these students were then tested bi-weekly against other students using the mediums of paper and email. It was found that students receiving their lessons on their phones improved their scores twice as much as those using paper and increased their proficiency in grammar twice as much as the students using emails.

Another example of an e-Learning system for language learning was conducted by (Felix, 2002). This study involved over 100 participants using an online language-learning course. In order to evaluate e-Learning's viability as a medium for language learning, this system involved a comprehensive language course and was delivered through the use of a web browser. It was discovered at the outset that most students felt more comfortable with the technological environment and enjoyed the experience more than the usual classroom routine - 17% did feel uncomfortable using the system

at the beginning of the study. As the experiment progressed they found that students found the material more effective and useful in its e-Learning format as compared to the traditional classroom format. The study goes on to state that the participants' newfound motivation could be linked with the "fun" and interactivity of using a computer over the usual classroom technique. Fun and interactivity are therefore important factors to take on board when developing systems as fun and interactive content is much more invigorating than bland mundane repetitive classroom drill exercises.

A final example of an e-Learning language learning suite can be found in "Language Online" (Chenoweth, 2006), an experiment undertaken by the Carnegie Mellon University. This course was used to teach French and Spanish at an elementary and intermediate level. The rationale behind the development of this course was to allow students with less available scheduled class hours to take some level of foreign language course. The course took on the format of a CBL, the class met once a week in person for an hour and other than that the course was all web and computer based.

The core of the course work involved reading notes, completing check sheets and written assignments to be submitted via email. The CBL course was measured against another non-web based courses running concurrently with the CBL - these classes met three times a week for 50 minutes and were required to buy a textbook. It was found, based on a comparison of exam results related to listening comprehension, vocabulary and reading, that the offline and online course were comparable, showing very little difference even in areas such as speech which one would imagine would be worse amongst the web based learners due to the lack of human interaction. This illustrated an interesting point that a lack of face-to-face contact might not necessarily lead to a lack in the level of education received.

2.4 e-Learning Design Elements

When developing an e-Learning system it is imperative to bear in mind the criteria by which the completed system would be evaluated. Such a set of criteria are outlined by (Moses, 2008) which allows for the pre and post evaluation of a system design. These criteria are as follows:

Content

Accuracy of content, relevance of content, clarity of presentation, suitability of difficulty to the students, allows for students to reach their learning goals, freedom from punishment for spelling and grammatical mistakes.

Media

Clarity of presentation and graphics, videos and audios are easy to understand and are utilized in an apt manner.

Activities

How challenging, interesting and appealing the activities involved are and how much this content caters for different learning styles. How much these activities aid in helping the students to reach their learning objectives.

Navigation

How intuitive the system navigation is, how consistent the locations are so that students know what to expect and where it can be found. Allowance for students to move at their own pace and to move between sections as freely as they wish.

Overall Appearance

Layout and design consistency throughout, simplicity and effectiveness and use of contrasting colours to make text clear and readable.

Technicality

What degree of difficulty is involved in the setting up of the system i.e. required 3rd party plugins or software requirements.

Testing

Are there appropriate testing mechanism in place in order to measure the students achievements. What form of feedback is relayed to the student, is this feedback giving the student any useful information. Are there enough exercises for students to practice before taking a test.

Through developing a familiarity with these criteria, a more effective software system can be developed as it gives developers an idea of how the end product will be evaluated and assessed.

These were of particular relevance to the development of the Hear3D software as it gave a glimpse as to what would be expected from the completed program before beginning its development.

These evaluation criteria can be used in the discussion the experiment to build a picture of how well Hear3D stacks up within each criteria, although every evaluation criteria is not relevant, there is a well laid out set which should be sufficient in order to discuss and evaluate Hear3Ds efficiency as a learning object.

When developing an e-Learning system it is also important to understand what makes up a good e-Learning ecosystem (Dillon and Hallett, 2001). A good ecosystem is based around 6 core elements, some of which have been touched upon earlier in this paper.

Firstly, the e-Learning must be web based; next there must be an online source for notes and learning material (Online University); there must also be learning objects present to aid in Learning; there also has to be some form of performance analysis, be it questionnaires or assignments; next there should be some form of collaboration, this could be collaboration with a teacher or collaboration with other students; and the final element is the presence of an intelligent search mechanism, this search should allow easy retrieval of any of the course learning objects or material relevant for the course. Figure 2 illustrates one such ecosystem.
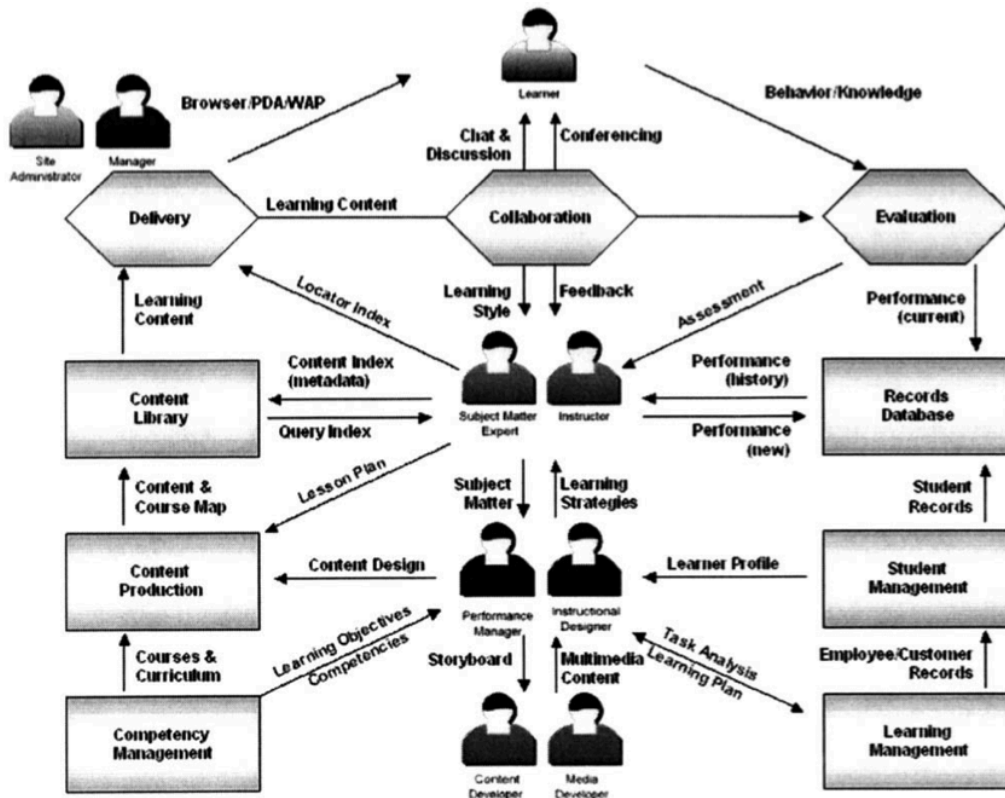
Figure 2.1: Example Of e-Learning Ecosystem

The development of Hear3D could be viewed as a learning object for such a system, allowing it to seamlessly adapt to a learning environment as long as a healthy e-Learning ecosystem has been established.

The development of an ecosystem brings many advantages to an e-Learning system. It allows developers to systematically design and code the system while maximizing interoperability with other third party applications and learning objects. It also affords developers more time to decide what applications are to be developed/acquired as they build the backbone for the system which leads to a better level of decision-making.

2.5 e-Learning Issues (Pitfalls)

A great deal of e-Learning systems do not reach their full potential due to the fact that they fail to achieve basic educational goals and objectives. This can happen for a host of reasons but one of the main errors made is the lack of creation of clear and measurable objectives and a strategy to convey these objectives (Ishmail, 2002). The design of such a strategy is an important factor in the success or failure of an e-Learning system. McGraw (McGraw, 2001) discusses the primary factors that should guide the creation of such a strategy.

1.A common vision as to how to describe e-Learning for the organization and its relationship with business/educational needs.

2.The development of an organizational support plan for the e-Learning system along with the development of policies of use for the system.

3.The development of content that allows for learning to be engaging, compelling and relevant to the needs of the users and the organisation.

4.Support for different learning profiles, (e.g. part time students or full time students) and long-term goals for these profiles.

5.A "standard-driven architecture" which is capable of integrating with existing systems and will not hinder or impede existing systems within the organisation.

In order to build further on our overview of pitfalls with regards developing an e-Learning system rather than just a strategy, the digital learning studio (Tribal Digital Learning Studio, 2011) discusses 5 pitfalls and how to avoid and limit their threat.

The right subject matter, but wrong learning

This means that, in general, how information is structured does not necessarily carry over into how the learning is structured. So, in other words, acknowledge how the learner is going to approach this content, which topic would make the most sense to start with or which topic would be the easiest in order to ease the students into the content.

There are three primary structures for digital content. Firstly, scenario based learning which involves teaching the student with the use of a real world situation or event as an aid. The next method is "just in time learning" which involves making small chunks of information and learning available to students whenever or wherever they want. The final method is "courseware". This is usually found in the form of short modules based on a topic but accompanied by additional background reference material which is made available to the students if they want to delve into the topic further.

Wasting digital opportunities

Wasting digital opportunities is all about not maximizing the use of the digital environment or even misusing the digital environment. Although this covers a wide range of topics some common themes are the use of audio, special effect and video. While these aides can be engaging, entertaining and educational, the complete opposite can also be the case. A great deal of thought should therefore be put into what audio/visual elements should be incorporated as they can be just as distracting as they can be useful.

Accessibility and Usability

Accessibility and Usability deals with making your program as user friendly as possible and making sure not to punish the user for making an error. Many safeguards can be put in place in order to maximize usability - even simple things like allowing for multiple screen sizes and storing course data in a variety of formats.

Excluding your champions

This is about ensuring you empower rather than exclude your teachers and tutors. Allowing teachers to maximize their input is a major factor in a good e-Learning system the teachers must also be trained on how to utilize the system and its potential to help them teach their students. Another important knock on effect from empowering teachers is that it will keep the coursework up to date rather than limiting the content to developers initial learning system content.

Protection from the unknowns

Planning ahead is key to avoiding the unknowns. Bearing things like platform in mind for example would be one discussion, even if the system is desktop based are there plans in future to release on handheld devices and if so how can we tailor the development as to not impede the development of such a system.

Through analysing these principles it builds even further on the evaluation and development of Hear3D and how it should and shouldn't be developed. It also gives valuable insight into how e-Learning systems and objects should be created in order to maximize their effectiveness.

Within the realm of e-Learning Hear3D would be classified as a Technology Enhanced Learning Object, it combines elements of TEL systems and learning objects forming a hybrid object that can be used as part of an e-Learning Suite.

2.6 Conclusion

This section started with a brief history of e-Learning. Next a discussion was formed on the various techniques for the delivery of e-Learning systems. Design elements that are important to e-Learning systems were then examined along with an analysis of some e-Learning systems that have been developed for language learning. The section was then concluded with the examination of common issues with the development of e-Learning systems.

3. **DIGITAL SIGNAL PROCESSING (DSP) AND SPATIAL SOUNDS**

3.1 Introduction

Digital signal processing, like so many other technologies, has its roots in the Second World War. World War II engineers and technicians discussed the application of digital techniques to accomplish signal-processing tasks. During the 1940s, a group of researchers, led by Shannon Bode at the Bell Telephone Laboratories, theorized the possibility of using digital circuits to accomplish basic filtering functions. At that time, there was no appropriate hardware available to accomplish this task which is why analogue techniques remained the prevalent option at the time. During the 1950's the theories behind digital signal processing were built upon further by Professor Linville at MIT and experiments were conducted at a very basic level as technology was still not at a sufficiently advanced stage to develop a fully digital system (Stranneby and Walker, 2004).

It wasn't until the dawn of the silicon chip in the 1960s that the discipline of DSP really began to gain momentum. The creation of these chips allowed for a complete digital system. It was, also, during this time that real advances in the field were beginning to emerge - in Bell Laboratories experiments were underway that discussed algorithm on the design of digital signal filters and as chips began to become cheaper and more mainstream DSP emerged as a fully-fledged discipline.

DSP is now a significant field in advance software development with large amounts of research being conducted in many of its sub-domains. In general, DSP now deals with audio such as speech, but processes such as sonar, radar and digital image processing all fall under the umbrella of DSP.

The processing associated with DSP can be accomplished with generic computer chips, but for real time digital signal processing a DSP chip which is specifically manufactured for signal processing is required. These chips differ as generic chips that process data such as words only re-arrange stored data while DSP chips are optimised for mathematical operation algorithms that are crucial to DSP such as filtering (Smith, 1997).

3.2 Digital Signal Processing Overview

DSP focuses on the processing of a sequence of numbers known as a digital or discrete time signal (see figure 3) in order to improve or alter it in some way. This discrete time signal is usually created through processing an analogue signal. These discrete time signals need to be processed in order to analyse, convert or display the information contained within the signal. Converters such as Analogue-to-digital (ATD) take the real world analogue signal and transform it to the 1s and 0s of a digital signal; from here a digital signal processor takes over and captures the digital information and begins processing it; and it then feeds the processed signal back (after its alteration) for use in the real world, this can be done through another converter known as a Digital-To-Analogue (DTA).
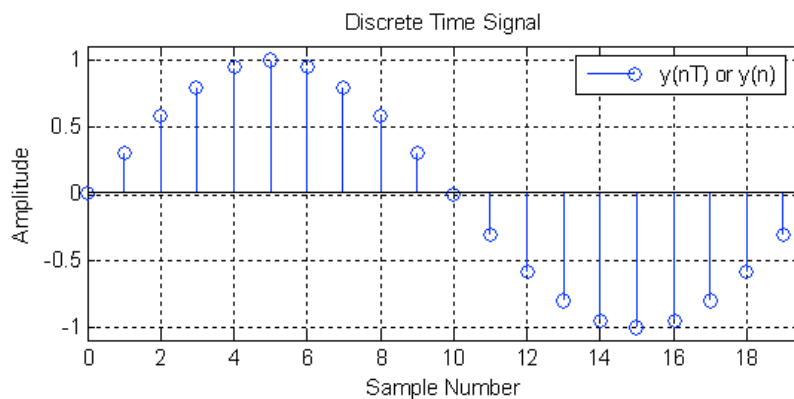
Figure 3.1: Example Of A Discrete Time Signal

During the signal processing in the digital signal processor, a number of manipulations take place. One of the most basic forms of manipulation is filtering. Digital filtering deals with processing a piece of a discrete time signal in order to reduce or enhance certain aspects of the signal (Smith, 2007). Anything that modifies the signal in some way is a filter. So in the domain of audio, a crude example would be that a speaker cable is not a filter but the speaker itself, as all speakers affect the sound in a different way, is a filter.

DSP is a complex and incredibly mathematical based subject, without digital signal processing many of the tasks we do daily would be unachievable. For example MP3 players cannot function without DSP they require it in order to produce and store audio information. DSP is also used in televisions and particularly in HD television

sets where many image processing techniques are used. Digital image processing can be seen as the sub discipline of DSP specifically dealing with the two dimensional image signals.

DSP has also found significant usage in the telecommunications industry where DSP techniques are used in almost every phone call for echo cancelling and equalization. Furthermore, the advent of mobile phones has brought even more uses for DSP - functions such as speech coding and in particularly cryptographic uses such as voice scrambling.

Finally, modern day cars literally would not start without the DSP controlled ignition and injection systems now found in most modern cars. Staying cool would also prove difficult without the heavily DSP entwined climate control systems and car accidents would also be more prevalent without the countless safety features implemented using DSP such as intelligent suspension systems, Anti-Skid systems, four wheel drive systems and airbag deployment control.

3.3 Spatial Sounds (Also known as: Soundscapes, 3D sounds)

On a daily basis sounds inform us of many things going on around us. From the rustling of leaves in the morning to the noise of the owls at night, we perceive all of these sounds in three dimension (3D) as opposed to when we listen to our music in our headphones which seems very "flat" in comparison (2D). In our natural environment we react to these sounds in different ways and, since it is in 3D, it offers us the advantage of potentially delivering information regarding real events such as the location of the sound or how far away it is. This could lead us to believe that humans extract and prefer more information when it is conveyed in a 3D form (Demarey and Plenacoste, 2010) Spatial sound is the manipulation of audio for the purpose of adding the illusion of position to the audio source i.e. making a sound appear like it is happening behind you or a conversion from 2D to 3D.

Headphones are essential to the creation of this illusion and specialised equipment is required to create the effect until the recent development of some Java libraries.

Simulated spatial sounds have their history in gaming, in particular the video game Super Street Fighter II. This game developed some of its soundtrack with theories of spatial sound, particularly the method of placing the sound outside the stereo bias (a basic version of surround sound). The National Aeronautics and Space Administration (NASA) developed the first system which made use of high precision real time 3D sounds. NASA developed a system for astronauts on spacewalk missions (missions outside ships hull). In particular, the system was used for astronauts repairing satellites as these astronauts needed to be in constant contact with many different personnel that were providing mission critical information.3D sounds were utilized in order to spatialised the different personnel around the astronauts auditory field with the goal of making it easier to distinguish what member of personnel was speaking. So, for example, mission control could have been spatialised to the front, another astronaut could be spatialised to the left and the pilot could be spatialised to the right.

Around the same time as the development of NASA's 3D system the market began to flood with technologies calling themselves 3D audio. Most of these technologies were cheap ineffective 3D audio systems and, because of this, the potential of 3D audio systems were muddied due to an unclear image as to the effects that true 3D audio can have (Ausim, 2004).

There are numerous ways in which 3D effects can be created and there are many levels as to the effectiveness of each technique. One of the most effective (and most expensive) techniques is the use of binaural recordings. Binaural recordings is accomplished using specialised microphones that act as a set of recording ears, two microphone inputs are spaced apart to the same distance that separate ears on a human head, through doing this and splitting each signal to the left and right side of headphones a very effective and engaging technique can be achieved.

Within the realm of programming packages, the best of the freeware options is considered to be Java3D (Sheridan et al., 2004) as it achieves the best level of realism as compared to other freeware packages. However, Java3D is still in its infancy and, as such, still remains in the shadow of much more advance and expensive specialised 3D libraries such as MorrowWind3D or QSounds.

There are many important factors to keep in mind during the design of any soundscape experience. The spatial sounds must be designed in a manner that must not overwhelm users with sounds from too many locations; the effect should not take the users attention away from the content being presented, but rather reinforce the content without creating annoyance.

Annoyance is the overall evaluation of disturbances and unpleasantness with a focus on negative feelings evoked by noise. This must be borne in mind when developing soundscapes as annoyance should be avoided at all costs to stop any negativity in the learning experience. A study of annoyance in spatial sounds showed that multi-directional soundscapes (more than one source) created a far higher level of annoyance than uni-directional sound sources (one source) (Genuit and Klaus, 2006).

This will be an important consideration in the development of Hear3D as keeping annoyance to a minimum will ensure an effective communication of the language learning content.

The design aspects on how to best implement soundscapes have been discussed in various papers. The process is considered by (Cohen And Ludwig, 1991) as only partially completed on applying spatial sounds to any audio clip. The other important aspect is filters such as reverb and equalization in order to give a *fuller* audio experience, their guideline on the use of filters is that "the idea is to create a just noticeable but ignorable, unambiguous but un- intrusive" (Cohen And Ludwig, 1991) addition to the sound clips so that they do not sound flat after being converted to a spatial audio file.

3.4 Application Of Spatial Sounds

Much research has been conducted in the area of using 3D sounds as a medium for educational content, particularly to aid people with visual disabilities. The systems that have been developed are usually implemented using a "feed-forward to feed-back loop" (Brooks and Petersson, 2007) this means that the user performs some form of action (feed-forward) and is given some form of response (feed-back) e.g. AudioChile (Sanchez and Sáenz, 2006) illustrates the benefits of using 3D sounds for education with the use of a joystick to teach children with visual impairments about Chilean

geography and culture - the 3D sounds to allow the children to sense their way around an environment and in particular to sense objects, sense game boundaries and avoid obstacles. A survey with the participants of this study showed that sound was the highest testing factor, with 100% of participants feeling that the 3D sounds conveyed meaningful information.

3D sounds have, also, been used for activities other than educational purposes. The US military developed 3D sounds as feedback cues (Doughlas et Al, 2008) for soldiers with the intention of increasing their decision making and navigation in complex situations. This was executed by spatialising sounds to compass points (e.g. North-West). These sounds were in the form of a woman's voice recording of different auditory cues such as "alert". The system was then tested with the use of a simulator and a tactile feedback belt (providing vibration to compass points around a belt).

The results uncovered that the visual and tactile feedback had a higher success rate than the visual and spatial sounds feedback. However, The paper then goes on to state that one possible reasons for the lacklustre performance of the 3D audio cues may have been that the 3D audio system was "a one size fits all" and that "3D audio is most effective when tailored to each individual". This demonstrates the potential importance of allowing users of Hear3D to be allowed to choose their own sound positioning, as spatial sounds are subjective and different people will have different preferences with regard sound positioning. It is, therefore, important to allow a level of customisation to ensure the maximum efficiency of the spatial sounds effect.

Studies have also been conducted in order to evaluate spatial sounds potential ability to aid in interacting with user interfaces, particularly where screen size is a limited resource. One such study involved the development of a navigation system for a tablet that utilised spatial sounds and gesture control (arm movements) in order to evaluate spatial sounds abilities to be used for navigation (Cheng, 2001). That study found that the spatial technique worked well only when the user was provided with some form of feedback. This was accomplished by asking users to localise a sound and then provided the participants with the correct answer, although the experience of browsing using gesture and spatial sounds was not enjoyed by the users which was explained by the author due to the unusual technique involved in browsing compared

to the familiar point and click environments that we are familiar with.

Other more unusual applications which make use of 3D audio can also be found, e.g. such as the development of a driving simulator making use of 3D sounds (Xun-xiang et al., 2008).The aim behind this study was to try and add some much needed realism to driving simulators in order to enhance the overall experience. Although a complete system was never competed elements of the system were put forward for testing.
The main development procedure of this experiment was the development of 3D engine noises that add much needed realism to other cars that the user is not driving in driving simulators.

3.5 Conclusion

This section started with a brief history on how digital signal processing began. This was then followed by a discussion of spatial sounds, both its history and the factors that effect its effective development. The section then concluded with an examination of some research that involved spatial sounds.

4. SECOND LANGUAGE LEARNING

4.1 Introduction

The following section outlines the history of language teaching techniques and discoveries, with a focus on audio based methods in the past. Second language acquisition (SLA) is a well discussed topic with many formal approaches put forward over the decades. SLA is by no means a new topic, but studies and review of teaching methods are constantly underway to improve SLA techniques and thereby bring further benefits to educational systems.

SLA is often compared with First Language Acquisition due to it being the first and most effective language acquisition experience that we encounter. But there are many differences between the two. For example, children learning a second language are much more likely to reach a native-like level of speech over an adult when it comes to SLA. In fact, it is very difficult for an adult to reach a native's level of speech no matter what the level of study is conducted. This phenomenon is known as fossilization. Fossilization is a term for the plateau that a second language speaker reaches. Although when you think of fossilization you think of dinosaurs that is the reason for the name as second language acquirers are encased and confined by their first language experience and techniques which prevents them from being able to progress past this level of speech (Washburn, 2001).

4.2 Techniques For Second Language Teaching

There are three main approaches to language learning - the structural approach, the functional approach and the interactive approach. The structural approach is based on examining how the components of a language relate to each other while the functional approach is based around what the learner needs in order to function as a language speaker. Finally, the interactive approach relies heavily on speech and interaction with the language.

There has been much research into the various aspects of language teaching and the approaches to take in order to maximise the learning experience. Up until the 1950's the most prevalent structural method used for the teaching of language was the classic method (Anthony, 1963). This method focuses on grammatical rules, memorisation of vocabulary, as well as a variety of declension and conjugation, translation of text, and written exercises workmanship and is still an extremely popular choice for language teaching to this day. It is, for example, the most commonly used framework for teaching English in Japan. The classical method is also known as the Grammar Translation Method, but teaching with this classical method has many shortcomings. Language teaching in the twentieth century has evolved and modernised since the development of the classical method.

One of the first audio based methods for language learning was the audio-lingual method. The audio-lingual method was one of the first structural methods to involve audio, it was developed in the USA during World War II, the method was brought about by the US government's realisation that it needed more people who could communicate fluently in multiple languages for war time roles such as translators and interpreters. At that time foreign language learning was heavily reliant on reading instructions, there were no textbooks or other course based material available at the time. New material and methods had to be devised, which lead to the creation of the audio-lingual method. The first iteration of this method was known as the "oral method". Towards the end of the 1950s, the audio-lingual method began to take the shape of its modern day form, this time it was with thanks to the space race. Existing course work and textbooks were redesigned to incorporate elements of behaviourist psychology which was beginning to emerge at the time. Under this method students listened to a recording of actors acting out a scene in a foreign language, students then practiced with a variety of drills, while emphasis was put on using the foreign language as much as possible with the intention of the teacher reinforcing correct language behaviours (Chastin and Woerdehoff, 2011).

The typical structure of an audio-lingual course at this time was as follows

- First the student listened to a dialog in the foreign language that they memorised.

- Questions in the foreign language were then asked about the dialog that had been listened to, with interaction taking place in the form of the foreign language.

- A brief introduction to the grammar of the next lesson, which included, for example, verbs.

- Drill exercises were executed in a variety of forms such as teacher's questions on grammar, or filling in the *blanks*.

- A vocabulary list was reviewed in both foreign and native language.

- Lessons generally finished with some form of reading exercise.

Due to weaknesses in class performances, the audio-lingual methods are rarely the primary method for foreign language instruction today, mainly due to Noam Chomsky's attack on the then current learning styles as a set of habits (Valdman, 1970).

The next iteration in the history of language teaching techniques was the direct method. This was an interactive approach, although this method has its roots of development in the 1900s, it did not garner much notice until the 1960s. This method focuses on refraining from using the learners native tongue. This is done on the basis that second language acquisition must be an imitation of first language learning. The rational behind this method was that babies did not need a second language in order to learn their first language which means a native tongue is not needed to learn a foreign one. According to the principles of this method all target language texts and learning aides must be withheld from students for as long as possible.

The first functional approach methodology was developed during the 1960's (Murcia et al., 1997) and was known as situational language teaching. During the development of this methodology the creators were very much aware of the direct method and were trying to build upon the direct approach by developing a scientific approach based content to the direct method. The foremost difference between the direct approach and

the newly created oral approach was that theoretical principles were used for the selection of content, this content was developed when it was discovered that languages have what's known as a core vocabulary of approximately two thousand words, and it was deduced that the learning of these words would greatly aid reading skills, it was also discovered that there was a core set of patterns regarding sentence construction known as grammar control. The approach gained its name due to the content being devised around situations; this was done in order to lead to good habits for the corresponding real world situation. Although this approach is not used in its entirety anymore, it is the basis for most English as a foreign language textbooks.

One of the more abstract teaching methods can be found in suggestopedia. That method was developed by a psychologist in Bulgaria called Georgi Lozanov and he claimed that his method allowed for the acquisition of a second language three to five times more quickly than any other method. Suggestopedia is based around the creation of a positive feeling amongst students with classes taking place in three phases.

The first phase, deciphering, the student is introduced to the lesson content - in the case of language learning this would be grammar. The concert session involves two stages - the passive and active stages. In the active stage, the students read aloud with the teacher and, in the passive stage, they just listen to the teacher. The reading content depends on the topic, it could be tenses or grammar rules. Music is played in the background during this phase in order to maximise the comfort and confidence levels of the students.

In the third stage, elaboration, students express the various things they have learned in the class in a variety of ways, games such as hangman could be played or songs could be sang involving the content involved.

Suggestopedia has garnered significant attention and is held in both a good and bad light (Uschi and Lawson, 1994). It has been called a pseudo-science, which means that it does not adhere to any scientific method of research even though it is being claimed as one. Suggestopedia has also been thought to have a placebo effect and the students who believe in it subconsciously work harder. Lozanov has no problem with this claim as the placebo effect has been known to work and he claims that by

creating an enjoyable environment, the teacher is nurturing the development of knowledge (Eggers, 1984).

4.3 Language Learning Principles

Language learning can be a difficult task and depends on different learning styles of individuals. A learning style is a characterisation of how individuals acquire, retain and retrieve information. Mismatches can often occur between an individual's favoured learning style and a teachers lecturing methods. It is, therefore, important when developing the software to use effective methods to ensure a high quality of information is conveyed to the listener. Felder and Henrique's developed 8 rules on how to tailor content for all types of learning styles (Felder and Henriques, 1995), these 8 rules are as follows:

Motivate learning

It is important to motivate the learner. If the learner is not motivated he/she will not pay attention or lose interest in a topic. It then becomes more difficult for a student to catch up if topics are building on each other, as is the case with learning a language. Motivation can be achieved in a variety of ways one of the most effective ways is by having a motivated teacher who is interested in the topics being discussed and has a genuine interest and desire to teach. Keeping course work varied also keeps students motivated as they will not get bored with a standard routine. Finally encouraging some cooperation and collaboration between students keeps motivation high with students building up some camaraderie within the class.

Balance concrete information with conceptual

By balancing the learning of concrete information such as definitions with conceptual information such as syntax you ensure that you maintain the interest of the students. If, on the other hand students just spend a day on concrete information such as learning pages of grammar, both motivation and interest will plummet. The balance does not need to be equal, it just has to break up the content into easier chunks.

Make liberal use of visuals

Through the use of visuals it becomes much easier to reinforce words meanings with students as sight is a universal language and the meaning remains the same across all languages. The use of visuals also breaks up some of the mundane content and can add an element of fun to the class environment.

Balance structure with non-structure

This is incredibly important when it comes to language learning. Balancing structure with non-structure ensures that a certain amount of presented reading is balanced with language conversation. So, for example, it could be weighting up class time reading aloud and balancing that with some open conversation among the class in the target language.

Use Drill Exercises Sparingly

The use of drill exercises are always important in learning, but the overuse of such drills can have a severely detrimental effect on students motivation and ambition. By not overusing this method, it is possible to prioritise the important grammar elements that are needed to ensure that students gain a comprehensive knowledge of the language and they will be far more likely to remember the fewer the number of drills and words chosen.

Do not fill every second of the lecture with lecturing (Allow time for reflection/discussion)

Its important not to just talk at students for the hour or so that they are in the classroom. Some time must be allowed for the students to reflect on the content and how it fits into their overall body of knowledge. Some open discussion at the end of a class also allows lecturers to clear up any misconceptions or questions that a student had during the class.

Give Students the chance to co-operate.

By allowing students to collaborate and bond a good environment for learning, collaboration within teams also has its benefits as team members wouldn't want to let each other down. Collaboration within language learning is hugely beneficial when it is done in the target language as it makes students think on their feet and put to use what they learned in the class.

Balance inductive and deductive presentation of material.

This involves teaching sometimes through the target language and other times in the native language, this is important as to build up student's familiarity with the language and how to communicate with it. Although this cannot be done until students have a basic grasp of the language when it is initialized it can have a huge impact on students understanding. It would also be imperative to explain important topics such as the tenses in the native tongue as to ensure that there is no confusion.

These guidelines give a good overview of tactics to keep in mind when developing content for a course, although they are not applicable to all classes and class types, they do have some aspects that are applicable to all styles of teaching. In the case of Hear3D these principles were a heavy influence to the development of the French educational module in an attempt to make the content as engaging and interesting in possible. These principles will be revisited in the experiment chapter in order to discuss why certain decisions were made with regards the language script and elements of interactivity.

4.4 Measurement Of Language Learning

There are many ways to asses variables in language learning. The Attitude/Motivation Test Battery test (AMTB), for example, seeks to evaluate two affective variables - motivation and anxiety (Gardener and MacIntyre, 1993). This is done through questioning each participant with regards the two variables with two questions for each. For motivation, the attitude towards teacher is one and the attitude towards the course is the second. For anxiety French class anxiety is first and French use anxiety

is second. These variables are usually measured with the use of positively and negatively phrased questions of equal amount for each question, and these are generally based on the use of the Likert 7 point scale. There is much support for the effectiveness of the AMTB with extensive research being conducted (Gardener & Lysynchuk 1990, Gardener & MacIntyre 1991). This test could be used in the implementation of the questionnaire in order to capture data regarding the participants motivation and anxiety and whether the application helped alleviate any of these factors.

As a framework for evaluating the level of French achieved the Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR) can be used to form a profile of proficiency. The CEFR ranges in level from A1 (Basic User) up to C2 (Advanced User). Hear3D could assist users in achieving the first proficiency level. The first proficiency level, A1, has 2 main requirements which are listening understanding and speaking understanding. The listening understanding concerns itself with being able to understand simple sentences concerning personal information about yourself, your family and your immediate surroundings. The speaking production focuses on the speakers ability to convey simple sentences in conversation, such as personal details like where you live. The Hear3D course can be tailored in a fashion to accommodate the learning of these basic listening and speaking language skills. This could also be used as a basis for evaluation for participants, as if they can complete these tasks they could be graded at a level of A1 within the CEFR framework.

4.4 Conclusion

This section started with a history of language learning, before moving on to the techniques involved in teaching a second language. These techniques are implemented in the development of the language-learning module, which will be discussed in the experiment chapter. This section then concluded with ways to measure the language learning of students.

5. PSYCHOACOUSTICS

5.1 Introduction

Psychoacoustics is the study of sound perception; it draws together psychology and physiology in order to study human response to sounds of any kind such as music or speech. Since the dawn of psychoacoustics much study has been conducted into the perception of sounds and its characteristics. This subject is particularly apt for the discussion of this project as elements of Hear3D have been developed in order to maximise and utilise some psychoacoustic properties. This chapter will discuss the basic principles of psychoacoustics, then there will be a discussion on attention and alertness which plays a huge part in learning before finally discussing some of the research conducted in this area.

5.2 Psychoacoustic Overview

Some basic principles of psychoacoustics that have been developed (Jabloun and Champagne, 2003) over the years will be briefly outlined in the following paragraphs in order to build a base of knowledge for further discussion.

Masking Effect

The masking effect happens when the perception of a sound is impaired or effected by the occurrence of another sound. This phenomenon is discussed at great length as to the criteria of what it takes to mask a sound. It takes into account the effects of loudness, different types of frequencies and intensities. It has found practical application in some environments such as the use of white noise in certain factories in order to nullify loud machinery.

Pitch Perception

Pitch perception deals with the study of pitch and scales of pitch, it delves into studies such as the study of the limits of sound perception i.e. sharpest/flattest note a human can perceive. Some practical work has been conducted in this area such as the creation of the mosquito alarm which emits a high frequency sound which is only perceptible by people under 20, it is used as a deterrent for teenagers loitering in various areas such as in front of shops.

Loudness Formation

Loudness formation is the subjective measure of a sounds strength attributes such as sound pressure, power and intensity. This is a big area of discussion as loudness has been linked with hearing loss and discussions on what attribute of loudness are directly responsible for hearing loss.

Timbre

Timbre is the tone of a sound which distinguishes it from another sound with the same pitch i.e. the difference between someone singing a note and playing the same note on a guitar would be a difference in timbre. This is a very deep topic as much research has been conducted with the advent of computer based sound development as almost limitless variations are available for experimentation compared with before the development of computers there were only physical instruments available.

Sound Localisation

Sound localisation is the ability to identify the location of a sound source in a 3D environment in both direction and distance. The brain achieves this by differentiating subtle nuances in intensity and timing cues (Blauert, 1983). Our ears and brain also act as a filter to change the intensity and timbre of the sound in order to maximise our ability to identify the originating location of the sound. This is the principle psychoacoustic property that Hear3D aims to manipulate.

These core principles give an outline of what the study of psychoacoustics is, in particular this study is relevant to this project as through the use of one of the principles (sound localisation) it is possible to raise a users alertness levels in order to increase the level of attention paid to the language learning content.

5.3 Alertness & Attention

Attention is an important cognitive process especially within the realm of learning, attention is the ability to concentrate on one task without paying heed to anything else, attention has also been referred to as the allocation of processing resources (Posner, 1994) which highlights its importance to learning as it is important when learning to try and block out other things going on and attempt to process as much of the educational content that you are dealing with as possible. Such is the importance of attention that it is one of the most researched topics within psychology.

Within psychoacoustics it has been discussed that there are 2 primary aspects of how we perceive stimuli in an environment, these are the Bottom-Up and Top-Down approaches (Sarter, Givens And Bruno, 2000). The bottom-up approach states that we perceive sounds based on the properties of the sounds and that it is more of an involuntary reaction to the sound i.e. jumping at a loud bang. The Top-Down approach is that the listener decides before the sound that they are going to focus on that sound i.e. sprinters waiting for a start gun. The importance of the Top-Down method is that the this form of attentional control has been heavily linked with the acquisition of new skill sets (Scerif, 2010). This Top-Down approach can also be viewed as how users interact with the Hear3D software, when users are presented with a choice that will change the localisation of the audio the users may afford the audio more attention then they would normally do to a standard audio recording, this link will be discussed in much more detail during the concluding chapters as a possible explanation for user results.

5.4 Applications Of Psychoacoustics

Much research has been conducted in the arena of psychoacoustics, with studies being conducted involving spatial sounds and others with a focus on language comprehension and auditory attention. In (Genuit and Fiebig, 2005) the authors study the benefits of psychoacoustic to the design of soundscapes. Here the authors attempt to use psychoacoustics to improve the quality of evaluation of soundscapes. As was annoyance is a key factor of this study and in particular an effective way to measure

it, what the authors decide upon is the use of binaural technology to capture as many of the elements effecting the psychoacoustic properties as possible, these are namely, the masking effect, spatial distribution and sound impression. The use of this binaural recording system (which simulates the human the human head with two microphones) allows for high quality recordings to be used during the calculation process, which calculates the affective properties of the sound such as loudness, timbre and strength. This allows the authors a much more valid means of calculating the psychoacoustic properties of soundscapes as compared with the typical two dimensional decibel meter.

A large amount of study has been conducted in the area of psychoacoustics and attention, one such study by (Coch, Sanders and Neville, 2005) studied the human ability to selectively pay attention to a single sound source, children and adults were presented with two concurrent narratives being played through a set of headphones, these two narratives would switch from side to side i.e. left side of headphones to the right and participants were asked to follow only one of these narratives. Embedded in each of these narratives were event related potential (ERP) stimuli which are brain measurements for a specific stimulus. In thus case the ERPs were a buzzer in one narrative and a spoken word in the other. What was particularly interesting in the outcome was that it emerged the left hemisphere of the brain showed significant specialisation for the linguistic processing.

5.5 Conclusion

This section started with an introduction to the area of psychoacoustics. The basic principles involved in psychoacoustics were than discussed. An examination of alertness and attention than took place to build possible reasoning for the experiment results. The section was than concluded with an analysis of the application of psychoacoustics in research.

6. EXPERIMENT AND EVALUATION

6.1 Introduction

This section will discuss the creation and conduction of the experiment. This will be broken into the five primary areas involved in the experiment development. Reasoning for design decisions will be given along with an evaluation of each of the experiment stages. A discussion will than take place based on the results of the two experimental groups.

The experiment related to this project is broken into five main areas.
- Language module content development;
- Hear3D application development;
- Questionnaire Development;
- Participant selection for test and control group;
- Completion of experiment and interviews;

The development of the French language educational content involved the development of a script for the module, which captured the required base level vocabulary that needed to be conveyed on the tape in order to achieve as close to the first rank in the CEFL as was possible. The live audio recordings were made using an audio interface and other recording equipment. The subsequent mastering of the content necessitated the clipping of audio to remove unwanted noise and errors and the use of filtering to add some tones.

The development of the Hear3D application involved extensive library setup, advanced programming development and extensive design and redesign during the course of the project as the functionality of the Java3D libraries became more apparent.

The creation and conduct of the experiment required the selection of both test and control group participants, the development of a cohesive questionnaire for completion by all participants and the orchestration of interviews with a sample of the participants.

6.2 Language Learning Content Development

The development of the language-learning module began with the capturing of the basic vocabulary required in order to adhere with the CEFL standard breakthrough beginner A1 level. Although the module aims to achieve this level, it is in the context of a project of this nature an incredibly difficult task given the amount of time that will be demanded of each project participant. Participants were, firstly, asked to listen to the audio recording paying attention to the content. A time limit of 10 minutes was imposed on the French language module and the development of the content within this time frame meant that only the most relevant and important elements of level A1 were fully expanded in the module. The basic needs for a level A1 user are as follows:

➢ *Can comprehend familiar and common expressions*

Although this specification is extremely vague and difficult to cater for, some of the most common French expressions were built into the module such as *Tres Bien* and more concrete information such as the days of the week.

➢ *Can introduce themselves and can ask simple questions about location and their family*

This section was worked into the module. The listener is taught how to say common greeting expressions such as hello, goodbye and how to talk about their family on a basic level i.e. how many brothers and sisters they have.

➢ *Can interact on a basic level*

To conform with this section, vocabulary was incorporated regarding common day-to-day topics such as the weather, food and school. In order to simulate a form of interaction, *speak and respond* sections were developed into the module in which the user can respond to what the teacher is saying.

The CEFL framework was essential to the development of this language module as it gave good concrete indicators as to what grammar was needed in order to achieve a basic level of French.

After the script was developed, the next stage was to begin the recording process with the French language professional. This took place over the course of a week as multiple retakes were required in order to ensure the highest level of quality in the recordings. High quality was essential, as without such a high level of quality within the recordings, the effectiveness of the Hear3D software would be significantly diminished. The recordings were accomplished through the use of an audio interface (Focusrite Saffire 6 USB(see figure 1)) which allows for the signal of a microphone to be captured through computer software. In the case of this experiment, the open source software audacity was used for the capturing and manipulation of the sound. Audacity (see figure 1) is an open source digital audio workspace. It was chosen for use in this project as it is open source and encompasses much more advanced features than the other open source recording software (such as for example, the closest other option, Wavosaur, which offers no form of compression or tone generation).

Figure 6.1: Focusrite Saffire 6

The recording process took the shape of a two hour session on the first day where a discussion took place on how the planned script compared with methods with which the teacher was familiar and had used in class. Major changes were not required to the script, but the running order of the content was changed slightly in order to start with the easier material to ease the listener into the language module.

The second half of the first meeting involved a *first take* recording of the script. Most of the content was captured on this first recording. However, a human error occurred with regards the microphone gain. Microphone gain is essentially the volume level at which the microphone records the voice onto the computer, even though the gain was in its default position it arose that this volume was extremely low when played back

through headphones. The whole recording, therefore, required to be reworked in the next session. In the following recording session, the microphone gain was optimised to allow a high volume level during playback, but this caused issues with background noise that were altered and changed during the mastering stage. The majority of the content was captured in this second session but further meetings in the following three days to re-record some sections that the language professional felt were not satisfactory. At the end of the week, it was possible to begin the second phase of the audio creation - mastering. (See appendix A & B for scripts)

Mastering is the use of audio tools and techniques for the enhancement of a piece of audio. Mastering can be done in countless ways with dozens of techniques and hundreds of effects, but, in the case of this recording content, it was limited to the tools included in audacity. Surprisingly, audacity (See figure 2 for example of workspace) does contain quiet a few of the more advance filters such as a compressor.
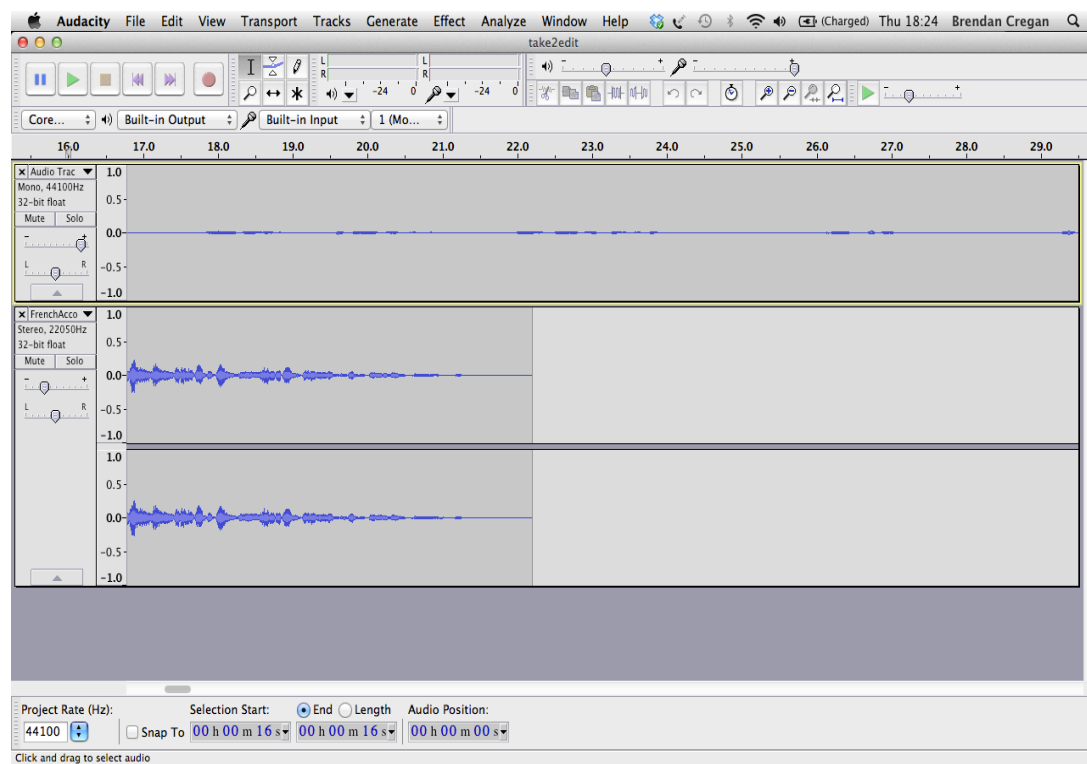
Figure 6.2: Audacity Workspace

The mastering process began with the clipping of tracks to remove all unwanted background noise and all unneeded speech, these gaps were then all replaced using audacity's ability to automatically generate silence. After the first mastering iteration was completed, noise removal was used to eliminate any unwanted underlying

background noise from the vocal recordings and then the audio was normalised - normalisation levels off a piece of audio volume and eliminates volume variations in different sections of the recording- sections sounding louder than other parts is a common problem with vocal recording and its primary cause is the speaker moving closer and further from the microphone.

Next, the audio was passed through a compressor. Compression is essential to mastering and is often seen as the *final touch*. Compression is similar to normalisation but it deals with the smoothing of sounds - instead of a loud sound just occurring it adds a volume curve to the beginning of a sound which gives it a clearer and easier to listen to tone.

After compression, all that remained to be done to ensure high quality audio was to add the tones to signify the interactive sections of the module. These tones, which signify that the listener could and should respond in order to maximise their interaction levels, were added through the use of audacity's tone generator.

A piece of French music was inserted at the beginning of the module. It is a key principle of suggestopedia that learning can be stimulated if the student feels that he/she is in a relaxed environment and such an environment can be created through the playing of music at the beginning of the module.

6.2.1 Language Learning Content Development Evaluation And Summary

This script was developed with the previously discussed (Felder and Henriques, 1995) principles in mind. These principles were worked into the script in order to maximise potential for language learning and for the content to form a basis for evaluation. The various design choices taken during the development of the script will now be outlined, with the reasoning behind these decisions being given. (See Appendix A for full script)

Motivate learning

To motivate the learner, the content was presented in a friendly fashion by adding some themed French music to the beginning of the content, the interactive elements of the content were also responded to with praise by the teacher e.g.

* TEACHER*	"What is your name?"	(French & English)
+LISTENER+	"My Name Is ..."	(French)
* TEACHER*	"Excellent!"	(French)

This was done to encourage user participation and increase motivation.

Balance concrete information with conceptual

This was more difficult to achieve. But, through balancing content elements such as grammar relating to days of the week with content such as learning to use verbs such in ways such as expressing your name or where you live a balance was achieved between the two types of information.

Make liberal use of visuals

Although this could not be applied to the recording of the audio content it was integrated in the design of the Hear3D Graphical User Interface (GUI) just to add a reader to the frame to add a sense of perception as to where the reader is sitting.

Balance structure with non-structure

By balancing interactive conversation with structured listen and repeat sections, this principle is conformed with and this approach, also, stops the users from becoming bored during the course of the module.

Use Drill Exercises Sparingly

Although drill exercises are unavoidable, the potential monotony has been broken up in this module to allow for a more enjoyable user experience.

Do not fill every second of lecture with lecturing

Through the breaking up of content the users get time to reflect and utilise what they have just learned during the module. This supports the maximisation of user motivation.

Give Students the chance to co-operate.

This is not readily available for users of this module, but, in future modules, it could be developed with a chance to hear other students responses to the questions presented through live audio recordings.

Balance inductive and deductive presentation of material.

This involves the teaching of students through the target language, this was a guiding principle for the development of the Hear3D language module as it is the primary way in which information is conveyed to the users.

Many issues arose during the course of the language module development. Primarily the issues resided around the design choices of the script. Time and content were the two foremost issues that had to be tackled.

Time

The running time of the module was given careful consideration. Although the dropout rate of questionnaire participants does not depend on the questionnaire's length, the longer the questionnaire and accompanying tasks are, the more fatigued the participants get and the more likely they are to increase their speed of answer and pay less attention (Cape, 2010). For this reason, an overall time limit of 15 minutes was judged to be the most appropriate time limit in order to attempt to raise the quality of the answers given.

Content

The choice of content was a difficult task as the CEFL is a very broad course with many different types of base user tests in circulation depending on the country. For that reason, it was imperative to work closely with the language professional to ensure as high a quality script as possible and that it was as close to the CEFL standard as possible.

Overall, the module received favourable comment in the *additional comments* section of the questionnaire:

"With no experience in French I felt I learned a lot from this. It was easy to follow and gave me time to speak along with the CD" (18-24 Female)

"The voice on the disc was clear and easy to understand" (65+ Male)

"The quality of the sound was very good and clear" (65+ Male)

This section outlined the development of the language content. Then the criteria based in the literature review were used to evaluate the content. The section was then finished with a discussion on how the module was received by the participants.

6.3 Hear3D Application Development

The development of 3D audio is quite similar to the development of three-dimensional graphics. The system as a whole is developed in a 3D plane (see Figure 4).
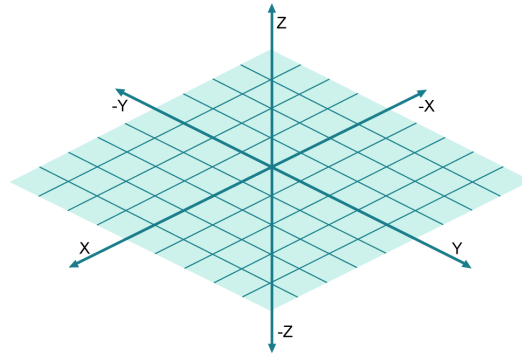
Figure 6.3: An Example Of A 3D Scene

There are two primary areas of interest when discussing the development of 3D audio. Firstly, the sound source i.e. the originating point of the audio and secondly, the listener. Both components share two common characteristics, their positions in the 3D arena which is set using the x, y and z coordinates, which permits the setting of the listener or sound source within the 3D scene e.g. setting a location of (0, 0, 0) would position an element in the origin of the 3D graph. The second characteristic that is shared between the listener and the source is their orientation. The listener orientation is implemented in a similar fashion to the setting of the location except that an additional three fields point in the direction that the listener is facing i.e. (0, 0, -1) in figure 5 is pointing due north. This development setup allows for accurate and efficient placement of sounds and easy orientation manipulation.
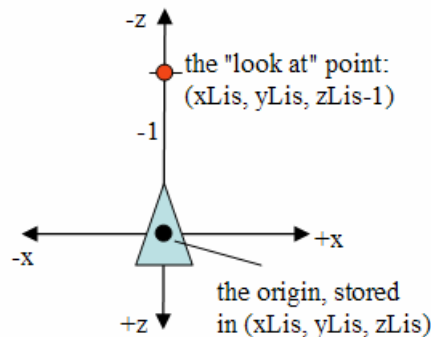
Figure 6.4: The Setup of a listener in a 3D environment

The Java3D application programming interface (API) was originally developed for use as a 3D graphics API but has since proved to be adaptable as a medium for the application of three dimensional sounds and, from a developer's perspective, it made sense to keep all three dimensional functionality in the same API.

The API works through the use of two spatial sound classes, namely PointSound and ConeSound. Volume and left to right stereo mix depend on the listener's position in the three dimensional environment and can be altered based on the developers choice of coordinates.

The API requires a considerable amount of libraries to be imported and configured in order achieved a spatialised sound system, particularly with regards the importing of OpenAL.

OpenAL acts as the SoundDevice for Java3D as some of the aspects of Java3D contain fatal bugs, namely the two primary classes – PointSound and ConeSound. The bugs were of such magnitude that these two classes were moved to being optional extras of the Java3D package. For this reason, OpenAL is required as its serves as a medium for the creation of audio sources in a 3D environment being listened to by a single listener.

The final element required is JOAL custom mixer, A Java wrapper for OpenAL and Java3D. The JOAL custom mixer acts as the primary sound mixer and allows for the quick playback of sound sources which removes the long-winded approach needed when programming for game development.

The coding for this project was accomplished using Eclipse Indigo as the development environment. The programming aspect of this experiment will be discussed under three main headings – Firstly a discussion of the GUI implementation, than a discussion on the 3D audio programming and finally a discussion on the design changes and problems that arose during the course of the development.

The GUI for Hear3D was developed to be as simple and intuitive as possible as the application was targeted across a wide range of people with different levels of technological literacy. Because of this, it was decided to use one frame for the implementation and implement action listeners within the frame to capture the users positional choice.

This JFrame layout was implemented as follows:

```
JFrame frame = new JFrame("Hear3D");
frame.setVisible(true);
frame.setSize(500,500);
frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
JPanel panel = new JPanel();
frame.add(panel);
```

Figure 6.5: JFrame Implementation (Source: Authors Code)

Here a new JFrame is created, its size is set using setSize() and a JPanel is added to the frame. Which created the frame pictured below.
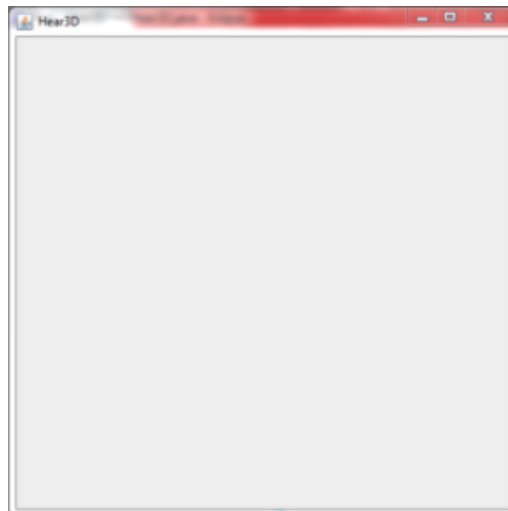
Figure 6.6: Hear3D Development – 1st Iteration

The next step was to add a picture to the centre of the frame to give some visual indicator as to where the reader was located in the environment. This was accomplished as follows:

```
ImageIcon image = new
ImageIcon("C:\\Hear3D\\ReaderImage.jpg");
JLabel imageLabel = new JLabel(image);
imageLabel.setBounds(195, 183, 100, 100);
panel.add(imageLabel);
```

Figure 6.7: Icon Implementation (Source: Authors Code)

This was achieved by adding the image to a JLabel and then centring it on the frame. Which produced the following JFrame:
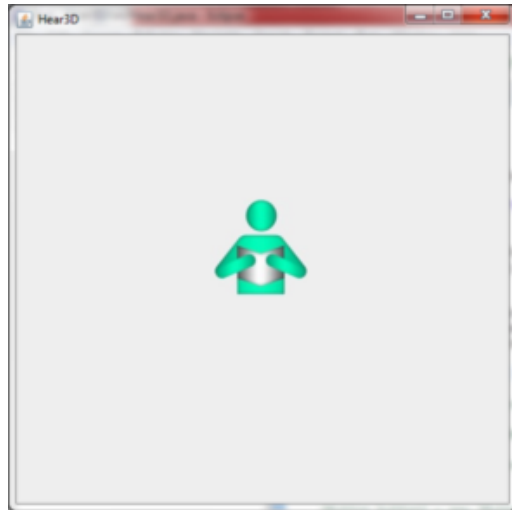
Figure 6.8: Hear3D Development – 2nd Iteration

Buttons were then added based on the layout of a compass (i.e. North, south etc.). All had one button and action listeners were implemented to keep track of which one a user presses.

```
JButton button2 = new JButton("North");
button2.setBounds(195, 10, 100, 100);
panel.add(button2);
button2.addActionListener (new Action2());
```

Figure 6.9: Button and action listener implementation (Source: Authors Code)

Here a button is being added to the JFrame by setting its bounds (SetBounds()) then an action listener is being create for the new Action – Action 2.This produced the final GUI:

Figure 6.10: Hear3D Development – 3rd Iteration

Next is the final part of the programming and the core of the whole system, the implementation of the 3D sound setup.

```java
static class Action2 implements ActionListener {
  public void actionPerformed (ActionEvent e) {
       try{
       SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class
);

     SoundSystemConfig.addLibrary( LibraryJavaSound.class );

     SoundSystemConfig.setCodec( "wav", CodecWav.class );

  }
  catch( SoundMixerException e1 )
  {

     System.err.println("error with soundconfig");

  }

       SoundSystem SoundMixer = new SoundSystem();

       SoundMixer.setPosition (0, 0, -200);

             SoundMixer.quickPlay( false,

             "FrenchLessonMono.wav", false,

             0, 0, 0,

             SoundSystemConfig.ATTENUATION_ROLLOFF,

             SoundSystemConfig.getDefaultRolloff());
```

Figure 6.11: Hear3D Spatial Sound Implementation (Source: Authors Code)

Here the action that was defined on the button is being called, the program then attempts to load the appropriate libraries into the mixer. In particular, it is adding the compatibility for the .wav audio file type and the OpenAL adapters. If the program loads these correctly it then creates a new SoundSystem.

The listeners position is then set :

```
SoundMixer.setPosition (0, 0, -200);
```

Figure 6.12: Hear3D Spatial Sound Implementation (Source: Authors Code)

The core of the custom JOAL mixer next comes into play - the quickplay method, this allows for the playing and of a sound and the setting of its location in 3D space.

```
SoundMixer.quickPlay( false,
"FrenchLessonMono.wav", false, 0, 0, 0,
 SoundSystemConfig.ATTENUATION_ROLLOFF,
SoundSystemConfig.getDefaultRolloff());
```

Figure 6.13: JOAL QuickPlay Method (Source: Authors Code)

 The two false fields above can be edited to true to allow for looping of a sound or for setting priority of a sound. The setting of attenuation is set at its default of roll off which means that as sounds come to an end it rolls down the volume before it is finished to add a cleaner end to an audio clip.

This method was used to change the listener for each button in space a total of eight in all and provided an easy and efficient way of playing and picking a 3D sound location.

In order to evaluate the effectiveness of Hear3D, the criteria of learning objects, already discussed in the literature review were used to analyse the design elements of Hear3D as follows:

Content

The content of the Hear3D audio has been discussed in great detail in the previous section and is in line to the greatest extent possible with the CEFL.

Media

The clarity of presentation in Hear3D is minimal but it is all that is required for the Hear3D experiment. It could be further improved on by the creation of a menu system and a video introduction on how the software operates and what it is trying to accomplish.

Activities

Hear3D has one activity – the choice of audio source. This is all that is required for the purpose of this project but much more could be added such as the integrating of some learning material texts.

Navigation

Navigation is one of the areas that suffers in Hear3D as the JOAL mixer has some issues with the playing of a second piece of audio once one source has begun to play. This creates a slight difficulty when trying to interact with the various sound sources as users must close the window and open a new one to change their positional preference.

Overall Appearance

The overall appearance of Hear3D is simple and intuitive. Through the removal of having to click your way around the environment as discussed in the proposal, it now becomes much easier to get a sense of the environment as the audio is spatialised based on a compass. This creates a much more defined interface which lends itself to the interface.

Technicality

The degree of difficulty with the compiling and running of Hear3D is compromised due to the wide range of external libraries in use. In addition, these libraries require fine-tuning in Eclipse to link them with the appropriate JAR files. Issues also arise with the quality of the effect as the 3D effect is not nearly as immersive as the commercially available spatial sound development libraries (e.g. morrowwind3D). These issues relating to the limited quality of the Java3D spatial effect are mainly due to the spatial element of the package not being fully supported by the community anymore. In fact, many of the necessary install elements were optional extras.

Testing

Although there are no specific testing elements in the Hear3D software, these elements could be added at a later date. Building on the previously mentioned potential to add learning material to the software, it might also be possible to allow a medium for the testing of this material. This could be achieved in many ways (e.g.

through the development of multiple choice quizzes).

This section outlined the background and approach to the creation of the Hear3D software. This included a discussion on the development process, a discussion then followed on the evaluation of Hear3D's capabilities as a learning object using criteria based in the literature review. Included in this, were suggestions of potential enhancements to possibly improve the system in future.(See Appendix E for all code)

6.4 Questionnaire Development

Two questionnaires were developed to test both the control group and the test group i.e. the users of Hear3D. The majority of questions were common to both questionnaires. Both groups were issued with an AMTB (Attitude/Motivation Test Battery) which was integrated in the starting section of the questionnaire. This section was included to filter the participants to discover if they had a genuine interest in learning French or if they were anxious about learning French. The next section of the questionnaire was the development of twenty questions to test the participants on what they had heard during the module. These questions formatted around a multiple-choice template with four possible answers. This design choice acknowledged the reality that it would have been too much to expect participants to spell words in French without their being provided with some form of written study material.
Questions had different levels of difficulty, but all the possible answers to all questions sounded phonetically similar. This approach was taken to try and maximise the potential that Hear3D could have with the identification of sounds compared with a standard set of four different words. (See appendix C & D for full Questionnaires)

The user was also asked to state if they had any previous language learning experience and if so, to state their level of exposure to the language. While this was the final section in the control group questionnaire, a further section was developed for the participants of the experiment with Hear3D in an attempt to capture as much about their experience with the spatialised audio as possible.

In the additional section for the Hear3D users, a question based on the Likert scale, asking if the user thought Hear3D hindered their learning. The next question asked if

the user thought Hear3D altered the audio in a significant way. The user was then asked if he/she thought that the audio manipulation assisted learning. These three questions were chosen to determine if users perceived that the sound affected their experience. Without having to put it into their own words, they circled one of seven options ranging from strongly disagree to strongly agree. This was essential information to capture as it built a picture as to what participants thought of the software and what they thought of the spatial audio. Next, users were required to state if they thought Hear3D's audio manipulation had assisted their learning. The purpose of this request was to capture any feelings that users had towards the software. Users were asked to state which sound location they chose followed by the reason of their choice. This question was asked to elicit their reasons for choosing picked certain locations and it threw up some interesting discussion topics. Finally, the user was asked if he/she felt that using Hear3D had raised or lowered their ability to concentrate. This was asked to assess how users felt about the impact the audio manipulation had on their concentration, and, in particular, to check for any annoyances or software impediments to their ability to extract information from the audio.

The development of the questionnaires was a difficult process that required multiple revisions. This was due to the importance of anticipating the information that would be required for a satisfactory discussion for the results of the experiment.

The overall design of the questionnaire was a successful element of the study. This was due largely to the inclusion of a French language professional in the design process. Another factor was the inclusion of the AMTB, which allowed for the screening of participants to be conducted. This allowed for the removal of participants which had little or no interest in the French language.

Some elements of the questionnaire could be further refined in the light of project experience, particularly with regards the French questions - Grammar variety within the test could be created by using other question types such as *fill in the blanks*.

6.5 Participant selection for test and control group

The overall number of participants was based on various other studies conducted in similar areas e.g. spatial sounds – Lumbreras & Sanchez (1999) utilised a small group

of only six for their experiment while the previously mentioned AudioChile by J. Sánchez, M. Sáenz.(2006) had a group of 30 participants. Another experiment, involving a speech modification program geared towards learning, by (Tallal & Miller, 1996) only had seven participants. A study by (Alizadeh I and Sadegh, 2010) for improving language skills through the use of email laid out a design for a control group of 15 participants and an experiment group of 15. This collection of studies confirmed that the design of a control and test group of 15 in each was on par with, if not exceeding, the average for similar experiments.

In order to ensure that a correct and accurate result was returned from the questionnaires, detailed consideration was given to the selection and filtering of the experiment participants. Firstly, it had to be defined that no language professionals could undertake either the control or software experiment. For that reason, the following categories of participants were removed from the study:

- Any person who had recently undertaken study of the French language at a level higher than the junior certificate. Users between the ages of 18 and 30 with this experience with French were, therefore, removed.
- Any person who had studied French at any level higher than the leaving certificate.

The profile of participants selected for the project is given in the table below (table 6.1)

	Control Group	Hear3D Users
Male	8	7
Female	7	8
18-24	4	5
25-34	4	1
35-44	3	0
45-54	1	2
55-64	1	4
65+	2	3
Previous French Experience	4	4

Table 6.1: Breakdown Of Participants

Overall, there is a good cross section of participants. Apart from the 24-34 and 35-44 age groups in the Hear3D users group. On the other hand, this weakness gives strength to the other age groups and helps build a better picture of the other age groups preferences.

This section outlined how the participants were chosen and a set of criteria were outlined in order to avoid advance French students from being in the test bed.

6.6 Conduct of experiment

The conducting of the experiment began with the running of the control group experiment. This was completed over the course of three sessions over a period of two weeks. The control experiment involved transferring the audio content to a CD and testing 5 people at a time using a CD player; questionnaires were then circulated after the CD had finished; and the completed questionnaires were collected. The members of the control group were spread across a wide age group which maximised the quality of the experiment.

The next stage in conducting the experiment was running the Hear3D trial with the participants. This proved to be a time consuming task as all users had to use the machine on which Java3D, OpenAL and the JOAL mixer had been installed and configured on. However, the Hear3D had been developed on a laptop and this allowed a degree of mobility. This experimentation was completed over the course of two weeks with each individual user using the computer one by one to choose their sound source and answer the questionnaire. The following protocol was developed in order to efficiently demonstrate to the user what he/she was doing and what would happen during the course of the experiment:

- Firstly a description of the software was given and an outline of the experiment. This was done so that the participants knew exactly what was expected of them and that they were aware that there would be a questionnaire based on the educational content after the experiment.
- Headphones were provided to the user and a description of what Hear3D was attempting to achieve with the effect.

- The user was then played some sample audio so that they could get a feel for what the sound would be like.

- Participants were then asked to choose the location where they would like to sit in the virtual environment given the orientation of the sound source i.e. think of the computer as the teacher sitting right in front of you.

- Participants then listened to the audio and were presented with a questionnaire to complete when they are finished listening.

The use of this protocol and process of experimentation ensured the smooth running of the experiment; it was easy to understand and made sense to the participants; and most importantly, all participants were exposed to the same treatment and given the same set of instructions.

In this section the experimental procedure was outlined. This included a protocol that was developed to ensure equal treatment to all of the participants. The experiment section of the research worked well due to this protocol. It ensured that all the participants received the same instruction and explanation as to what was expected of them.

Some issues did arise during the experiment. There were occurrences of software failure, three in total. Unfortunately, this meant that these participants could not restart the test as they would have an unfair advantage from hearing some of the audio already. This meant that their results had to be removed from the research.
This section of the experiment could be improved upon and advanced in many ways. (e.g. the effectiveness of the software on long-term memory could be evaluated by retesting all the participants after several months).

6.7 Results

The results of the research experiment are presented in this section. The two groups of participants are first discussed separately and an analysis is conducted on the groups' results. The answers chosen by each group are then fully discussed and points of similarity and difference are noted.

6.7.1 Control Group Results

The following is a table of the raw statistical data for the 20 questions (i.e. questions number 7 to 26 of the questionnaire) aimed at testing the knowledge retention of the control group participants these are sorted by age and gender.

AGE	GENDER	TOTAL WRONG
18-24	female	1
18-24	male	1
18-24	female	2
18-24	male	2
25-34	male	4
25-34	male	1
25-34	female	5
25-34	female	6
35-44	male	6
35-44	female	3
35-44	male	6
45-54	female	5
55-64	male	7
65+	male	2
65+	female	3

Table 6.2: Control Group Statistics (sorted by age and gender)

These results show that, of the 15 participants, the average number of questions answered incorrectly was 3.6. The best scorers in the test scored 19/20 correct - 3 participants.

These results can be further broken down according to the age groups with the best scoring group being the 18-24s who averaged at 1.5 incorrect answers. Next the 65+ averaged at 2.5, then the 25-35 at 3.33. The 35-44 and 45-54 both averaged out at five incorrect answers while the worst testing group was the 55-64 who averaged seven incorrect answers. A gender breakdown of these results can also be discussed with the female participants averaging 3.57 incorrect answers and the male participants scoring an average of 3.62 incorrect answers.

The following is a statistical breakdown of the answers given by the control group participants. Each participant's answer (i.e. the number of the multiple choice answers) is given, with incorrect answers shown in red. The total number of incorrect answers for reach individual question is shown in the bottom row of the table.

Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26
2	4	2	2	2	2	4	1	3	3	2	3	1	4	3	2	3	4	3	1
2	4	3	2	2	2	4	1	4	3	1	3	1	4	3	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	2	3	1	4	3	2	3	4	3	1
2	4	3	2	2	2	4	1	4	3	2	3	1	4	3	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	1	4	1	4	3	2	3	4	3	1
2	3	2	1	2	2	4	1	4	3	3	3	1	4	2	1	3	4	3	1
2	3	3	3	2	2	4	1	3	3	2	4	1	4	2	2	3	4	3	1
2	4	2	3	2	1	4	4	4	3	3	2	4	4	2	2	3	4	3	1
2	3	3	3	2	2	4	1	4	3	1	4	1	4	3	2	3	4	3	1
2	3	3	3	2	2	4	1	4	3	2	2	1	4	3	2	3	4	3	1
2	3	3	3	2	2	4	1	4	3	3	3	1	4	3	2	3	4	3	1
2	4	3	3	2	1	4	1	3	3	1	3	1	4	2	2	3	4	3	1
2	3	3	2	2	2	4	1	4	3	3	3	1	4	3	1	3	3	3	1
2	3	2	3	2	1	4	1	4	3	3	4	1	4	2	2	3	4	3	1
2	3	3	2	2	2	4	1	3	3	2	2	1	4	2	2	3	4	3	1
0	**8**	**4**	**6**	**0**	**3**	**0**	**1**	**4**	**0**	**11**	**8**	**1**	**0**	**6**	**2**	**0**	**1**	**0**	**0**

Table 6.3: Answer Data Of Control Group (Incorrect Answers In Red)

The control group had a total of 54 incorrect answers from all 15 participants. There were 8 questions which none of the participants got wrong. These were:

- 7.Do you remember how to say "my name is" in French?
- 11.Do you remember the word for "Tuesday" in French?
- 13.Do you remember the word for "7" in French?
- 16.Do you remember the word for "woman" in French?
- 20.Do you remember the word for "Biology" in French?
- 23.Do you remember the word for "cheese" in French?
- 24.Do you remember the word for "coffee" in French?
- 25.Do you remember the word for "pork" in French?
- 26.Do you remember the word for "goodbye" in French?

Interestingly, two of these questions were the interaction-based questions in the audio (i.e. the listener had the option to respond if he/she so desired). The other questions involving the potential interaction scored 8 wrong (question 8) and 6 wrong (question 10).

The question to which most incorrect answers were given was question 17 which was:

- 17.Do you remember the word for "Fog" in French?

The correct answer was 1) brouillard but the most commonly chosen answer was 2) brouille.

6.7.2 Hear3D Results

The following is a table of the raw statistical data to the same 20 questions aimed at testing the knowledge retention of the Hear3D participants these are sorted by age and gender also:

AGE	GENDER	TOTAL WRONG
18-24	Male	4
18-24	Female	5
18-24	Female	5
18-24	Male	0
18-24	Female	1
25-34	Male	1
45-54	Female	3
45-54	Female	3
55-64	Male	2
55-64	Male	1
55-64	Female	2
55-64	Female	4
64+	Male	6
64+	Female	6
64+	Male	3

Table 6.4: Hear3D Group Statistics (sorted by age and gender)

These results show that of the 15 participants the average number of questions answered incorrectly was 3.06. The best scorers in the test scored 20/20 correct - one participant, but, 3 participants scored 19/20 which was the best score for the control group.

These results can be further broken down according to the age groups with the best scoring group being the 25-34 with a score of 1 incorrect answer, but there was only one participant of this age group. Next were the 55-64 age group with an average of 2.25 incorrect answers with a total of 4 in the group. An average of 3 incorrect

answers were scored for the 18-24 and the 45-54 age groups. The worst scoring participants of the Hear3D users were the 64+ who had an average of 5 incorrect answers.

The following is a statistical breakdown of the answers given by the Hear3D users.

Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26
2	4	3	3	2	2	4	1	2	3	2	4	1	4	2	2	3	4	3	1
2	2	3	3	2	2	4	1	3	1	1	3	1	4	2	1	3	4	3	1
2	4	3	3	2	2	4	1	4	3	2	3	1	4	2	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	2	3	1	4	3	2	3	4	3	1
2	1	3	3	2	1	3	1	4	3	1	3	2	3	3	2	3	3	3	1
2	2	3	3	2	2	2	1	4	3	1	2	1	3	2	2	3	4	2	1
2	1	3	3	2	2	3	1	4	3	2	3	1	4	3	2	3	4	3	1
2	4	3	3	2	2	4	1	2	3	2	3	2	4	2	2	3	4	2	1
2	4	3	3	2	2	4	1	4	3	2	3	1	1	3	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	1	3	1	4	3	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	2	3	1	4	3	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	2	3	1	4	2	2	3	3	3	1
2	2	3	3	2	2	4	1	3	3	2	4	1	4	3	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	1	3	1	4	2	2	3	4	3	1
2	4	3	3	2	2	4	1	4	3	1	3	2	4	2	2	3	3	3	1
0	5	0	0	0	1	3	0	4	1	9	3	3	3	8	1	0	3	2	0

Table 6.5: Answer Data Of Hear3D Group (Incorrect Answers In Red)

The above table documents the answer selection of the Hear3D users.

The control group had a total of 43 incorrect answers from all 15 participants, which is a decrease of 12 answers from the 55 that the control group got incorrect. There were 7 questions which none of the participants got wrong. These were:

Interestingly there were only 7 answers that all participants got correct in this test, but were much different from the questions that all participants of the control group got correct. These answers were:

- 7.Do you remember how to say "my name is" in French?*

- 9. Do you remember how to say "Yes" in French?

- 10.Do you remember the word for "sister" in French?*

- 11.Do you remember the word for "Tuesday" in French?

- 14.Do you remember the word for "9" in French?

- 23.Do you remember the word for "cheese" in French?

- 26.Do you remember the word for "goodbye" in French?*

Interestingly all the participants got 3 of the interaction-based questions correct (which are marked with an asterisk).

As was the case with the control group the most incorrectly answered question overall was question 17 which was:

- 17.Do you remember the word for "Fog" in French?

But the amount of people who got this question correct were greater as six Hear3D users got this question correct as compared with the 4 that answered it correctly from the control group.

	Control Group (Incorrect Answers)	Hear 3D Group (Incorrect Answers)
Male	3.6	2.4
Female	3.57	3.6

Table 6.6: Both Groups Incorrect answers by gender (of a possible 20)

The Hear3D users and control group can also be compared by gender. Of the 7 male participants, the average number of incorrect answers was 2.4 while the female participants scored significantly worse with an average of 3.6 incorrect answers. These two statistical breakdowns are compared in table 4.

	Control Group (Incorrect Answers)	Hear 3D Group (Incorrect Answers)
18-24	1.5	3
25-34	3.33	1
35-44	5	X (No Participants)
45-54	5	3
55-64	7	2.25
64+	2.5	5

Table 6.7: Both Groups Incorrect answers by age (of a possible 20)

This table (table 5) shows the impact that Hear3D had on participants scores in different age groups. There is a notable increase in the amount of correct answers in some of the groups. The male participants show a significant increase in the amount of correct answers, an increase of 1.2 on average. There is small decrease (0.03) in the amount of correct answers between the female control and Hear3D group.

The 25-34 age group also show an increase in the number of correct answers with the difference being, 2.33.

6.8 Analysis of Results

The following section will give an analysis of the interesting data that emerged from the research experiment. A discussion will be forward based on this data which will draw from background outlined in the literature review as to outline possible reasoning's for the results.

The following is some of the statistical data regarding the questionnaire results of both the Hear3D participants and the control group.
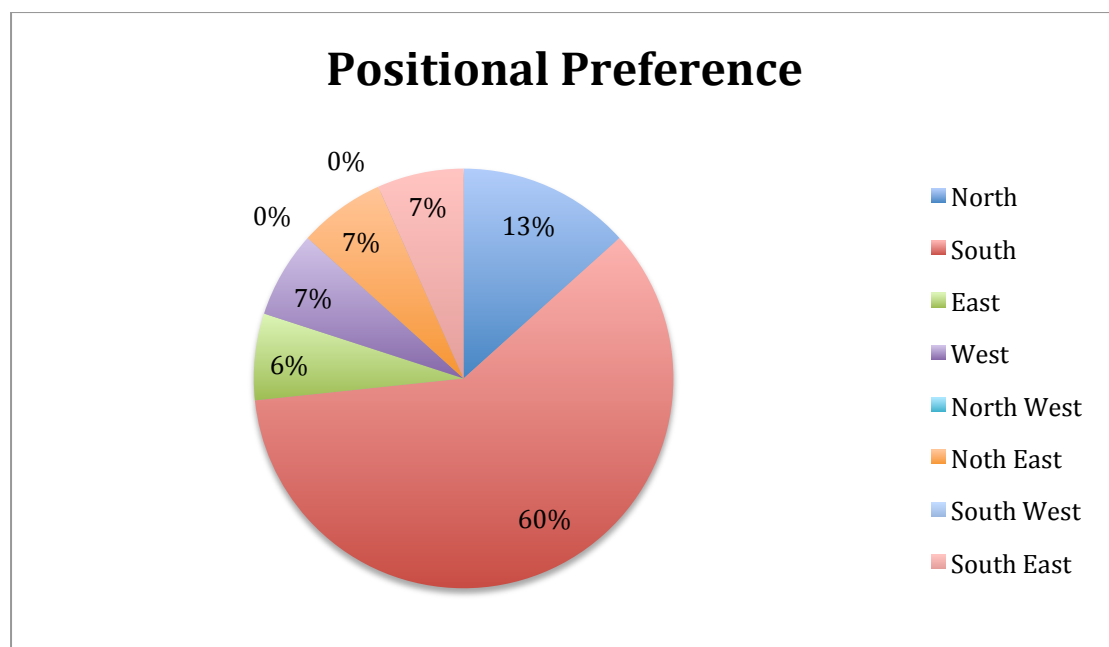

Figure 6.14: Hear3D Positional Preferences

The study of the Hear3D users positional preference created some interesting statistics (see table 6.14). Of the 15 participants 60% of them chose south as their positional preference (i.e. sitting directly in front of the sound source). Interestingly most of the people chose this position to simulate the traditional teacher/student format of sitting facing the teacher. This decision of where students sit has coined the phrase of classroom geography in some recent research. Although limited research has been conducted in the domain of virtual classroom geography.

The users choice of where he/she sits in this virtual class throws up some intriguing results. Particularly the fact that even though there is no real teacher, people seem motivated to sit in the traditional classroom fashion. Even when examples of other seats in the virtual classroom are played for the users. Another interesting development was for the users who choose north (15%). All of these users gave the reason for sitting in this location was to no sit in front of the teacher as they would feel uncomfortable doing this in a real classroom. This is another example of people's decisions in the real world passing over into their choices in the virtual classroom. These results develop potential avenues of further research, particularly in the are of encouraging users to choose sources outside of their comfort zone and not be drawn to decisions they would make in a real classroom.
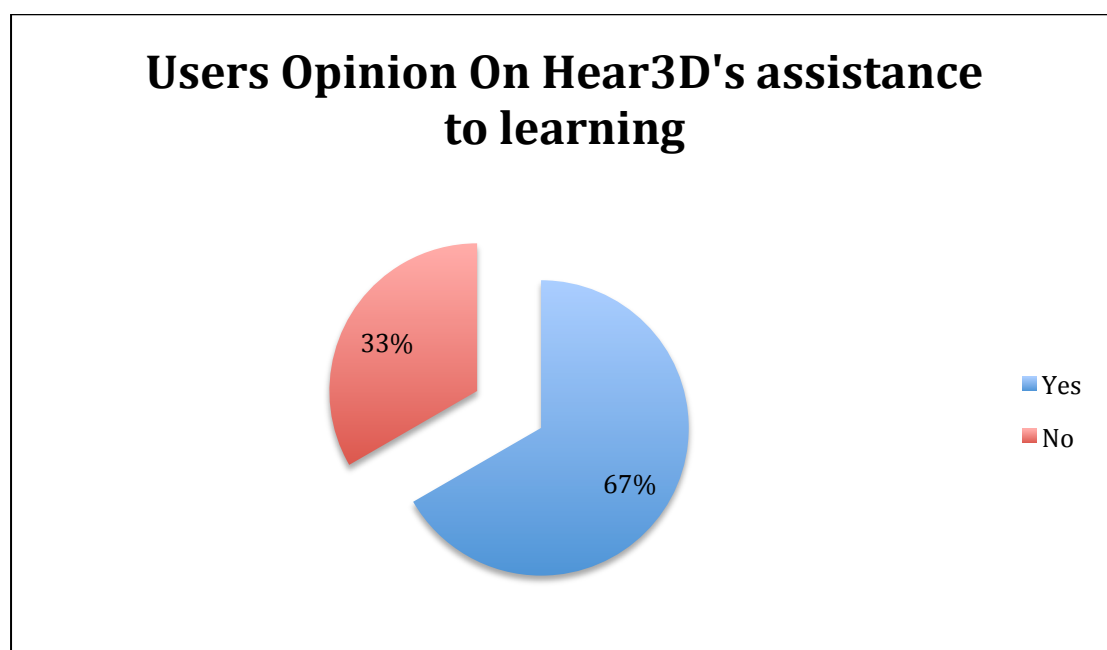

Figure 6.15: Hear3D Assistance to learning

Figure 6.15 gives an indication as to users opinion on whether or not the Hear3D system assisted their learning in any way. This analysis was developed through the use of question 30 (Do you think that Hear3D's audio manipulation assisted your learning?). The results to this question show that of the 15 participants 67% of them felt that Hear3D assisted them in their learning. This is a useful measurement as it can be used to evaluate how effective the participants felt the software was. The fact that 67% felt there was a positive experience show the potential beneficial effects that the software can have. From the additional comments section and from talking to participants the main reason for the assistance to their learning was the novelty and interaction revolving around the audio manipulation.

Through the incorporation of this effect to the module participants seemed far more engaged in the listening process as their choices impacted directly on their learning experience.
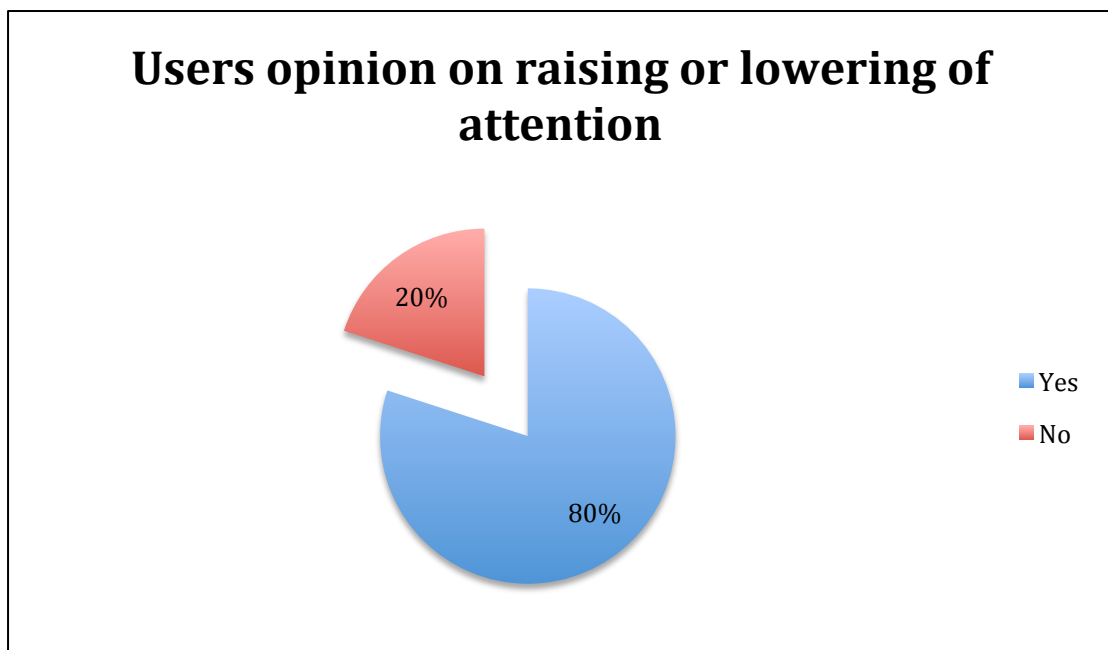
Figure 6.16: Hear3D effect on attention

Figure 6.16 gives an indication as to the users of the Hear3D systems opinion of whether or not the system increased their level of attention. The users opinion on Hear3Ds effect on raising or lowering attention was gathered using question 36 (Do you think your choice of source raised or lowered your ability to concentrate?). 80% of participants felt that the software raised their attention levels. From the

literature review it was shown how attention and alertness can be essential to the learning process.

In the case of Hear3D there are multiple reasons as to why it raised the users attention. Users were paying more attention to the audio (particularly at the start) as they wanted to listen out for the spatial sounds effect on the audio. The interaction with the choice of source also raises interaction levels and as was discussed in the literature – interaction increase attention.

The fact that Hear3D increases attention is of great potential benefit and opens the door to much further research. This is due to even hen the sound effect isn't even overwhelmingly obvious the user is still oblivious to this and will still pay more significantly more attention than non-software users.
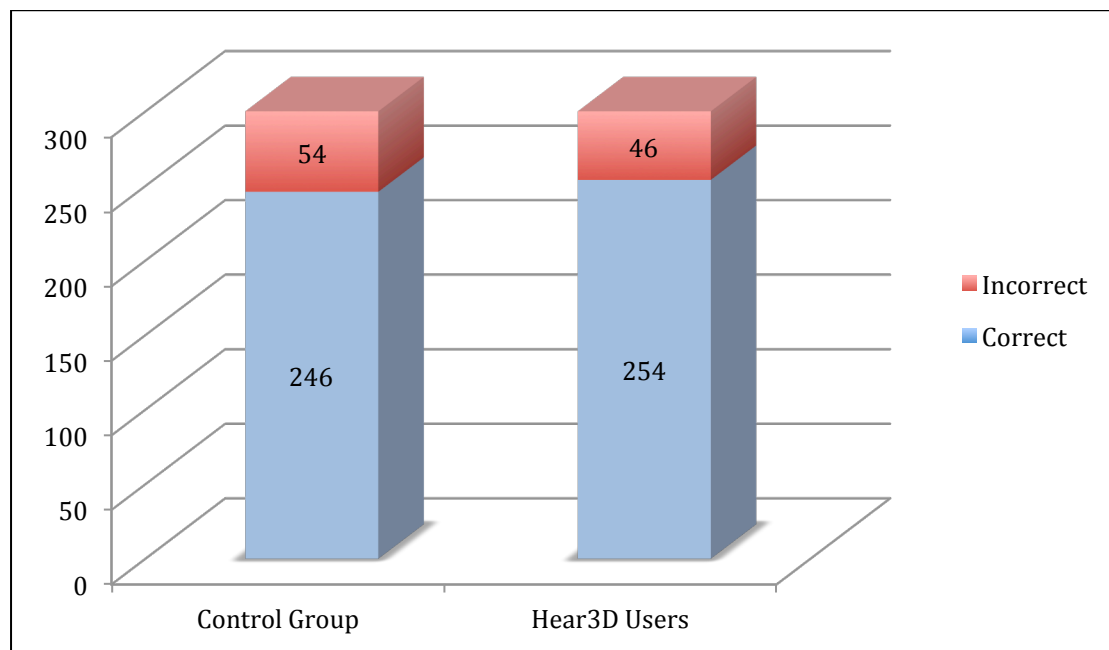
Figure 6.17: Control group vs. Hear3D group

Figure 6.17 is an overall graphical representation if the two groups correct and incorrect answers. Between the two groups there is an increase of 8 correct answers. Although this is a relatively small increase, with more participants there could be a significant difference.

This is promising for any future research to be conducted in the area of spatial sounds and knowledge retention as the results are showing an increase in the amount of correct answers. The fact that the average score increased from 16.4 in the control group to 16.9 in the Hear3D group further illustrates this potential.

If further research was conducted in this area there could be a far greater representation of spatial sounds effects on knowledge retention through the utilisation of binaural recordings to gain a better perspective on spatial sounds effectiveness as an aid to knowledge retention.

7. CONCLUSION

7.1 Introduction

This chapter will provide a synopsis of the research conducted during the course of this project. Firstly a research definition and overview will be given. Next a statement on contributions made to the body of knowledge resulting from the experiment will be given. A review will then take place based on the evaluation and limitations of the experiment. Areas of further research will then be outlined before a conclusion, which will summarise the deliverables and objectives presented and achieved during this research.

7.2 Research definition and research overview

The research experiment of this project consisted of the creation and evaluation of a software system – Hear3D. This software was tested as a means to evaluate the potential effects that spatial sounds could have when applied to educational content, in particular, French language learning audio.

The experiment involved the testing of two groups of participants, a control group (that listened to educational content on a standard format i.e. CD player) and an experimental group (that listened to the same audio content but their audio was slightly modified based on their interaction with the Hear3D software). These two groups were then assessed using the same questions based on the same education content.

Research into these results were then outlined and incorporated elements from the literature review as to possible implications it had based on the experimental results.

7.3 Contributions To The Body Of Knowledge

The following four contributions to the body of knowledge were made during the course of this research:

Users positional preferences in a three dimensional audio environment.

As a result of the experimental process it arose that users of Hear3D showed a strong preference to emulating the traditional classroom geography of sitting in front of the teacher/sound source. Even though the users were in a virtual environment and had been presented with 8 locations to chose from, 60% of users still chose to sit in front of the sound source (south). It also emerged that some users sat in the north location, as they would feel more comfortable not sitting in front of the teacher/sound source.

Measurement of the effectiveness of spatial sounds for language learning.

Presented in the experiment results is a measure of the effectiveness of 3D audio based on the experiment conducted. The results seemed subjectively dependent on the user, but an overall increase in test score between the control group and the Hear3D users was found.

Measurement of spatial sounds effect on attention.

Through the surveying of participants it was uncovered that 60% of Hear3D users felt that the spatial sounds increased their level of concentration which is a crucial element in the learning process.
A software system for the testing of spatial sounds.

A system for the testing of spatial sounds in an interactive environment was developed. Incorporated into this was an original language learning module and an interactive GUI. This format could be used again in the future to run further research on the basis of this study.

7.4 Experimentation, Evaluation and Limitation

7.4.1 Experimentation

Experimentation was conducted through the development of a spatial sound environment – Hear3D. This experimentation resulted in the four contributions that were discussed in the previous section. The creation of this software allowed for the testing of the research question – what effect do spatial sounds have on learning.

7.4.2 Evaluation

For the evaluation process, two groups of participants were tested. Firstly a control group were presented with French language learning audio and were then tested on this content with a multiple choice style questionnaire. Next the Hear3D users engage with the software to position themselves in the 3D classroom which alters the sound of the audio based on their choice (the content of the audio is the same across both groups). The Hear3D users were then tested using the same multiple choice questions.

These results were than compared and contrasted and a picture was developed of the Hear3D users preferences with regards their positioning in a 3D environment.

The conclusion from these results were that spatial sounds have the potential to benefit audio-based educational content. The second finding is that the users positional preferences in an interactive virtual environment are still heavily influenced by the traditional student role of sitting in front of the teacher.

7.4.3 Limitations

Limitations of this experiment were mainly due to the difficulty in creating the Hear3D software.

The spatial sound effect was not as prominent as was hoped for during the development process, but the effect is relatively prominent when positioned to the east or west.

The software was also limited to usage on the laptop on which it was developed. This meant that the testing and experimentation stages were tedious and time consuming.

The selection of participants was also a difficulty considering a lot of people have some degree of exposure to the French language.

7.5 Future Work & Research

As a result of this research many avenues of potential future work and research have emerged:

Binaural Recordings Environment.

The understanding of 3D audios effect on knowledge retention could be furthered through the use of binaural recordings. These recordings give a far more vivid sense of sound location than the Java3D system. Through the development of such a system further light could be shed on 3D audios benefits to knowledge retention.

Study of virtual classroom geography.

Further research could be developed involving the study of users decisions in a virtual classroom as opposed to a real classroom. Even from the small elements that it brought forward during the course of this research were extremely interesting. Further study in this area could receive great attention in the coming years as computers and the Internet continue to combine and interact with learning.

Application of sound positions to language learning content.

Further study could be created around the pre-application of spatial sound sources to audio content. This could develop a better understanding of which sources are better than others, as in the Hear3D experiment most people chose the south position. This would also allow for a greater amount of participants as the Hear3D software wouldn't be required and the content could be circulated on the Internet.

7.6 Conclusion

7.6.1 Objectives

The following objectives were achieved:

- *Development of a language-learning module.*
- *Application the sound source set-ups to the language module (Programming).*
- *Development of the module into an intuitive questionnaire.*
- *Measure the effect of the module through the results of questionnaires.*
- *Identify types of sound positional Preferences.*
- *Assess the effectiveness of the spatialised sounds on the knowledge retention by the participants.*

7.6.2 Deliverables

The following deliverables were also accomplished during the course of this research:

- *Language Module-High quality audio recorded using Audacity.*
- *Hear3D-spatial audio software.*
- *Questionnaires Developed for testing of both participant groups.*

7.6.3 Conclusion

This research has made every effort to evaluate the effectiveness of spatial sounds with regards knowledge retention. A system (Hear3D) was developed in order to test this research. Spatial sounds and language learning are still prominent areas of research. This project has established numerous areas of further research and study.

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PROGRAMMING REFERENCE:

Java3D: <http://www.oracle.com/technetwork/java/javase/tech/index-jsp-138252.html>

JOALMixer:<http://www.paulscode.com/docs/SoundSystem/paulscode/sound/libraries/LibraryJavaSound.html>

OpenAL: <http://connect.creativelabs.com/openal/Downloads/Forms/AllItems.aspx>

APPENDIX A

Module Script (French)

TEACHER	"Bonjour"
* TEACHER*	"Je m'appelle Rena. Apprenons le francais"
* TEACHER*	"Comment t'appelles tu"
+LISTENER+	" Je m'appelle..."
* TEACHER*	"Tres Bien"
* TEACHER*	"J'habite a Paris"
* TEACHER*	"Ou Habites-tu?"
+LISTENER+	" J'habite ..."
* TEACHER*	"Tres Bien!"
* TEACHER*	"Je vais a l'ecole a Paris"
* TEACHER*	"Vas-tu encore a l'ecole"
+LISTENER+	"…"
* TEACHER*	"Tres Bien"
* TEACHER*	"As-tu une grande famille?"
* TEACHER*	"Il y en a 3 dans la mienne. J'ai une frère et une soeur"
+LISTENER+	"frère / soeur"
* TEACHER*	"Tres bon, ton francais s'ameiliore deja"
* TEACHER*	"Apprenons des mots de tous les jours, commencons par les jours de la semaine"
* TEACHER*	"Lundi, Mardi, Mercredi, Jeudi, Vendredi, Samedi, Dimanche"
* TEACHER*	"Sais-tu quell jours de la semaine nous avons aujourd'hui?
+LISTENER+	"….."
* TEACHER*	"Apprenons les mois nous sommes"
* TEACHER*	" Janvier, Fevrier, Mars, Avril, Mai, Juin, Juillet, Aout, Septembre, Octobre, Novembre, Decembre"
* TEACHER*	"Sais tu dans quell mois nous sommes?"
+LISTENER+	"….."
* TEACHER*	"Tres bien, Apprenons quelques nombres maintenant"
* TEACHER*	"1,2,3,4,5,6,7,8,9,10"
* TEACHER*	"maintenant peux tu me dire combine de jambs a un chat"
* TEACHER*	"Commencons par les personnes"

* TEACHER*   "home, femme, garcon, fille"

* TEACHER*   "Parlons du temps"

* TEACHER*"Soleil, ciel, pluie, brouillard, nuage, vent, il fait beau, il fait chaud, il
pleut, il vente"

* TEACHER*"   Parlons de l'ecole"

* TEACHER*"   ecole, professor, bibliotheque, notes, class, craie, bureau,
controle, devoirs"

* TEACHER* "Anglais, francais, espagnol, allemande, biologie, chimie, physique,
maths"

* TEACHER*"parlons de norriture"   (French/English)

* TEACHER* "banana, citrone, orange, pomme, poulet, porc, boeuf, beurre, fromage,
lait, the, café, petit-dejuner, diner, dessert"

* TEACHER*"OK, Merci d'avoir pris le temps d'avoir suivi ce cours, je pense que
nous avons appris beaucoup aujord'hui, mais une derniere chose, apprenons a dire au
revoir"

* TEACHER*   "Au revoir"

+LISTENER+   "Au Revoir"

APPENDIX B

Module Script (English)

TEACHER	"Hello"	(French & English)
* TEACHER*	"My Name Is Rena, Lets learn some French"	(French & English)
* TEACHER*	"What is your name?"	(French & English)
+LISTENER+	"My Name Is ..."	(French)
* TEACHER*	"Excellent!"	(French/English)
* TEACHER*	"I Live in Paris"	(French/English)
* TEACHER*	"Where do you live?"	(French/English)
+LISTENER+	"I Live in ..."	(French)
* TEACHER*	"Excellent!"	(French/English)
* TEACHER*	"I go to school in Paris"	(French/English)
* TEACHER*	"Are you still in school? Yes/No?"	(French/English)
+LISTENER+	"Yes/No"	(French)
* TEACHER*	"Very Good"	(French/English)
* TEACHER*	"Do You have a big family?"	(French/English)
* TEACHER*	"There are 3 in mine, I have 1 brother & 1 sister"	(French/English)
+LISTENER+	"I Have….."	(French)
* TEACHER*	"that's very good, your French is already improving"	(French/English)
* TEACHER*	"Lets learn some everyday words, starting with the days of the week"	
* TEACHER*	"Monday, Tuesday, Wednesday, Thursday, Friday"	(French/English)
* TEACHER*	"Do you know what day it is today in French?"	(French/English)
+LISTENER+	"Its…."	(French)
* TEACHER*	"Lets learn the months of the year"	(French/English)
* TEACHER*	"January….."	(French/English)
* TEACHER*	"Do you know what month it is?"	(French/English)
+LISTENER+	"Its…."	(French)
* TEACHER*	"Very good, now lets learn some numbers"	(French/English)
* TEACHER*	"1,2,3,4,5,6,7,8,9,10"	(French/English)
* TEACHER*	"now lets learn some everyday grammar"	(French/English)
* TEACHER*	"lets start with grammar of people"	(French/English)
* TEACHER*	"man, woman, boy, girl"	(French/English)
* TEACHER*	"lets talk about the weather"	(French/English)
* TEACHER*	"Sun, Sky, Rain, Fog, Cloud, Wind, its nice, its warm, its raining, its windy"	
* TEACHER*	"lets talk about school"	(French/English)

* TEACHER*   "school, teacher, library, grades, classes, chalk, desk, test, homework"

* TEACHER*   "English, French, Spanish, German, Biology, chemistry, physics, maths"

* TEACHER*   "lets talk about food"   (French/English)

* TEACHER*   "banana, lemon, orange, apple, chicken, pork, beef, butter, cheese, milk,
tea, coffee, breakfast, dinner, desert"   (French/English)

* TEACHER*   "OK, thanks for taking the time to do this course I think we have learned
          enough for today, but one last thing, lets learn to say goodbye" (French/English)

* TEACHER*   "Goodbye"

+LISTENER+   "Goodbye"

APPENDIX C

Control Group Questionnaire

**Could you please circle your Age: Under 18   18-24   25-34   35-44   45-55
55-64   64+**

1.I wish I could speak French.

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Indifferent | Slightly Agree | Moderately Agree | Strongly Agree |

2.Learning French Is Great

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Indifferent | Slightly Agree | Moderately Agree | Strongly Agree |

3.I have a desire to learn French

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Indifferent | Slightly Agree | Moderately Agree | Strongly Agree |

4.I think learning French is a waste of time

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Indifferent | Slightly Agree | Moderately Agree | Strongly Agree |

5.I would get nervous if I had to speak French

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Indifferent | Slightly Agree | Moderately Agree | Strongly Agree |

6.I wouldn't enjoy having to express myself in French.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Indifferent	Slightly Agree	Moderately Agree	Strongly Agree

7.Do you remember how to say "my name is" in french?

je m'apperre   je m'appelle   je m'apres   je m'apitant

8. Do you remember how to say "I live in" in french?

J'habitelle   J'habitant   J'habitere   J'habite

9. Do you remember how to say "Yes" in french?

Ouir   Ouie   Oui   Outil

10.Do you remember the word for "sister" in French?

Soi   Soierie   Soeur   Soie

11.Do you remember the word for "Tuesday" in French?

Mare   Mardi   Marechal   Maree

12.Do you remember the word for "February" in French?

Feve   Fevrier   Feutrer   Feuillet

13.Do you remember the word for "7" in French?

Sepia   Septante   Serai   Sept

14.Do you remember the word for "9" in French?

Neuf   Nettie   Net   Nerf

15.Do you remember the word for "school" in French?

Ecorcer   Eclusier   Ecolier   Ecole

16.Do you remember the word for "woman" in French?

Feminite   Felure   Femme   Feloque

17.Do you remember the word for "Fog" in French?

Brouillard Brouille   Brouillone Broussailleaux

18.Do you remember how to say "Rain" in French?

Plusieurs   Pluvial   Pluie   Plut

19.Do you remember the word for "week" in French?

Semaine   Semailles Semblable Semblant

20.Do you remember the word for "Biology" in French?

Biomasse Bise   Bipede   Biologie

21.Do you remember the word for "food" in French?

Nourrisson Nourrir   Nourriture Nourrice

22.Do you remember the word for "apple" in French?

Pommade Pomme   Pommeau Pommelee

23.Do you remember the word for "cheese" in French?

Froler   Froment   Fromage   Froneer

24.Do you remember the word for "coffee" in French?

Cafard   Cafardeux Caf   Cafe

25.Do you remember the word for "pork" in French?

Porc-epic   Porcin   Porc   Porche

26.Do you remember the word for "goodbye" in French?

Au Revoir   Au Revolte   Au Revolu   Au Revard

27.Have you any previous experience with french? (Yes/No)

28.If so, what sort of experience do you have?

37.Thank you for taking the time to complete this survey, if you have any additional comments or notes it would be much appreciated to state them in the box below.

APPENDIX D

Hear3D User Questionnaire

Could you please circle your Age: Under 18   18-24   25-34   35-44   45-55 55-64   64+

1.I wish I could speak French.

Strongly   Moderately Slightly   Indifferent Slightly   Moderately   Strongly
Disagree   Disagree   Disagree   Agree   Agree   Agree

2.Learning French Is Great

Strongly   Moderately Slightly   Indifferent Slightly   Moderately   Strongly
Disagree   Disagree   Disagree   Agree   Agree   Agree

3.I have a desire to learn French

Strongly   Moderately Slightly   Indifferent Slightly   Moderately   Strongly
Disagree   Disagree   Disagree   Agree   Agree   Agree

4.I think learning French is a waste of time

Strongly   Moderately Slightly   Indifferent Slightly   Moderately   Strongly
Disagree   Disagree   Disagree   Agree   Agree   Agree

5.I would get nervous if I had to speak French

Strongly   Moderately Slightly   Indifferent Slightly   Moderately   Strongly
Disagree   Disagree   Disagree   Agree   Agree   Agree

6.I wouldn't enjoy having to express myself in French.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Indifferent	Slightly Agree	Moderately Agree	Strongly Agree

7.Do you remember how to say "my name is" in french?

je m'apperre   je m'appelle   je m'apres   je m'apitant

8. Do you remember how to say "I live in" in french?

J'habitelle   J'habitant   J'habitere   J'habite

9. Do you remember how to say "Yes" in french?

Ouir   Ouie   Oui   Outil

10.Do you remember the word for "sister" in French?

Soi   Soierie   Soeur   Soie

11.Do you remember the word for "Tuesday" in French?

Mare   Mardi   Marechal   Maree

12.Do you remember the word for "February" in French?

Feve   Fevrier   Feutrer   Feuillet

13.Do you remember the word for "7" in French?

Sepia   Septante   Serai   Sept

14.Do you remember the word for "9" in French?

Neuf   Nettie   Net   Nerf

15.Do you remember the word for "school" in French?

Ecorcer   Eclusier   Ecolier   Ecole

16.Do you remember the word for "woman" in French?

Feminite   Felure   Femme   Feloque

17.Do you remember the word for "Fog" in French?

Brouillard Brouille   Brouillone Broussailleaux

18.Do you remember how to say "Rain" in French?

Plusieurs   Pluvial   Pluie   Plut

19.Do you remember the word for "week" in French?

Semaine   Semailles Semblable Semblant

20.Do you remember the word for "Biology" in French?

Biomasse Bise   Bipede   Biologie

21.Do you remember the word for "food" in French?

Nourrisson Nourrir   Nourriture Nourrice

22.Do you remember the word for "apple" in French?

Pommade Pomme   Pommeau Pommelee

23.Do you remember the word for "cheese" in French?

Froler   Froment   Fromage   Froneer

24.Do you remember the word for "coffee" in French?

Cafard   Cafardeux Caf   Cafe

25.Do you remember the word for "pork" in French?

Porc-epic Porcin   Porc   Porche

26.Do you remember the word for "goodbye" in French?

Au Revoir Au Revolte Au Revolu Au Revard

27.Do you think Hear3D helped your learning?

Strongly	Moderately	Slightly	Indifferent	Slightly	Moderately	Strongly
Disagree	Disagree	Disagree		Agree	Agree	Agree

28.Do you think Hear3D hindered your learning?

Strongly	Moderately	Slightly	Indifferent	Slightly	Moderately	Strongly
Disagree	Disagree	Disagree		Agree	Agree	Agree

29.Did you think Hear3D altered the sound significantly?

Strongly	Moderately	Slightly	Indifferent	Slightly	Moderately	Strongly
Disagree	Disagree	Disagree		Agree	Agree	Agree

30.Do you think that Hear3D's audio manipulation assisted your learning?

Strongly Disagree	Moderately Disagree	Slightly Disagree	Indifferent	Slightly Agree	Moderately Agree	Strongly Agree

31.Do you think that Hear3D's audio manipulation assisted your learning?

32.Have you any previous experience with french? (Yes/No)

33.If so, what sort of experience do you have?

34.Which of the sound positions did you choose?

35.For what reason (if any) did you choose this source?

36.Do you think your choice of source raised or lowered your ability to concentrate?

37.Thank you for taking the time to complete this survey, if you have any additional comments or notes it would be much appreciated to state them in the box below.

Hear3D Source Code

'^*

```
public class Hear3D {

public static void main (String[] args){

  JFrame frame = new JFrame("Hear3D");
  frame.setVisible(true);
  frame.setSize(500,500);
  frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
  JPanel panel = new JPanel();
  frame.add(panel);

  ImageIcon image = new ImageIcon("C:\\Hear3D\\ReaderImage.jpg");
  JLabel imageLabel = new JLabel(image);
  imageLabel.setBounds(195, 183, 100, 100);
  panel.add(imageLabel);

      //NORTH WEST
  JButton button = new JButton("North West");
  panel.setLayout(null);
  button.setBounds(10, 10, 100, 100);
  panel.add(button);
  button.addActionListener (new Action1());

      //NORTH
  JButton button2 = new JButton("North");
  button2.setBounds(195, 10, 100, 100);
  panel.add(button2);
  button2.addActionListener (new Action2());

      //NORTH EAST
```

```java
JButton button3 = new JButton("North East");
button3.setBounds(375, 10, 100, 100);
panel.add(button3);
button3.addActionListener (new Action3());


        //WEST
JButton button4 = new JButton("West");
button4.setBounds(10, 185, 100, 100);
panel.add(button4);
button4.addActionListener (new Action4());


        //SOUTH WEST
JButton button5 = new JButton("South West");
button5.setBounds(10, 355, 100, 100);
panel.add(button5);
button5.addActionListener (new Action5());


        //SOUTH
JButton button6 = new JButton("South");
button6.setBounds(195, 355, 100, 100);
panel.add(button6);
button6.addActionListener (new Action6());


        //SOUTH EAST
JButton button7 = new JButton("South East");
button7.setBounds(375, 355, 100, 100);
panel.add(button7);
button7.addActionListener (new Action7());


        //EAST
JButton button8 = new JButton("East");
button8.setBounds(375, 185, 100, 100);
panel.add(button8);
button8.addActionListener (new Action8());
```

```java
        }

        //NORTH WEST
static class Action1 implements ActionListener {
        public void actionPerformed (ActionEvent e) {
                try{
                SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class );
            SoundSystemConfig.addLibrary( LibraryJavaSound.class );
            SoundSystemConfig.setCodec( "wav", CodecWav.class );
            }
            catch( SoundSystemException e1 )
            {
              System.err.println("error linking with the pluggins" );
            }

              SoundSystem SoundMixer = new SoundSystem();
              SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
              SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
                  200, 0, -200,
                  SoundSystemConfig.ATTENUATION_ROLLOFF,
                  SoundSystemConfig.getDefaultRolloff()
                  );
          }
          }
          //NORTH
static class Action2 implements ActionListener {
  public void actionPerformed (ActionEvent e) {
          try{
          SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class );
      SoundSystemConfig.addLibrary( LibraryJavaSound.class );
      SoundSystemConfig.setCodec( "wav", CodecWav.class );
  }
```

```
        catch( SoundSystemException e1 )
    {
        System.err.println("error with soundconfig" );
    }
            SoundSystem SoundMixer = new SoundSystem();
            SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
            SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
                0, 0, -200,
                SoundSystemConfig.ATTENUATION_ROLLOFF,
                SoundSystemConfig.getDefaultRolloff()
                );
    }
}


        //NORTH EAST
static class Action3 implements ActionListener {
        public void actionPerformed (ActionEvent e) {
                try{
                SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class );
              SoundSystemConfig.addLibrary( LibraryJavaSound.class );
              SoundSystemConfig.setCodec( "wav", CodecWav.class );
            }
            catch( SoundSystemException e1 )
            {
            System.err.println("error with soundconfig" );
            }
                SoundSystem SoundMixer = new SoundSystem();
                SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
                SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
                    -200, 0, -200,
                    SoundSystemConfig.ATTENUATION_ROLLOFF,
                    SoundSystemConfig.getDefaultRolloff()
                    );
            }
```

```java
        }


        //WEST
static class Action4 implements ActionListener {
        public void actionPerformed (ActionEvent e) {
                try{
                        SoundSystemConfig.addLibrary(
LibraryLWJGLOpenAL.class );
                        SoundSystemConfig.addLibrary( LibraryJavaSound.class );
                        SoundSystemConfig.setCodec( "wav", CodecWav.class );
                }
                catch( SoundSystemException e1 )
                {
                    System.err.println("error with soundconfig" );
                }

                    SoundSystem SoundMixer = new SoundSystem();
                    SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
                    SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
                        200, 0, 0,
                        SoundSystemConfig.ATTENUATION_ROLLOFF,
                        SoundSystemConfig.getDefaultRolloff()
                        );
         }
         }


         //SOUTH WEST
static class Action5 implements ActionListener {
         public void actionPerformed (ActionEvent e) {
                 try{
                 SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class );
        SoundSystemConfig.addLibrary( LibraryJavaSound.class );
        SoundSystemConfig.setCodec( "wav", CodecWav.class );
   }
```

```
   catch( SoundSystemException e1 )
{
   System.err.println("error with soundconfig" );
}
            SoundSystem SoundMixer = new SoundSystem();
            SoundMixer.setListenerPosition( 0, 0, 0 );
            SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
            SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
          200, 0, 200,
          SoundSystemConfig.ATTENUATION_ROLLOFF,
          SoundSystemConfig.getDefaultRolloff()
         );
     }
   }


//SOUTH

static class Action6 implements ActionListener {
       public void actionPerformed (ActionEvent e) {
             try{
             SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class );
     SoundSystemConfig.addLibrary( LibraryJavaSound.class );
     SoundSystemConfig.setCodec( "wav", CodecWav.class );
   }
   catch( SoundSystemException e1 )
   {
     System.err.println("error with soundconfig" );
   }
            SoundSystem SoundMixer = new SoundSystem();
            SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
            SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
            0, 0, 200,
            SoundSystemConfig.ATTENUATION_ROLLOFF,
            SoundSystemConfig.getDefaultRolloff()
```

```
            );
        }
    }
//SOUTH EAST
static class Action7 implements ActionListener {
        public void actionPerformed (ActionEvent e) {
                try{
                SoundSystemConfig.addLibrary( LibraryLWJGLOpenAL.class );
    SoundSystemConfig.addLibrary( LibraryJavaSound.class );
    SoundSystemConfig.setCodec( "wav", CodecWav.class );
  }
  catch( SoundSystemException e1 )
  {
    System.err.println("error with soundconfig" );
  }
            SoundSystem SoundMixer = new SoundSystem();
            SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
            SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
          -200, 0, 200,
          SoundSystemConfig.ATTENUATION_ROLLOFF,
          SoundSystemConfig.getDefaultRolloff()
        );
        }
    }


//EAST
static class Action8 implements ActionListener {
        public void actionPerformed (ActionEvent e) {
                try{
                        SoundSystemConfig.addLibrary(
LibraryLWJGLOpenAL.class );
                SoundSystemConfig.addLibrary( LibraryJavaSound.class );
                SoundSystemConfig.setCodec( "wav", CodecWav.class );
            }
```

```java
        catch( SoundSystemException e1 )
        {
          System.err.println("error with soundconfig" );
        }
            SoundSystem SoundMixer = new SoundSystem();
            SoundMixer.setPosition( "FrenchLessonMono.wav", 0, 0, 0 );
            SoundMixer.quickPlay( false, "FrenchLessonMono.wav", false,
                -200, 0, 0,
                SoundSystemConfig.ATTENUATION_ROLLOFF,
                SoundSystemConfig.getDefaultRolloff()
                );
      }
    }
  }
```