THE FORMAL DESCRIPTION OF AEROBIC DANCE EXERCISE : A CORPUS-BASED COMPUTATIONAL LINGUISTICS APPROACH

By Adam Bull

Submitted in accordance with the
requirements for the degree of MPhil

University of Leeds
School of Computer Studies

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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ABSTRACT

Over the past three decades the fitness activity known as Aerobics has evolved into one of the most popular and widely used forms of exercise in the world. It is now taught by specifically trained fitness professionals with high levels of knowledge in the fields of human kinesiology, physiology, anatomy and exercise theory. In the past, little attempt has been made to formally record and analyse the choreography itself, or to involve the use of computer technology.

There is a clear need for the development of a formalism for representing Aerobic choreography, and this is investigated in the research presented. The development of such a formal model for the language of Aerobic Dance Exercise using Computational Linguistics techniques is described, and some of its potential uses explored.

In particular the Bodytronix Project, as it became known, involved the collection of a corpus, or representative set, of Aerobics workout routines from qualified and practising fitness leaders; the conversion of the corpus into a standardised knowledge-representation language, or tree bank, held on computer; the extraction of a lexicon of Aerobics moves, annotated with formalised semantic and syntactic descriptors; and the

extraction of a formalised grammar, or language model, of an Aerobics workout based on the theory of Generalised Phrase-Structure Grammars (GPSG's).

ACKNOWLEDGEMENTS

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Thanks to all my friends and contacts in the fitness industry who have provided much crucial help and information, without which this research could not have been completed.

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Last, but by no means least, thanks to my mum and dad who are always on my side when it matters most.

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Nothing would be done at all if a man waited 'till he could do it so well that no-one could find fault with it.

– John Henry Newman

You have to sweat. If I've got time, you've got time... I exercise as if my life depends on it, which in a way it does.

– Jane Fonda

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ABBREVIATIONS

AAHPERD – **American Alliance for Health, Physical Education, Recreation and Dance**

ACCOLADE – **A Computerised Corpus of Legal Aerobic Dance Exercise**

ACHPER – **Australian Council for Health, Physical Education and Recreation**

AI – **Artificial Intelligence**
A branch of science attempting to model manifestations of human intelligence using computer-based means.

ASSET – **The National Association of Health and Exercise Teachers**
One of the three main professional organisations for fitness leaders.

bpm – **Beats per minute**
Used as a measurement of music speed.

CF – **Context-Free**
A grammar with no context expressions.

CF-PSG – **Context-Free Phrase Structure Grammar**
A simple ‘re-write’ grammar with no context expressions.

DCG – **Definite Clause Grammar**
A formalism found chiefly in logic programming, used for encoding simple grammars using inference rules.

EAG – **Extended Affix Grammar**
A unification and feature-based extension of a CF grammar.

GPSG – **Generalised Phrase Structure Grammar**
A generative unification grammar designed to capture generalisations which exist in the languages to which it is applied.

HIA – **High Impact Aerobics**
A term used to define exercises used in an Aerobics class where both feet leave the floor simultaneously (e.g. jogging, jumping-jacks). Such exercises cause particularly high impact forces on joints in the lower body when landing.

ID/LP – **Immediate Dominance/Linear Precedence**

Rules used in GPSG's to capture generalisations apparent in natural language.

NLP – **Natural Language Processing**
A branch of AI dealing with the computer-based analysis and modelling of written or spoken human languages.

PC's – **Personal Computers**

POW – **Polytechnic of Wales Corpus**
A tagged corpus of children's spoken English.

PSG – **Phrase Structure Grammar**

RSA – **Royal Society of Arts**

TABLES AND FIGURES

NOTES ON CONVENTIONS USED

References

References are shown by the surname of the principal author or editor, followed by the year of publication, enclosed in square brackets.

e.g. [Chomsky, 1957]

Where two publications exist by the same author in the same year, a hash figure is added to differentiate between the two.

e.g. [Bull, 1990 #1] [Bull, 1990 #2]

Where two publications exist by different authors of the same surname, a first initial is added to differentiate between the two.

e.g. [Thompson H, 1992] [Thompson M, 1992]

CHAPTER 1 : Introduction

Over the past three decades the fitness activity known as Aerobics has evolved from its rough and ready beginnings into one of the most popular and widely used forms of exercise in the world. Once taught by anyone with enough enthusiasm and a loud voice, it is now a skilled science taught by specifically trained fitness professionals with high levels of knowledge in the fields of human kinesiology, physiology, anatomy and exercise theory.

Research into the safety and effectiveness of various aspects of Aerobics has been ongoing for some time, but has concentrated chiefly on either the general class style (e.g. High Impact, Low Impact, Step Aerobics) or the individual exercise movements which form the building blocks for class choreography. Little attempt has been made to formally record and analyse the choreography itself, or to involve the use of computer technology.

The recording of class choreography remains an arbitrary and haphazard affair belying its vast potential for progressing knowledge in the field. There is a clear need for the development of a formalism for representing Aerobic choreography, so that classes may be recorded in a standard and universally-understood manner. Such a tool would allow easy conveyance of new choreographic ideas from one instructor to the next, would help in the training of new instructors, would enable the in-depth analysis of the effects of particular exercise sequences on participants, and would allow fitness trends to be monitored. Even legal grey areas such as intellectual copyright would benefit from a standardisation of Aerobic choreography representation methods.

1.1 Brief Description of the Research

The research presented in this document describes the development of a formal model for the language of Aerobic Dance Exercise using computational linguistics techniques, and explores some of its potential uses.

The following key elements were involved in what will henceforth be referred to as the Bodytronix Project:

- The collection of a corpus, or representative set, of Aerobics workout routines from qualified and practising fitness leaders.
- The conversion of the corpus into a standardised knowledge-representation language, or tree bank, held on computer.
- The extraction of a lexicon of Aerobics moves, annotated with formalised semantic and syntactic descriptors.
- The extraction of a formalised grammar, or language model, of an Aerobics workout.

1.2 Structure of the Thesis

The Bodytronix Project brings together two completely distinct fields of knowledge which have traditionally had nothing to do with each other, namely Computational Linguistics and Aerobic Dance Exercise. Consequently, this thesis is likely to be read by people who are unfamiliar with one or the other of these fields. Chapter 2 therefore contains a general introduction to the key areas of interest, allowing readers to gain a required minimum level of background knowledge in all fields. The chapter also describes other existing research related to the Bodytronix Project.

Chapter 3 provides a broader overview of the project, its contribution to knowledge, and its practical values to the Fitness Industry and Scientific Community. The chapters

which follow then describe each aspect of the research in detail. Finally, there is an assessment of the completed work together with conclusions and a discussion of possible future projects based on the research.

1.3 A Note on Terminology

The term ‘Exercise to Music’ is a generic term used when referring to any form of exercise requiring music to regulate its flow. Many formats of Exercise to Music class exist (including Aqua-fitness, Circuit Training, Cardiofunk, Jazzercise, etc.), but this thesis deals with the format known most commonly as ‘Aerobics’, or ‘Aerobic Dance Exercise’.

Whenever the *proper noun* ‘Aerobics’ is used in the following text, it refers to the exercise class format. This should not be confused with the noun ‘aerobics’, which refers to *any system* of sustained exercise designed to increase the amount of oxygen in the blood and strengthen the heart and lungs. ‘Aerobics’ always appears as a plural noun.

People who lead Exercise to Music classes are most commonly referred to as ‘teachers’, ‘instructors’ or ‘fitness leaders’, and these terms are used interchangeably in the text.

1.4 A Personal Justification by the Author

The Bodytronix Project is unique, and lies in an area not well covered in scientific literature. There are occasions where statements are made which appear self-evident to experts in the fitness industry, but which cannot be readily supported by documented evidence. I believe it is necessary to briefly justify why I am personally able to make such statements, and to explain how my unusual combination of expertise has allowed me to undertake the project successfully.

My academic background is tied strongly to Computer Science and the third year of my BSc, including my final year project [Bull, 1989] was dedicated exclusively to all aspects of Artificial Intelligence (AI) and Natural Language Processing (NLP). From this training I gained the necessary computer skills, and a basic knowledge of computational linguistics which I developed during the course of my PhD research.

My knowledge and practical experience of Aerobics and the fitness industry is also extensive, however. I hold several internationally recognised qualifications in the teaching of Exercise to Music (including SHAPE, RSA and Step Reebok certification in the UK, and ACHPER certification in Australia) and have had over four years of practical experience in teaching various class formats to a wide cross-section of the public.

I regularly attend workshops and masterclasses to maintain my knowledge, and have had articles published in several major Fitness Industry Journals (including those from ASSET [Bull, 1991 #2], the Fitness Professionals organisation [Bull, 1991 #3] and the Australian Fitness Leaders Network [Bull, 1991 #4]).

My unusual combination of backgrounds resulted in the formulation of the Bodytronix Project and gave me the ability to successfully marry the two key fields of interest. Although much of the exercise theory presented in this thesis draws directly from my own experience and knowledge of Aerobics, I have wherever possible confirmed apparently self-evident truths with other experts in the field if no existing scientific references could be found.

CHAPTER 2 : Background Knowledge

In order to understand the importance of the work described in this thesis, as well as to appreciate the complexity of the tasks undertaken, it is necessary to have a basic understanding of the chief subject areas involved. The following chapter is aimed at providing this background knowledge, as well as describing other current research which is related to the Bodytronix Project.

2.1 Introduction to Aerobic Dance Exercise

Physical fitness is described by the World Health Organisation as "the ability to carry out daily tasks with vigour and alertness, without undue fatigue, and with ample reserve energy to enjoy leisure pursuits and meet unforeseen emergencies".

It is essential that everyone should try to maintain their health and fitness through regular exercise and a reasonably sensible diet. Aerobic Dance Exercise provides one of the most comprehensive, safe and time-efficient means of achieving physical fitness.

Two dictionary definitions are of particular interest at this point :

Aerobics : Any system of sustained exercise designed to increase the amount of oxygen in the blood and strengthen the heart and lungs [Collins, 1987].

Dance : To move the feet and body rhythmically, esp. in time to music [Collins, 1987].

When the two are combined, the result is an exciting, safe, and highly effective form of exercise which can be enjoyed by people of any age, and of any fitness level.

Using the simple definition given above, this thesis assumes aerobic dance to be a legitimate form of dance in its own right, as opposed to just a sporting activity. This is done because much associated research is concerned with the field of dance and it is therefore easier, when considering the value of this work to the Bodytronix Project, to think of Aerobics as a dance form.

While this point of view is quite valid, it is worth mentioning that there are conflicting ideas about what constitutes dance. Joann Kealiinohomoku for instance, in her own definition of dance, states that:

> '...Dance occurs through purposefully selected and controlled rhythmic movements; the resulting phenomenon is recognised as dance by the performer and the observing members of a given group.'

This definition sets apart activities that might appear at first glance to be dance, but which are purely sport or ritual in the eyes of those participating, from those which would be considered as dance by the same participants.

2.1.1 The Aerobics Phenomenon

Aerobics is fast becoming one of the world's most popular forms of fitness-related activity, and its growth in the UK over the last decade has been phenomenal. In 1988 it was found that, amongst people over the age of 15, Aerobics classes (together with the related activities of Keep Fit and Dance Exercise) were the most popular sporting pastimes after swimming, and in 1991 more money was spent on clothing, footwear and equipment for Aerobics and Keep Fit than on any other sport apart from golf [Sports Council, 1991].

In the UK today more than 8 million people (14% of the entire population) regularly participate in Aerobics, with approximately 24,000 classes being taught each week by over 8000 qualified instructors [Thompson N, 1992]. For those exercising at home there are over 130 readily available video workouts [Videolog, 1992], and an even higher number of books and publications. Globally, the 1992 World Aerobics Championships

attracted 25 participating countries [Thompson N, 1992], and it is expected that Championship Aerobics is to be included for the first time as a demonstration sport in the next Olympic Games.

Well planned classes can provide a safe and non-competitive environment where people can improve their fitness level whilst having fun at the same time. They have many proven physiological and psychological benefits from reducing the risk of heart disease to alleviating stress (see [Egger, 1989] and [Cullum, 1989] for more details). Specialist classes cater for groups such as the physically or mentally disabled, people with medical conditions, the very young or old, and pre/postnatal women, making Aerobics an activity uniquely available to almost all of the population.

2.1.2 The Complexity of a Modern Aerobics Class

Exercise classes conducted to music have existed for many years (See [Connoly, 1987] for a brief history), but only in the last two decades has considerable scientific research been undertaken to discover the physiological effects of specific aerobic exercises [Gianoli, 1989] and training techniques [Cooper, 1983] [Cooper, 1988].

The once haphazard practice of class planning is now a skilled science requiring the talents of a trained professional. Safety and effectiveness are of supreme importance as the rapidly increasing numbers of participants lead to higher occurrences of both chronic and acute exercise-related injuries. Gyms and fitness centres must now cater for a more discerning and knowledgeable clientele demanding quick results and able to sue careless or negligent instructors for injuries they may have caused through bad class planning.

Modern fitness leaders must employ a sound knowledge of physiology, biodynamics, and kinesiology, as well as be aware of current research into exercise safety, effectiveness and popularity trends. Other skills such as music analysis, class management and communication techniques are also necessary. A comprehensive

reference text covering all aspects of knowledge required by a modern instructor is provided by Howley [Howley, 1992].

In a well-planned class each exercise is carefully selected with consideration being given to such aspects as the muscle groups involved, movement intensity and execution speed, skill requirements, ease of transition from one movement to the next, equipment and floor type available, theme and style of the chosen music, and the physical limitations of participants in the target class.

2.1.2.1 A Typical Class Format

The format of a typical 60 minute class is shown in *Fig. 1*. A short warm-up period is followed by a section of more strenuous aerobic exercise, when the exercise intensity increases the heart rate to a level at which cardiovascular training effects will occur. This 'training zone' is dependant upon age and fitness, and is usually between 60% and 90% of the maximum heart rate [May, 1988].

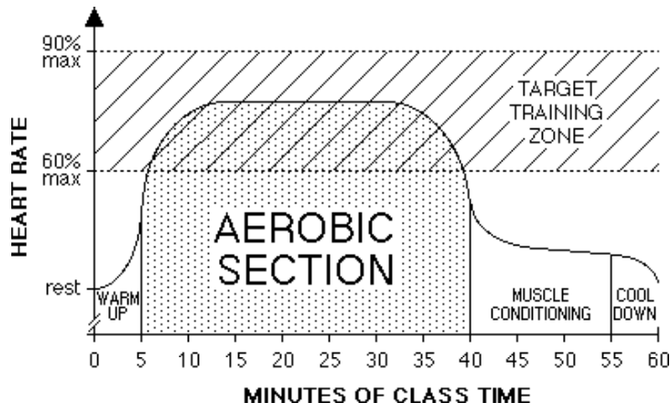

Fig. 1 : Structure of a typical Aerobics class showing the desired heart rate curve

After maintaining this intensity for some time, the heart rate is reduced slowly in preparation for a period of muscular conditioning (often referred to as 'floor-work' since the exercises are usually performed on the floor, as opposed to standing). Finally, there is a cool-down period of stretching and relaxation.

More detailed descriptions concerning the structure and purpose of each class section can be found in the relevant report by the author [Bull, 1990 #1]. Music is carefully chosen for each section of the class, with respect to its speed, style and mood. Appropriate speed is particularly important in order to maintain correct exercise intensity levels and to control exercise execution speed, ensuring a safe and efficient workout. *Fig. 2* shows how the speed of music (measured in beats per minute, or "bpm") might have varied during the class represented in *Fig. 1*.

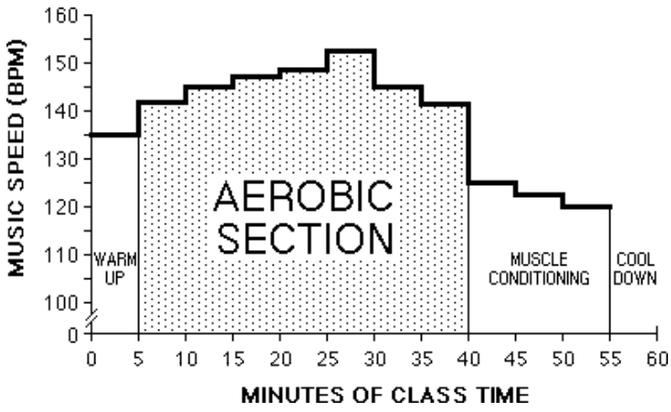

Fig. 2 : Typical music speed selection for a typical Aerobics class

Only the actual period of aerobic conditioning (see *Fig. 1*) is covered in the scope of the Bodytronix Project since the warm-up, muscle conditioning and cool-down sections of a full Aerobics class each bring their own individual difficulties. It is clear, however, that the general theories and formalisation techniques used for the aerobic section could equally be applied in each of the other sections with little modification.

2.1.2.2 Choreographic Transitions

The exercise movements being performed during a class are choreographed to the music being used and must change frequently in order to maintain correct levels of intensity, mental challenge and interest. Exercise sequencing is also needed to ensure that all muscle groups are worked effectively, and that repetitive stress injuries are avoided.

To give an idea of the size of the problem, consider the sample class format represented in *Fig. 1* and assume that on average a change of exercise will occur once every eight beats of music. Thus we can calculate:

Length of aerobic section	:	35 minutes
Average music speed	:	147 bpm
Total number of musical beats	:	35 x 147 = 5145 beats
Total number of changes of exercise	**:**	**5145 ÷ 8 = 643**

In other words, a teacher may need to choreograph over 600 exercise transitions for the aerobic section of the class. It can clearly be seen that planning an Aerobics class is not as straightforward often imagined by the general public.

2.2 Introduction to Artificial Intelligence

Artificial Intelligence (AI) is a vast subject area encompassing many fields of research such as Computer Vision, Human Animation, Natural Language Processing, Computational Linguistics, Robotics, and Expert Systems. Several areas are of significance to the Bodytronix Project, and these are briefly described in the following sections. Appropriate references are given for readers wishing to gain a more detailed insight into any of the subject areas.

2.2.1 Computational Linguistics and NLP

Computational Linguistics and NLP essentially represent different viewpoints of the same problem, and both strive towards similar goals. Both apply the concepts and techniques of computer science to the analysis of language in an attempt to create

formalised rule-based language models. NLP tends to be more application specific, however, whereas Computational Linguistics is concerned more with language theory for its own sake. Also, as its name suggests, NLP deals exclusively with 'natural languages', i.e. language forms used in natural human communication, whereas Computational Linguistics encompasses all language types irrespective of their origins or uses.

The research described in this thesis comes under the heading of Computational Linguistics because it is not immediately clear that Aerobics routine descriptions can be classified as a 'natural language'. Also, the Bodytronix Project deals purely with theoretical issues, although there are many obvious practical applications of the findings (these are described in Section 3.3).

2.2.1.1 Formal Models in Computational Linguistics

The rules which govern a natural language such as English operate at several distinct levels [Burton, 1987] [Gazdar, 1989] [Atwell, 1987], and this can be most easily demonstrated by showing examples where these rules are violated:

Phonological Level – The sound system of a language.
Violation : "Dwer jgkfk abb retjcsb"

Syntactic Level – The grammar of a language.
Violation : "I bed fell of out"

Semantic Level – The rules of meaning of a language.
Violation : "The rock ate the forest"

Pragmatic Level – Non-linguistic knowledge that allows us to interpret the language.
Violation : Paul says "Can you give me a hand?"
Jane responds by applauding!

The syntactic level is that most often studied in Computational Linguistics, and it is at this level where similarities can most closely be seen between the structure of English and that of Aerobics (See Chapter 8).

At the start of one of the most influential grammatical treatise ever written, the American linguist Noam Chomsky writes that a grammar is essentially a ‘device of some sort for producing the sentences of the language under analysis, [Chomsky, 1957].

Grammars used to represent syntactic structure usually consist of a lexicon of ‘terminal symbols’ (i.e. the ‘words’ of a language) stored with their syntactic properties (e.g. categorisations such as noun, verb, adjective), together with a set of rules specifying which combinations of these symbols are valid.

The rules generally work in a derivative way, showing how simple phrases can be combined into more complex ones until a whole sentence has been created. A simple grammar is shown in *Fig. 3*, represented using a formalism called PATR [Gazdar, 1989] which will later be adapted to represent the Aerobics grammar in Chapter 8.

Grammar Rules :

Rule {simple sentence formation}
S ∅ NP VP

Rule {transitive verb phrase}
VP ∅ V NP

Rule {noun phrase}
NP ∅ Det N

Lexicon :

Word loves:
<cat> = V

Word the:
<cat> = Det

Word girl:
<cat> = N

Word boy:
<cat> = N

Word boys:
<cat> = N

Fig. 3 : A simple Grammar

The grammar rules are known as ‘re-write’ or ‘phrase structure’ rules, and this type of grammar is a Phrase Structure Grammar (PSG). A sentence which can be generated by applying this grammar is shown in *Fig. 4* as a phrase structure tree.

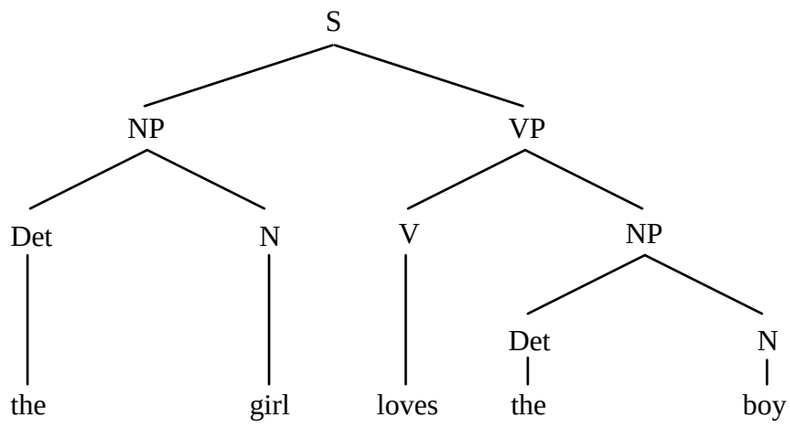

Fig. 4 : Applying the grammar rules from Fig. 3 – Phrase Structure Tree

The same sentence, together with its underlying phrase structure, can also be represented as a set of nested brackets as shown in *Fig. 5*. This method of representation is used within the Bodytronix Project for storing the corpus of Aerobics routines on computer (see Chapter 6).

[S [NP [Det **the**] [N **girl**]] [VP [V **loves**] [NP [Det **the**] [N **boy**]]]]

Fig. 5 : Applying the grammar rules from Fig. 3 – List Form

Grammars such as that shown above are limited because the rules take no account of the context in which they can occur. They are known as Context-free PSG’s (CF-PSG). For example, the above grammar would allow the sentence ‘the boy loves the girl’ as well as ‘the boys loves the girl’ because there is no generalised mechanism for checking the context in which the nouns ‘boy’ or ‘boys’ can appear.

Various extended versions of the basic CF-PSG form have been developed to overcome this problem, and the most useful of these to the Bodytronix Project is the Generalised Phrase Structure Grammar (GPSG). The most crucial difference is that GPSG treats all terminal items (i.e. words) and non-terminal items not as single units but as collections of feature-value pairs.

The values of these features can be passed up and down the phrase structure trees, allowing unification of lexical items to be carried out automatically. This property can be used to describe how words are allowed to behave in various contexts, and allow generalisations to be captured in a very compact form.

A detailed description of GPSG's is beyond the scope of this section, but more thorough introductions are provided by Keenan [Keenan, 1992] and Gazdar [Gazdar, 1985]. For an excellent introductory guide to all aspects of language, its structure and means of representation and analysis, the reader should consult 'The Cambridge Encyclopedia of Language' [Crystal, 1992].

2.2.1.2 Sub-languages

A natural language such as English is vast and diverse, and extremely difficult to capture fully using Computational Linguistic principles. To give some idea of the size of the problem, one of the largest grammars produced for English: 'A Comprehensive Grammar of the English Language' [Quirk, 1985], is 1,779 pages long.

In order to test new linguistic theories, or in applications where a full coverage of a natural language is not required (e.g. in data-base querying or some machine translation problems [Johnson, 1985]), a smaller subset of the language is used. These subsets are usually known as 'sub-languages', although experts have not yet fully agreed on an exact definition of what constitutes a sub-language [Thompson H, 1992].

The language of Aerobics could be considered to be a sub-language of spoken English since it is used for verbal communication within a limited domain, and with a restricted vocabulary.

2.2.1.3 Corpus Linguistics

Traditional methods for writing a formal grammar have involved linguistic introspection or, as described by Souter [Souter, 1990]:

> '…trying to elucidate the knowledge a native speaker has of how to form syntactic structures correctly in their language. Such grammars have rarely been large, empirical or objective, but have always handled well worn favourites such as "John Likes Mary", as the associated literature will testify.'

A more recent approach has been to derive the grammar from a large number of actual examples of the spoken or written language, gathered together in a 'corpus'. In this context a corpus is any collection of language data brought together for linguistic analysis.

A grammar developed from a corpus is constrained to be more objective, and able to deal with 'semi-grammatical' structures which occur in real language use. Its success relies partly on the corpus providing a large enough representative sample of the language under consideration.

There exist many large corpora, some containing just 'raw' samples of the language and some where the samples have been annotated (or 'tagged') to some degree. Two examples are the Polytechnic of Wales Corpus (POW), which consists of transcriptions of approximately 61,000 words of English spoken by children [Souter, 1990]; the LOB Corpus, which contains 500 text samples selected from texts printed in Great Britain in 1961 [Johansson, 1986];

A vast new corpus is currently being gathered, under the British National Corpus Project, which will contain over 100 million words of spoken English together with 90 million words of written English.

The Bodytronix Project is centred around the gathering of a corpus of Aerobic Dance Exercise routines for analysis using linguistics techniques, and so can be considered as falling within the field of corpus linguistics. General introductions to corpus linguistics and its applications can be found in [Oostdijk, 1991], [Atwell, 1990] and [Souter, 1993].

Oostdijk's book [Oostdijk, 1991] is particularly relevant to the Bodytronix Project as it describes how a large broad-coverage grammar was developed using a parsed corpus of English (the Nijmegen corpus) as a starting point. Oostdijk used example constructs in the parsed corpus to guide her expert linguistic intuitions in the design of an Extended Affix Grammar (EAG) for English.

EAG is a unification and feature-based extension of a context-free grammar, similar to PATR as used in [Gazdar, 1989]. By analogy, a combination of expert knowledge of Aerobics and examples from a parsed corpus, or tree-bank (see Chapter 6), were used in the Bodytronix Project to build a comprehensive unification-based grammar of Aerobics.

2.2.2 Human Figure Animation Techniques

There are many different approaches to the representation of the human body within a computer, and the animation of such information. In all cases there are several key problems to be overcome:

- How to make the animation sufficiently lifelike.
- How to make the figure accept instructions.
- How to perform the animation quickly enough to make it viable in real applications.

A discussion of the historical development of figure animation, and currently available systems, can be found in the report by Hall [Hall, 1989].

Human figure animation is relevant to the Bodytronix Project because it provides a means of representing the 'words' in the Aerobics Lexicon (i.e. the individual exercises from which routines are assembled) in a visual manner (see Chapter 7). Such representations will always be more rapidly and precisely understood than their textual counterparts, especially by people with little knowledge of the field of Aerobics.

2.2.2.1 Dynamic Vs Kinematic Systems

Much work has been done concerning dynamic control for the basis of figure animation [Badler, 1987]. Dynamic methods are concerned with modelling the physical forces acting upon the body, such as gravity, friction and muscle actions. They involve highly complex mathematical models and are computationally expensive.

The kinematic approach ignores the physical forces involved in producing movement, and concentrates on making sure that only physically possible movements occur at any joint. The precise movements of the body itself are directly controlled by the user of the system. This approach is more applicable in the field of dance, where translation from some form of choreographic notation to animation is required. This method is also more applicable, therefore, in the field of Aerobic Dance Exercise.

2.2.2.2 The NUDES System

The work most useful to the Bodytronix Project concerns the real-time animation of dancers, and has been undertaken by Herbison-Evans and Politis at the University of Sydney in the Computer Choreology Project [Herbison-Evans, 1985] [Politis, 1986], although various other systems are in existence, e.g. CHOREO by Savage [Savage, 1978].

The system used to animate the dancers is called NUDES (Numerical Utility for Displaying Ellipsoid Solids). A figure is created by first defining a collection of ellipsoids and then specifying how they are joined together to form a body. The ellipsoids may be given names which make specifying their movement more intuitive (e.g. the body may have an arm consisting of three ellipsoids called ‘right_upper_arm’, ‘right_forearm’ and ‘right_hand’).

Once the figure had been defined, it may be animated by describing how each body part moves over a period of time. Movement is specified using anatomical terms such as ‘flexion’, ‘extension’ and ‘rotation’, which again makes the system more intuitive to dancers or those with knowledge of human kinesiology.

When all intended actions have been specified, the system generates frames of animation which can then be displayed to provide the finished sequence. A typical NUDES figure is shown in *Fig. 6* at three levels of realisation.

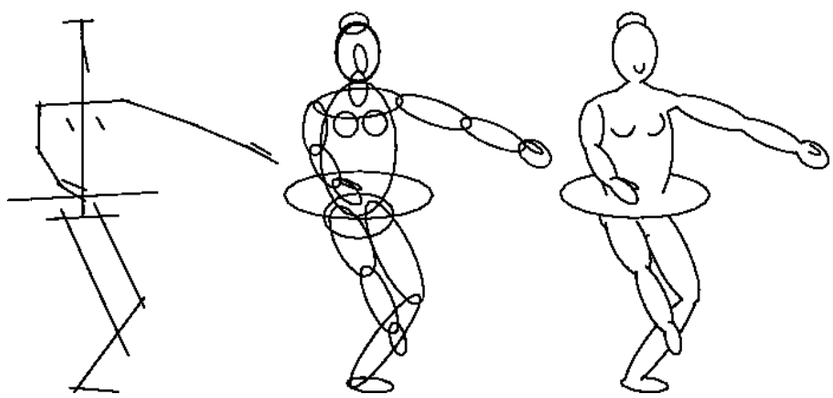

Fig. 6 : NUDES figure as axes only, full ellipsoids, and hidden line removal

The NUDES system is very versatile, and has been used to animate a variety of different physical forms [Herbison-Evans, 1987]. Two examples are shown in *Fig 7.* below.

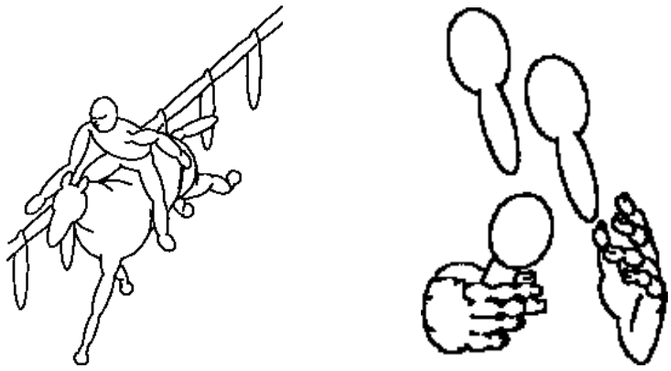

Fig. 7 : NUDES figures – Racehorse and Juggler

The relevance of NUDES to the Bodytronix Project is discussed in Chapter 7.

2.3 Dance Notation & Computer Choreography

Although dance has been present within society at least as long as any other form of human communication, a corresponding method of representation in written form has been relatively very slow to develop.

For centuries dance could only be passed on by demonstration, possibly because it was thought that the essence of such a complex and emotional activity simply could not be adequately conveyed through any other medium. As Isadora Duncan, the renowned dancer, put it: “If I could *tell* you what I mean, there would be no point in dancing” [Lansdown, 1977].

Dance *did* appear in writings and pictures throughout history, but not in a form detailed enough to allow reconstruction of the movement sequences involved, i.e. not for the purposes of teaching or recording choreography.

During the last five hundred years the desire to record, preserve and analyse original choreography finally led to the development of systems for notating dance on paper. Whereas the first systems could be used only to record specific dance steps, modern notation systems are capable of representing *any* movement in extreme detail. Although

usually still referred to as ‘dance notations’, because this is their primary domain of use, it would perhaps be fairer to use the less restrictive term ‘movement notations’.

Even today such systems are not readily accessible to the masses, however; their complexity requiring years of study to master completely. It has been said that “Dance notation is (or should be) to dance what music notation is to music and the written word to drama” [Guest, 1984]. This will not be the case until innovation simplifies the use and understanding of notation to the point where it can be understood by the non-specialist. Computers may be of considerable help in achieving this goal.

Like with dance, the permanent recording of Aerobics routines began late in the development of the field. Even today, however, there is no formal method for recording Aerobics choreography and the Bodytronix Project addresses this problem. Since Aerobics can be considered to be a sub-class of dance it was necessary to examine dance notation systems and test their applicability in the field of Aerobics (see Chapter 5).

A detailed description of the many dance notation systems currently in use is beyond the scope of this chapter, and the reader is advised to consult the book by Guest [Guest, 1984] for further information. Her book provides by far the most comprehensive guide to dance notation, from its early history to the modern day .

2.3.1 Computers in Dance

The use of computers in the arts has until very recently been minimal, but the potential is great. Already there are a few computer systems capable of assisting those whose job it is to record choreography, although they have not yet become widely accepted for use ‘in the field’ to any great extent. Some act as teaching tools for those learning to use notation, some act as ‘word-processors’ for dance, and others help visualise the choreography being recorded by use of figure animation (as mentioned in Section 2.2.2).

The most successful computerised systems to date have been created for Benesh Notation (e.g. Choreoscribe [Dransch, 1986], BED [Hagist, 1986] on the SUN workstation, and MacBenesh [Marcovici, 1987]), and Labanotation (e.g. LED [Hunt, 1989], NOTATE [Savage, 1978], and CHOREO-L [Sealy, 1978]).

It was found that Labanotation was potentially the most applicable system of movement notation to the Bodytronix Project, and this is discussed further in Chapter 5.

2.3.2 Labanotation

Labanotation, or Kinetography Laban, was created by Rudolf Laban in the early 1920's and is the most widely used form of choreographic notation. A detailed description of the system and its use can be found in the book by Guest [Guest, 1970]. Although used primarily for recording dance choreography, it has also been used in many other areas where body motions must be recorded in a consistent and systematic form (e.g. athletics, anthropology, physiotherapy).

The level of detail represented can be arbitrarily chosen to suit the task in hand, and it is this fact that makes Labanotation of particular interest to the Bodytronix Project (see Chapter 5). At its highest level, Labanotation can represent the general idea of a body moving in a certain direction, whilst at its lowest level it can fully record the precise actions of each individual joint and muscle in the body.

As a kinematic system, Labanotation describes movement and body positioning with no reference to the dynamics and forces applied to produce the effect. It consists of a set of symbols used to represent actions, body parts and timing, written on a vertical 'staff'.

The staff is read in an upward direction, and is divided into columns which hold information concerning the various body parts being manipulated. Columns can be sub-divided if necessary, e.g. the 'arm' column can be split into two if the upper and lower arms need to be represented individually to describe a more complex movement.

A pictorial introduction to Labanotation is given in *Fig. 8*, where the notation form of a simple exercise is shown, together with a brief explanation of how to 'translate' it into movement.

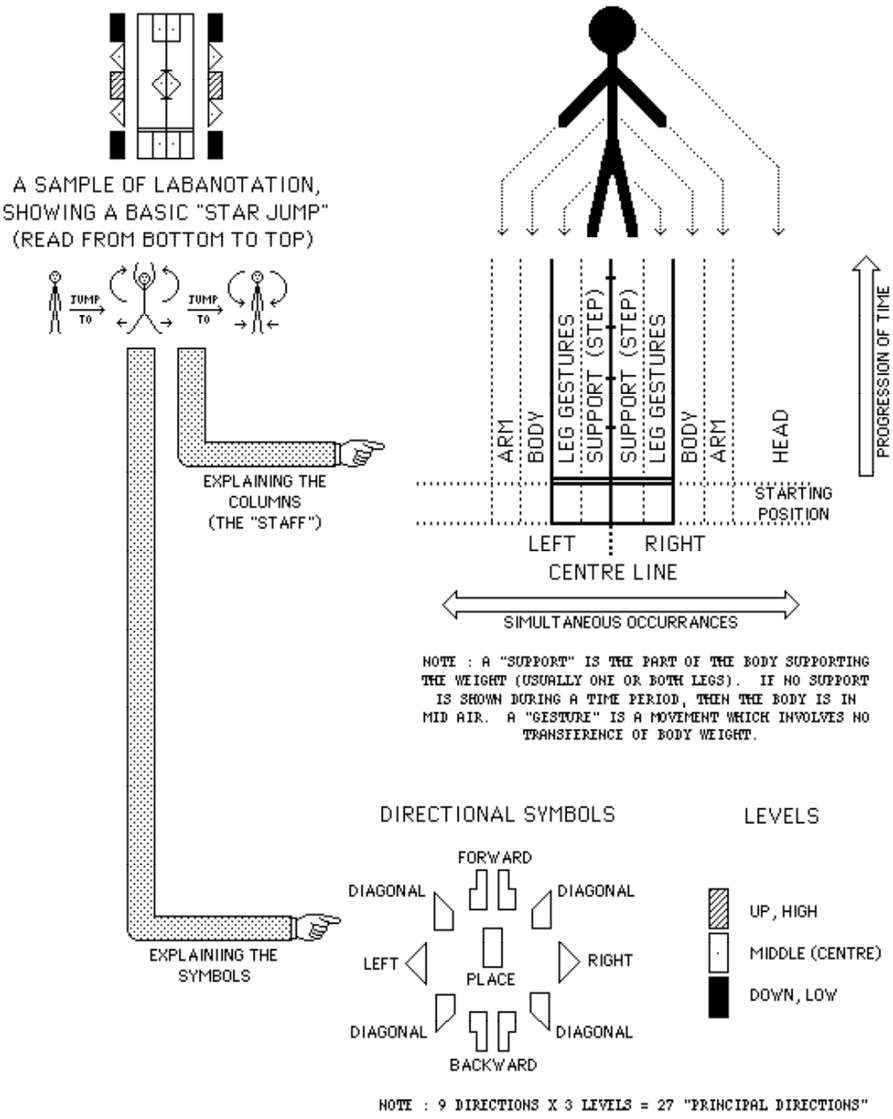

Fig. 8 : A Brief Introduction to Labanotation Fundamentals

2.4 Current Developments in the Computerisation of Sport

The following sections describe some of the common ways in which computers are now used within the sporting arena. Thorough investigation revealed no previous examples

of work similar to that undertaken in the Bodytronix Project, although one new research project is currently underway at Sussex University to apply discourse processing techniques to the language of Step Aerobics workouts [Delin, 1993].

It is clear that the application of computer science and Computational Linguistic techniques to the field of Aerobics is a new concept.

2.4.1 Motion Study & Kinesiology

Computers have been used for a number of years in the analysis of human body motion during various sporting events. Detailed analysis of an individual's technique can help reveal weaknesses and lead to an improvement in their performance.

In most cases the motion is recorded using high speed film and played back a frame at a time so that a digitiser can be used to record changes in the positions of various key points on the body. Various camera angles are used so that a three-dimensional representation of the body can be created inside the computer.

This type of kinematic study has been used to analyse sports as far ranging as golf [Brodie, 1983] and athletics [Ariel, 1980].

2.4.2 Exercise Prescription & Evaluation

Many computer software packages are available which are able to evaluate physical health and fitness. In most cases the user must enter data obtained by observation or manual testing methods, and this data is then analysed and compared to stored averages for the population. The software then provides appropriate statistical information and, in some cases, recommendations for future improvement.

All aspects of health and fitness can be dealt with, including body composition, aerobic fitness, strength, stress levels, disease risk, diet analysis, and exercise prescription. The use of computers in exercise prescription and evaluation is described in detail by Howley

[Howley, 1992], and a full listing of available computer software can be obtained from the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) [Baumgartner, 1992].

2.4.3 Control for Exercise Equipment & Gym Management

The other area where computers are frequently used in the sporting arena is in the control of powered exercise equipment (e.g. rowing and stepping machines, weight machine, exercise bicycles and treadmills), and in the management of gyms and leisure centres (e.g. customer databases, automatic billing, bookings, etc.).

These areas are of little concern to the Bodytronix Project, and interested readers are advised to read the detailed discussion by Dyson [Dyson, 1989].

Chapter 3 : Bodytronix Project Overview

This chapter is intended to describe the main features of the Bodytronix Project, and to explain why the work is of value in both theoretical and practical terms.

3.1 Scope of the Research

To successfully complete the Bodytronix Project five main tasks had to be performed, and each of these is briefly described in the sub-sections which follow. Chapters 4 to 8 then go on to explain in greater detail how these tasks were carried out.

3.1.1 Aerobics Corpus Acquisition

The first task of the Bodytronix Project was to collect a representative sample of Aerobics routines from qualified and practising fitness leaders. These routines were collected by means of a national survey and constitute a unique corpus which is the first of its kind anywhere in the world. Over 125 complete routines were collected from 37 instructors around the UK.

This corpus of Aerobics provided almost all the data necessary for the completion and validation of the project. See Chapter 4 for specific details.

3.1.2 Formation of an Aerobics Lexicon

Once the corpus had been assembled it was possible to create a lexicon of the individual moves from which Aerobics routines are assembled. As well as information provided by the corpus, the lexicon was based on the personal experience of the author together with other relevant sources (e.g. the books by Egger [Egger, 1991], Mowbray [Mowbray, 1990] [Mowbray, 1992], and Klinger [Klinger, 1986]).

Lexical entries include feature-based information concerning the use and form of the exercises, together with other important details such as written descriptions and commonly-occurring synonyms. See Chapter 5 for specific details.

Two versions of the lexicon were produced. The first is in printed form and constitutes an Aerobics Dictionary for use by fitness leaders [Bull, 1991 #1], although this dictionary is currently under re-writing to include photographic representations of the Aerobics moves instead of the original 'stick men' diagrams.

The second version, which is of central importance to the research, is stored on computer and forms the lexicon used by the Aerobics Grammar (see Section 3.1.5).

3.1.3 Formation of a Computerised Aerobics Corpus

Since no formal conventions exist for the recording of Aerobics workouts, the exercise routines acquired for the written Aerobics Corpus have no standard format. Although each instructor used their own personal methods strong similarities can clearly be seen, especially in the overall layout and vocabulary used.

Part of the Bodytronix Project involved the development of a standardised knowledge representation language so that the routines could be 'translated' into a common form. This language was designed first intuitively by the author, and then incrementally tested and reviewed during the production of a computerised version of the original Aerobics Corpus.

The language developed is described in Chapter 5, which deals with the ACCOLADE corpus (A Computerised Corpus of Legal Aerobic Dance Exercises) [Bull, 1992]. Translation of the textual routines into ACCOLADE format is a highly time-consuming task, and only a small part of the original corpus has as yet been coded. Spending more man hours on what is a skilled, but essentially routine, task seemed inappropriate as it would not have served to significantly further the research.

3.1.4 Investigating the Addition of Human Figure Animation

In order to make the Aerobics Lexicon more accessible to non-experts in the field of exercise, an investigation of the possible application of human figure animation techniques was undertaken in collaboration with the University of Sydney, Australia.

It was demonstrated that the NUDES system developed by Herbison-Evans (see Section 2.2.2.2) could be used to generate acceptable animations of the individual exercise moves. Once again, the time taken for a single person to complete such a task would have been very great and full implementation was left as a future project. See Chapter 7 for further details.

3.1.5 Building an Aerobics Grammar

The final, and most important, task of the project was to produce a formalised grammar of Aerobics. This was achieved by selecting the most applicable existing language model and adapting it to suit the specific circumstances.

As with the production of the ACCOLADE knowledge representation language, the grammar was first written intuitively using the author's extensive knowledge of the subject domain together with data from the Aerobics Corpus. The grammar was then tested (manually) on the corpus and augmented appropriately to produce the final version discussed in Chapter 8.

3.2 Contribution to Knowledge

The Bodytronix Project contributes completely original work in a number of areas, and some of the most important consequences of the research are discussed in the following sections.

3.2.1 In the Field of Computational Linguistics

The research has investigated the application of standard Computational Linguistics techniques in a new and unique language domain, and shown them to be only partially suited to the task of modelling the language of Aerobics.

For the first time a corpus of Aerobics has been gathered and coded into computerised form. The ACCOLADE corpus provides a unique and interesting body of data for study by other computational linguists. It is of particular value since it represents a highly constrained, but certainly non-trivial, sub-language of English.

It has also been shown that techniques used to animate human figures for the purpose of dance choreography can equally well be applied to Aerobics, but that the computerised dance notation systems available are inappropriate in this field.

3.2.2 In the Field of Aerobics

The Aerobics corpus is the first of its kind, and provides a valuable source of knowledge for the study of Aerobics. The data could be used for a wide range of applications from the study of exercise-induced injury to the recording of current style trends.

For the first time a standardised representation language has been developed for the recording of Aerobics routines, and a formal grammatical language model developed.

3.3 Practical Value of the Research

The findings of the Bodytronix Project are of practical use in a number of areas, and these are discussed in the following sections.

3.3.1 An Aerobics Dictionary

When planning a new class, most teachers draw on a repertoire of exercise movements which they have accumulated over time by observing other classes, watching video or television workouts, reading books and other related literature, and attending workshops and masterclasses. For a novice in the field of Aerobics the process of gathering a reasonable repertoire may take many years, even though most of the exercises they will eventually acquire are widely used and recognised by experienced teachers.

The chief problem is that there is no single comprehensive source from which a knowledge of the 'standard' exercises may be gleaned. A few books are available which catalogue some of the exercises most commonly used in Aerobics classes, although their structures are usually informal and none concentrate solely on Aerobics classes. Perhaps the most comprehensive text to date is "The Fitness Instructor's Exercise Bible" [Egger, 1991] which lists over 600 weight training, Aerobics and stretching exercises.

It can be observed that the knowledge acquisition bottleneck is one of the most fundamental problems facing new fitness leaders, slowing their development into successful teachers as well as delaying the spread of new findings in the field.

The Bodytronix Project has resulted in the development of an Aerobics Dictionary (see Chapter 5) which formally describes the most commonly-occurring Aerobics exercises in a way accessible to fitness leaders and the general public alike. Such a reference text could help alleviate the bottleneck problem.

3.3.2 An Aerobics Routine Generator

The material being taught in an Aerobics class must be updated and changed frequently for a number of reasons. If a class is too repetitive, then participants will become bored and cease to concentrate properly - this can lead to a decrease in the effort being put in

(therefore reducing the training effect) or even to the participants leaving the class altogether. Also, once people have become completely familiar with an exercise routine, improvement in skill and co-ordination will occur more slowly.

Planning an exercise to music class is very time consuming, however :

> "Setting up an Aerobic class can be a very time-consuming exercise. For every minute of your tape, it takes a minimum of an hour's work. A half-hour tape will take you 30 hours to put together." [Heathcote, 1988]

For this reason, many exercise teachers are not able to update their classes as often as they would like. More seriously, some plan badly using contra-indicated exercises or without proper thought to the ordering of the movements with respect to intensity, mixes of high and low impact, skill factors, etc.

A tool to help in the development of new routines would obviously be extremely useful, and may lead to increased safety levels and effectiveness of some classes. It could also serve as a teaching resource for use by students hoping to become fitness leaders. Such a tool should not be seen as an attempt to replace the creativity and individuality of the teacher, but merely as an aid in suggesting fresh ideas, or as a back-up for when the teacher simply does not have the time to generate their own new material.

The development of an Aerobics Routine Generator presupposes a comprehensive lexicon and grammar for the language of Aerobics, and the Bodytronix Project is an essential prerequisite to the development of a system such as that outlined in *Fig. 9*.

It is expected that information concerning the type of class required would be elicited from the teacher via a menu-driven user interface. These 'local' constraints, together with more general 'deep constraints built into the system, would be used in conjunction with the Aerobics Grammar to generate Aerobics routines from a database of stored exercises (i.e. the Aerobics Lexicon).

Once final editing had been carried out by the teacher, the routine would be printed out in a written format similar to that used by teachers themselves when notating their own

routines. Finally, it is hoped that the human figure animation techniques developed at Sydney University (See Chapter 7) would be employed in producing an animated display of the proposed class.

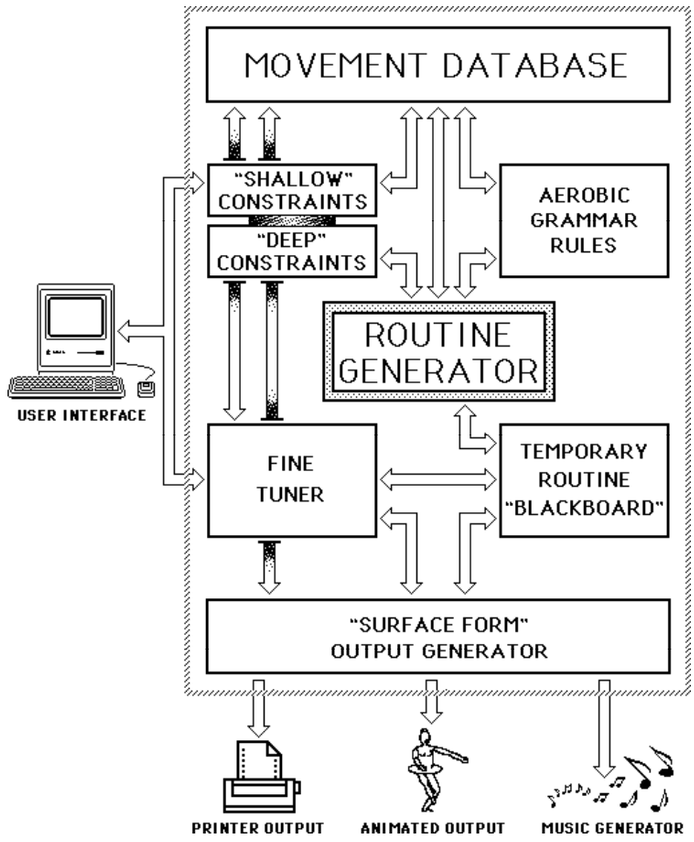

Fig. 9 : Possible system configuration for an Aerobics routine generator

The survey of fitness leader (See Chapter 4) revealed that 61% of instructors has access to personal computers (PC's) of some sort, so it is likely that the system would be developed in a language such as ICON or PROLOG. Both languages are well suited to AI systems development, able to be either interpreted or compiled, have excellent string handling capabilities (see [Griswold, 1983] and [Campbell, 1986] respectively), and are available on PC's and Apple Macintosh computers as well as on larger development machines.

An Aerobics routine generator would be able to considerably speed up the creation of new class material when teachers are short of time, and may lead to increased levels of safety and effectiveness in some classes. Computer tools used to aid the process of choreographing dance have already had a degree of success, e.g. ‘Choreoscribe’ [Dransch, 1986] and ‘COMPOSE’ [Schiphorst, 1990].

CHAPTER 4 : A National Survey of Fitness Leaders

In order to provide the basic exercise data for the Bodytronix Project, and to discover more about the needs of the potential users of the research, it was necessary to gather information from a selected national sample of well-qualified fitness leaders who actually teach aerobic dance classes. The following chapter provides details of how the survey was designed and implemented.

No such survey of exercise teachers had previously been undertaken, and the information gained has many potential uses outside the sphere of this project, e.g. in the fields of sports medicine, human movement studies and sports psychology (see Section 3.3).

4.1 Conducting the Survey

The following sections detail the survey design and implementation issues. Information concerning the costing of the survey is not strictly relevant to the research and is therefore not dealt with in this chapter, although details are included in Appendix 1.

4.1.1 The Survey Questionnaire

A questionnaire was designed which would evoke the necessary data from the target population. It consisted of a covering letter to explain the purpose of the research, an explanation of what exercise data was required, and a short list of questions related to the research and its potential applications (e.g. the Aerobics Routine Generator – see Section 3.3.2). A copy of the questionnaire can be found in Appendix 2.

Each teacher was asked to supply sample Aerobics routines, which they had successfully used in a class situation, written down in as much detail as possible (including beat breakdowns for the music used, exercise descriptions, and relevant teaching points).

The questions asked required YES/NO answers, and were as follows:

1) Are you a Grade 1 ASSET member?

2) If not, do you have an RSA teaching qualification?

3) Do you have access to a Personal Computer in your home?

4) If you work at a sports centre or health and fitness club, is a Personal Computer available there?

5) If a computer program able to generate safe and effective Aerobics routines was available, do you think exercise teachers would be prepared to use it?

Questions 1 and 2 were used to confirm the teaching status of the instructor (see Section 4.1.2). Questions 3, 4 and 5 checked the potential market for a practical computer system (see Section 3.3.2) based on the Bodytronix Project research.

4.1.2 Selecting the Target Population

In order to provide a representative sample of Aerobics routines it was necessary to gather data from as many teachers as possible from different areas of the country. A necessary constraint, however, was that the teachers targeted had to be well qualified and experienced in their work so that no potentially dangerous routines would be gathered.

Currently the most widely accepted qualification in the teaching of exercise to music in Great Britain is that provided by the RSA in association with the Sports Council [Bull, 1990 #1]. Teachers who posses this qualification are likely to have a higher than average teaching standard regarding safety, effectiveness and choreographic innovation.

Experience, as well as knowledge, is of obvious importance however, and this was taken into account when deciding on the target population. One of the largest associations

catering for fitness professionals in this country, and for teachers of exercise to music in particular, is ASSET (the National Association for Health and Exercise Teachers).

Whilst it is possible for anyone to become a normal ASSET member, there is also a special membership for those teachers who can prove they are amongst the best in the country. In order to qualify for this 'Grade 1' membership, a teacher must possess the RSA qualification and proof that they have been teaching regularly for at least two years.

Thus only those with knowledge *and* experience may obtain the Grade 1 status, and it was these teachers who therefore formed the basis from which the target population was selected. There were further important reasons for choosing those teachers who have obtained the RSA qualification, however, and these are described below.

As part of the examination, it is necessary for each student to teach an Aerobic Dance Exercise class of approximately 45 minutes in length (which is the typical length of a normal class). This class must be accompanied by a complete script, which is given to the examiners, detailing every move in a step-by-step format similar to that shown in *Fig. 10*.

One of the expected problems in the execution of the survey was that many teachers would not want to spend the time necessary in preparing a fully detailed class description. Those who were RSA qualified already had at least one full script prepared for the purposes of the examination, however, and this could be used as survey data.

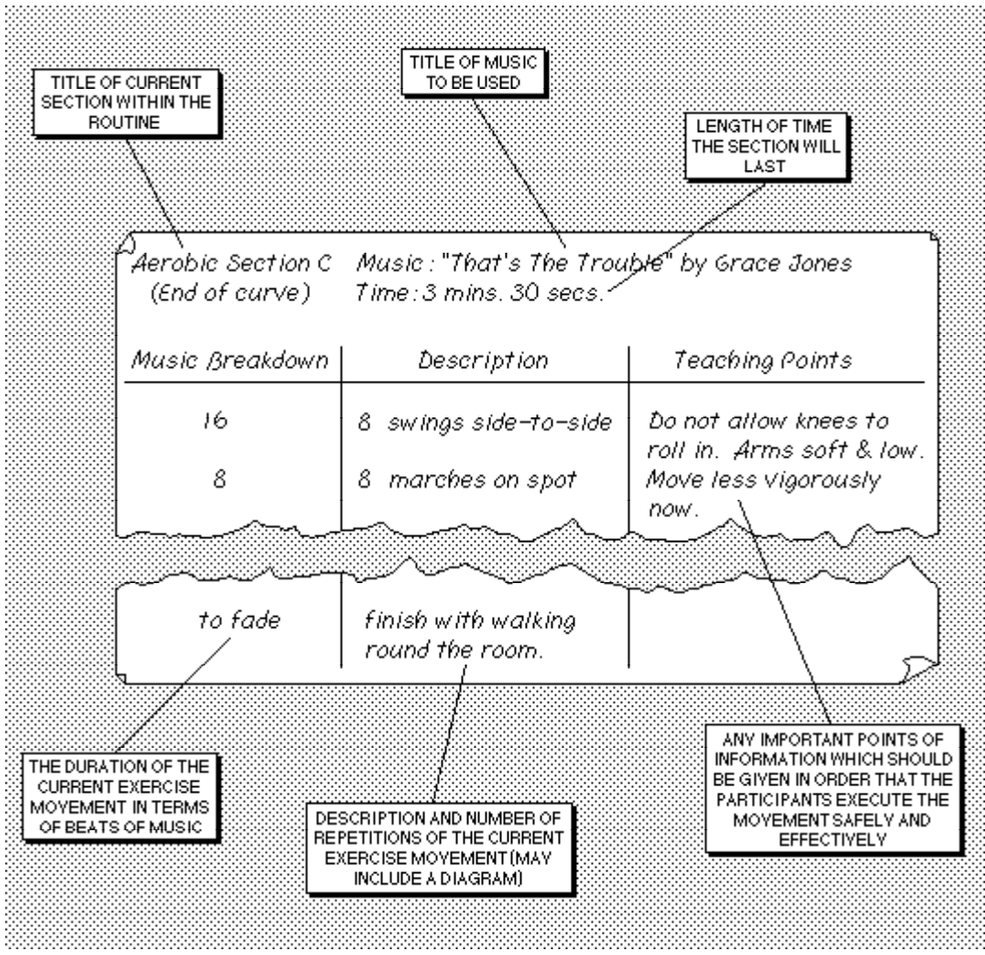

Fig. 10 : The general format of a written Aerobics routine

Moreover, these scripts are as neat and thorough as anything ever produced by the teachers in question (since they were trying to impress the examiners), and are designed to be understood by others, i.e. they are written in language that the teachers *expect* others to be able to understand, as opposed to using any personal shorthand they might normally employ to save time. This is ideal because the Aerobics Lexicon and Grammar developed in the Bodytronix Project needed to be universally comprehensible; thus the individual time-saving shorthand methods used by each teacher would have been of little use.

There are currently approximately 4,000 RSA qualified teachers [Chambers, 1990], and approximately 1,500 of them are Grade 1 ASSET members. The survey was aimed

primarily at these Grade 1 ASSET teachers (although exceptions were made for teachers of similar qualifications and experience).

4.1.3 Distributing the Survey Questionnaire

Obviously, the success of any survey initially depends on the ability to make contact with members of the target population. For obvious reasons ASSET was unable to divulge the addresses of its members directly, so contact had to be established via the association's regional representatives.

Each representative is responsible for the organisation of events in their region, and for liaising with the members therein. Most areas of the country are now under the control of at least one representative, and these areas are shown in *Fig. 11* below (correct at the time of the survey).

It should be noted that some regions which are *not* covered merely have a temporary vacancy for the post of representative. A full list of the representatives, including their names and contact addresses, is given (by permission) in Appendix 3, together with a list of areas temporarily without official representation. This list was correct in the Summer of 1990, when the survey was carried out. Note also that the Irish and Scottish regions do not appear on the map in *Fig. 11*.

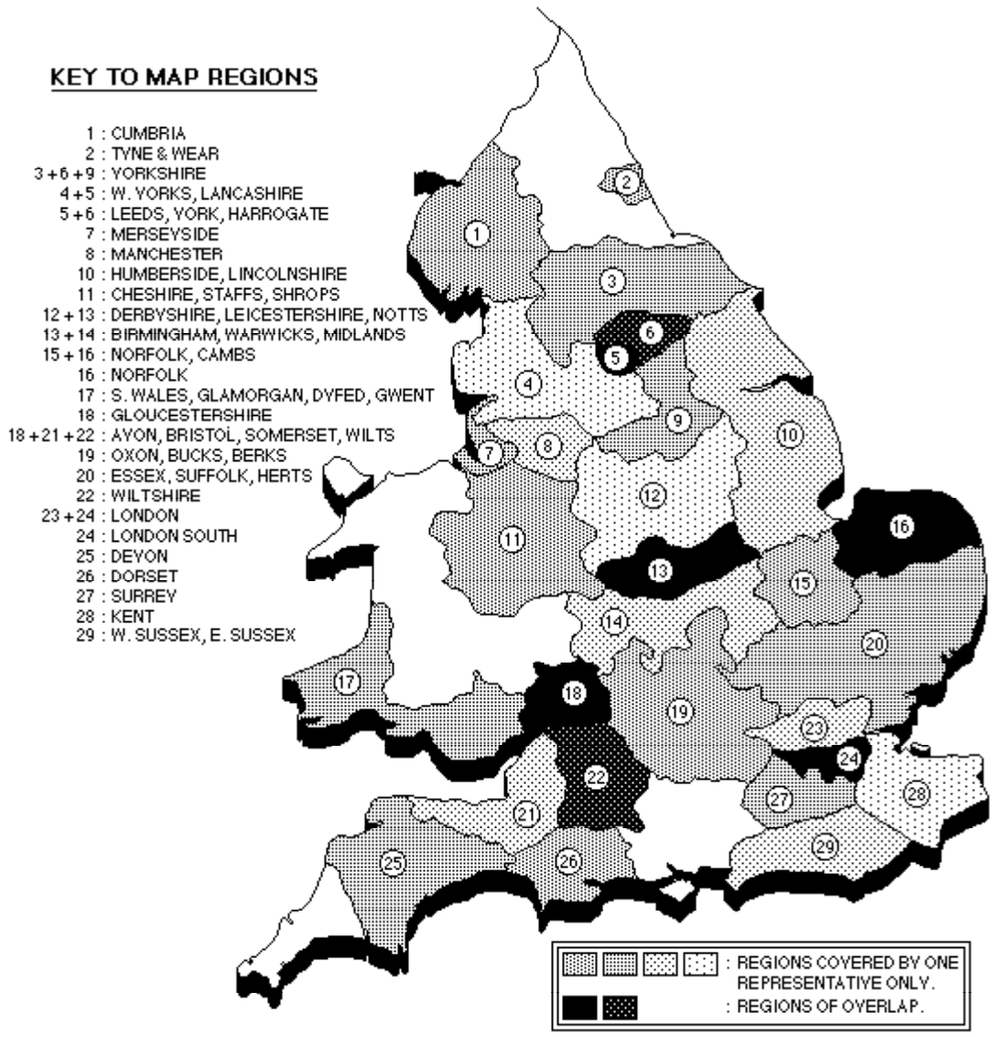

Fig. 11 : Areas covered by ASSET representatives

Each representative has the names and addresses of all those Grade 1 members in their region. For the purpose of the survey, the author personally contacted each representative by telephone in order to introduce himself and to explain the nature of the intended survey. A more detailed description of the work was sent to those who agreed to help, together with copies of the survey questionnaire (See Appendix 2) and stamped addressed envelopes for their return.

The representative then distributed the questionnaires to Grade 1 members within their region, and the members returned the required data by post. This path of communication is shown clearly in *Fig. 12*.

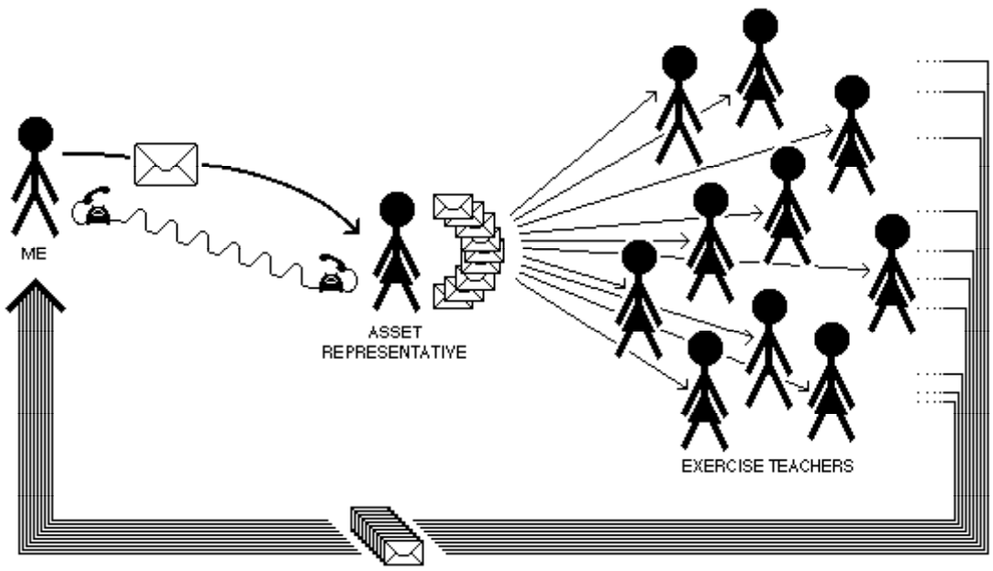

Fig. 12 : Path of communication during survey

Each teacher being surveyed received a letter containing the following:

- A letter of introduction, explaining the nature of the survey and the reasons for its initiation.
- The survey questionnaire itself.
- A stamped addressed enveloped for use in returning the information.

4.1.4 Anticipated Problems

A number of problems were anticipated for each stage of the survey, although the results show that they did not hamper the survey to any great degree.

- **Initial contact with the ASSET representatives** - This was not expected to cause much of a problem as the addresses and telephone numbers of the representatives were already known, and their job description involved them being easily reached by ASSET members.

  Delays might have occurred due to the timing of the survey, since the August/September period is a popular holiday season, and is also part of the summer vacation time for school children - thus some representatives may have been busier than usual.

- **Sending of the questionnaires to the teachers** - Questionnaire packs were only sent to those ASSET representatives who had already agreed to help with the survey, but their speedy co-operation upon actually receiving the survey documents could not be guaranteed. The representatives each had to address and then post between 10 and 20 envelopes for distribution to the target teachers.

  It was quite possible that this task could have been put off for longer than hoped, and that the representatives involved would have had to be contacted a second time in order to ensure that they complete the job in a reasonable space of time. It was not expected that distribution of the questionnaires would actually fail to take place, however.

- **Response from the teachers** - This is the stage at which the survey was likely to encounter its most serious problems, as the teachers could not be contacted directly by the author in order to ensure their support. At the very least, each teacher had to locate and photocopy several pages from their examination scripts (See Section 4.1.2) before returning the survey questionnaire, and it is possible that they might have had to write out an Aerobics class section by hand if they no-longer had their examination entries.

This would have entailed personal time *and cost*, and was thus quite likely to be met with little enthusiasm (although successful exercise teachers are generally, by nature, friendly and helpful). It was therefore necessary for the letter accompanying the survey to generate as much enthusiasm and interest in the project as possible, so that the teachers would *want* to help. Those teachers willing to help with the survey were still likely to take a relatively long time to respond compared with response times for more usual surveys.

Also, it must be remembered that teachers tend to be rather possessive of their own exercise routines. It was therefore important to stress that any information they supplied would be used only for the Bodytronix Project, and that the author would not, for example, be using their routines in his own classes.

4.1.5 Contingency Plan

A contingency plan was formulated in case the initial pilot survey proved unsuccessful, or the co-operation from the ASSET representatives was poor. This involved contacting the teachers possessing RSA qualifications via the RSA examination board itself. The RSA does not keep the addresses of those teachers who have passed the examination, but were are willing to supply lists of approved RSA courses throughout Great Britain.

The current locations of the centres at which these courses run can be seen on the map in *Fig. 13*. The locations were correct at the time of the survey. It should be noted that the Irish test centre does not appear on the map, and that there are were no Scottish test centres at that time.

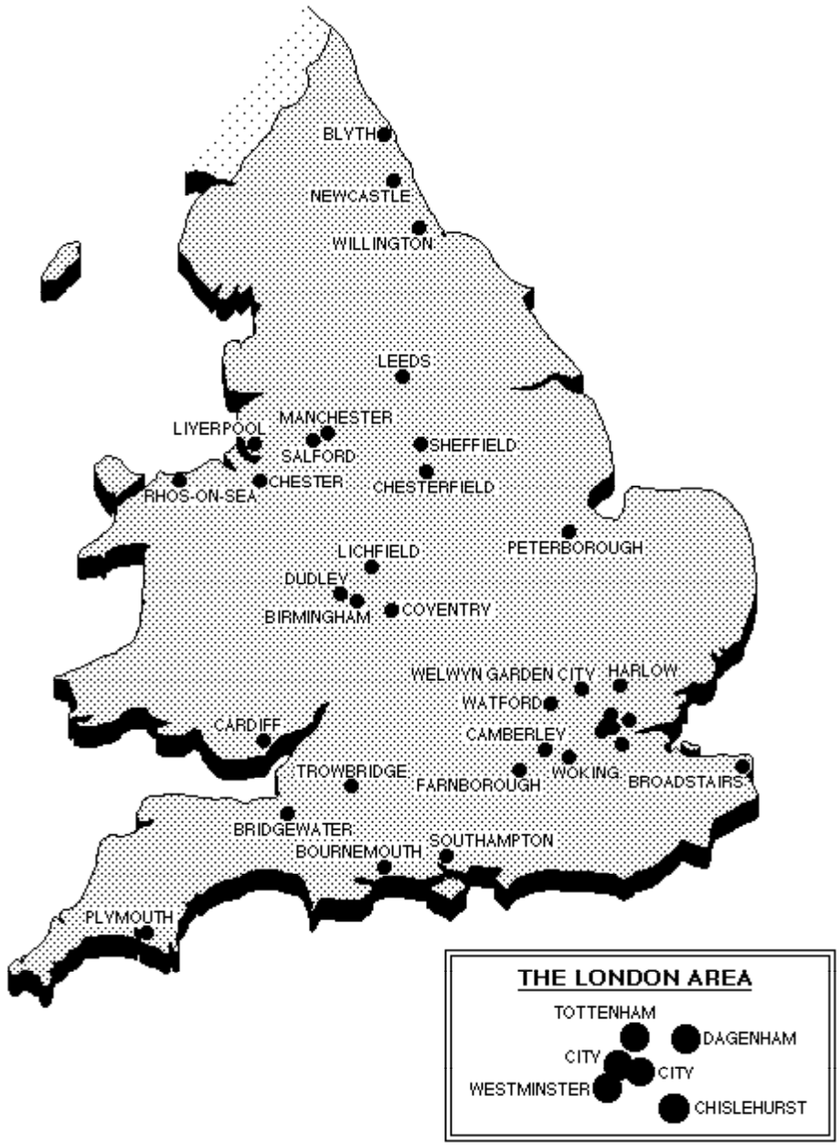

Fig. 13 : Test centres for currently approved RSA courses

The spread of centres across the country is perhaps not as even or complete as that provided by the ASSET region divisions, but it would nevertheless have been adequate for the purpose of the survey.

The original survey plan would have been followed, preceded by another pilot survey, but the course directors at each test centre would have been contacted instead of the ASSET representatives. This would have bee a slightly harder task because the contact

addresses and telephone numbers for most of the directors were immediately available. Also, the teachers who would receive the questionnaires could not be guaranteed to have had much actual teaching *experience*, as would Grade 1 ASSET members.

4.1.6 The Pilot Survey

In order to test whether or not a full-scale survey would be worthwhile in terms of the cost involved for the data obtained, a pilot survey was first undertaken. This was carried out in the Humberside area with help from Linda Lawson, who is the ASSET representative for this region, and who is known personally by the author.

Twenty questionnaires were distributed, and the response gave some indication of the average teacher's reaction to the survey in terms of quality and quantity of returned data, as well as in the time taken to reply to the request.

The pilot survey was deemed a success (see Section 4.2), and the full survey followed.

4.1.7 The Full Survey

In the full scale survey, each ASSET representative willing to participate was sent between 15 and 20 questionnaires (depending upon the number of instructors they expected to be able to contact), which they then distributed to Grade 1 teachers in their regions.

4.1.8 A Note on Standard Survey Procedures

It should be noted that the survey was unusual in several respects, and so many of the normal rules and procedures which apply to surveys in general were either inappropriate or unnecessary. An excellent introduction to survey design and analysis is provided by the book by Jolliffe [Jolliffe, 1986].

The main unusual features of the survey are described below :

- The most important data to be obtained from those surveyed is in the form of written exercise routines. Attempts to control the format of these routines would invalidate the data (since the format itself forms part of the subject of investigation), and also result in a drastic reduction in the number of returned surveys (since it would involve considerable extra work on the part of those surveyed).

  Thus the exact nature of the data was not known in advance, which meant that the methods used for storing and analysing the data were not decided upon until *after* the survey was underway.

- The only constraints on the target population were that it should include qualified and experienced teachers from as many parts of the country as possible. It was not important, for instance, that those areas having a higher density of teachers should have a greater representation within the target population. The actual spread of the target teachers was determined by the spread of the ASSET representatives.

- The target population was not actually decided upon by the survey's instigator, but in a secondary manner by the ASSET representatives. This was unavoidable but was, for the reasons mentioned above, quite acceptable for this particular survey.

4.2 Results of the Survey

This section describes the data which was captured during the survey, and provides a summary of its findings.

4.2.1 Time scale of the Survey

The pilot survey was initiated in mid August 1990, and all data received by November 1990. Time scales were approximately as follows:

● Initial arrangements with ASSET representative	2	weeks
● Distribution of questionnaires to the teachers	2	weeks
● Response from the teachers	8	weeks
● **Total Pilot Survey Time**	**14**	**weeks**

The full survey was initiated in mid November 1990, and all data received by April 1991. Time scales were approximately as follows:

● Initial arrangements with ASSET representatives	4	weeks
● Distribution of questionnaires to the teachers	2	weeks
● Response from the teachers	12	weeks
● **Total Survey Time**	**18**	**weeks**

4.2.2 Responses Obtained

A total of 467 questionnaires were distributed, and 37 instructors replied to give an overall response of 8%. Given the nature of the data required, this can be considered a relatively high value. The locations of these instructors can be seen on the following map (*Fig. 14*).

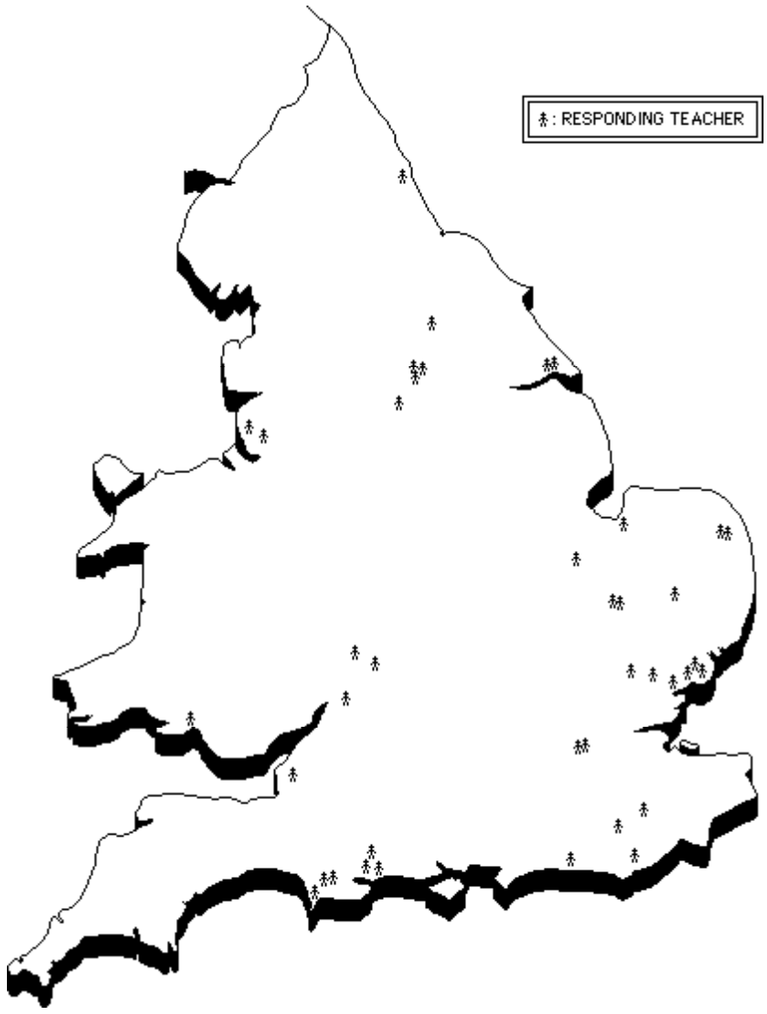

Fig. 14 : Locations of instructors responding to the survey

4.2.2.1 The Aerobics Routines

Altogether a total of 125 complete and unambiguous Aerobics routines were gathered from the 37 teachers who responded to the survey questionnaire.

Whilst there is no standard notation system for the recording of exercise routines, the general format varies little from teacher to teacher. This format is shown in *Fig 10.*, and actual examples of the routines collected are provided in Appendix 4. The routines are almost all either hand written, or typed using a conventional typewriter. Almost none of

the routines were word-processed, and exhaustive research has turned up no examples of existing computer-readable aerobic exercise routines, either in this country or abroad.

It should be noted that many teachers have not included all the details shown in *Fig. 10*, but that most adhered fairly well to this ideal format. An actual example of a routine supplied by an instructor is given in *Fig. 15*, and several more sample routines from the collected corpus can be seen in Appendix 4.

HARD
2nd AEROBIC - INCREASING THE INTENSITY - MIXING HIGH & LOW IMPACT
music - 'Sabrina - Boys, Boys, Boys'

	MUSIC	CONTENT	REPS	TEACHING POINTS
INTRO	88	jogs on spot	2x8	THROUGH THE FOOT
B	8888	4 gallop, 2 star jumps	x4 L&R	HEELS DOWN
C	8888	raise knee & kick	x8 L&R	YOU DONT HAVE TO JUMP
A	8888	double skips on spot	2x8	HEEL DOWN
	8888	flex foot & elbows	2x8 L&R	TIME TO CATCH YOUR BREATH
B	8888	4 gallop, 2 star jumps	x4 L&R	CAN DO HALF STAR JUMP
C	88	raise knee & kick	x4 L&R	CATCH YOUR BREATH
A	8888	double skips on spot	2x8	PRETEND TO SKIP ROPE
	8888	flex foot & elbows	2x8 L&R	FLEX TO THE SIDE
B	8888	4 gallop, 2 star jumps	x4 L&R	CAN JUMP LOW
C	88	raise knee & kick	x4 L&R	POINT TOE DOWN
A	88	double skips on spot	2x8	MAKE SURE HEEL TOUCHE DOWN
	88	flex foot & elbows	2x8 L&R	
B	8888	4 gallop, 2 star jumps	x4 L&R	CAN TAKE THE IMPACT DOWN
A	8888	double skips on spot flex foot & elbows	x8 x8	PRETEND TO USE ROPE
B	8888 884	4 gallop, 2 star jupms repeat	x4 L&R	SLOW DOWN IF YOU BECOME BREATHLESS

Fig. 15 : An sample Aerobics routine as written by an instructor

4.2.3.2 The Questions

A summary of the answers given to the five questions on the survey questionnaire is provided in Table 1. From these responses we can conclude the following important points:

- All responding teachers were RSA trained, and at least two thirds have gained more than two years of teaching experience (i.e. those who are Grade 1 ASSET members)

- Sixty percent of the instructors have direct access to a PC computer either at home or work.

- Eighty percent thought that an Aerobics Generating program (produced using the results of the Bodytronix research) would be used by fitness leaders.

No	NAME	DATE	TYPE	GRADE 1	RSA	OWN PC	WORK PC	USEFUL
1	Humphries, Lisa	15-01-91	5th Wk	Y	Y			Y
2	Osbone, Julie	11-01-91	5th Wk		Y			Y
3	Dennis, Jacqui	10-01-91	5th Wk	Y	Y			Y
4	Beale, Lindsay	11-01-91	5th Wk	Y	Y	Y		?
5	Trott, Becky	11-01-91	No data	Y	Y			Y
6	Ellis, Pat	08-01-91	5th Wk	Y	Y	Y	Y	
7	Earnshaw, Sue	09-01-91	5th Wk		Y	Y		?
8	Dickson-Smith, J	11-01-91	5th Wk	Y	Y			Y
9	Classon, Elaine	26-10-90	5th Wk	Y	Y	Y	Y	?
10	Lawson, Linda	01-11-90	5th Wk	Y	Y	Y	Y	?
11	Scott, Michelle	19-11-90	5th Wk		Y	Y		Y
12	Rayner, Linda	19-11-90	Various	Y	Y			Y
13	Mung, Tanya	21-12-90	5th Wk	Y	Y	Y	Y	Y
14	Galer, Sally	27-12-90	5th Wk	Y	Y	Y		Y
15	Jurriaans, Carol	03-01-91	5th Wk	Y	Y			Y
16	Dale, Mrs A	02-01-91	5th Wk		Y			Y
17	McCracken, Julie	17-12-90	5th Wk		Y			Y
18	Bray, Rebecca	23-01-91	1 Song	Y	Y		Y	Y
19	Biggs, Elaine	22-01-91	5th Wk	Y	Y			Y
20	Lucy, Beverley	23-01-91	10th Wk	Y	Y	Y		Y
21	Quirey, Shane	23-01-91	Various	Y	Y	Y	Y	?
22	Smillie, Mrs Danny	24-01-91	None	Y	Y		Y	Y
23	Millar, Mrs Linda	25-01-91	5th Wk		Y	Y		Y
24	Gallacher, Joanne	28-01-91	Various		Y			Y
25	Cosulich, Sabina	30-01-91	5th Wk		Y	Y	Y	Y
26	Want, Margaret	31-01-91	Various	Y	Y	Y		Y
27	Turrel, Cath	04-02-91	5th Wk	Y	Y		Y	Y
28	Davies, Julian	06-02-91	5th Wk	Y	Y			Y
29	Wormall, Sally	06-02-91	Add on	Y	Y			Y
30	Higgins, Abigail	11-02-91	5th Wk	?	Y	?	?	?
31	Parkyn, Chris	11-02-91	5th Wk	Y	Y	Y	N/A	Y
32	Jordon, Elizabeth	12-02-91	1 Song		Y	Y		Y
33	Williams, Janet	14-03-91	5th Wk		Y			Y
34	Rigg, Suzanne C.	28-03-91	5th Wk		Y			Y
35	Watson, Susan	3-4-91	5th Wk		Y	Y		Y
36	Gwilliam, Sian	17-02-91	1 Song	Y	Y			Y
37	Ring, Brenda	18-02-91	5th Wk	Y	Y		Y	Y
				65%	100%	43%	27%	81%

KEY : Date = Date the data was received from the instructor.

Type = Format of Aerobics routines supplied.

Grade 1 = ASSET Grade 1 Instructors.

RSA = RSA certified instructors.

Own PC = Instructors with a PC in their own homes.

Work PC = Instructors with a PC at their place of work.

Useful = Instructors who think an Aerobics Generator would be used.

Table 1 : Responses to the survey questions

CHAPTER 5 : A Lexicon of Aerobics

This chapter describes how the lexicon of Aerobics was extracted from the corpus of Aerobics routines (discussed in Chapter 4) and represented first in written form as a dictionary, and then in a computerised form for use with the Aerobics Grammar (discussed in Chapter 8).

5.1 The Written Lexicon – An Aerobics Dictionary

Once the Aerobics corpus had been gathered, each routine was examined and a list of all individual exercise moves extracted. This list was verified using the author's own knowledge of the field, together with various relevant reference texts (e.g. the books by Egger [Egger, 1991], Mowbray [Mowbray, 1990] [Mowbray, 1992], and [Klinger, 1986]).

The basic list of exercises was then augmented with additional syntactic and semantic descriptors to form a full written Aerobics lexicon, or dictionary. In the completed dictionary each move is represented in both pictorial and written form, and is accompanied by information concerning synonymous terminology (sometimes moves are known by several different names), common variations to the basic movement, safety and teaching points, and various other helpful information concerning the possible use of the moves.

A typical page from the dictionary is shown in *Fig. 16*, and other examples are provided in Appendix 5. There are currently 33 dictionary entries altogether. Some of the key features represented in each lexical entry are discussed in the following sections.

JUMPING JACK

Common Synonyms :

- Astride Jump
- Astride Lateral Jump
- Jack
- Star Jump

Exercise Features :

- 2 beat move
- High impact
- Travelling : F/B/On Spot
- Turning : 90/180 degs

Description Of The Basic Exercise :

- Start feet slightly apart. Weight is centred throughout the movement.
- Jump to position with both feet shoulder width apart.
- Jump back to starting position.

NOTES : This movement derives its name from that of a toy figure of a man with jointed limbs which could be moved by pulling attached strings.

For low impact version see "STEPPING JACK". See also "SHIMMY JACK".

Teaching Points And Safety Considerations:

- Cushion impact of landing by bending at the knee and ankle joints.
- In order to avoid stress to the knees, pelvic floor and uterine ligaments (in women), do not take the feet too far apart when jumping.
- Never turn palms outward if bringing the arms all the way up overhead, as this causes unnecessary pressure in the shoulder joints.
- The "Exercise Danger" book (*Ref DON1*) lists star jumps as an exercise of extreme danger, although other current texts regard them as safe if taught correctly, and if appropriate variations are chosen for the level of the class participants.

Commonly Occurring Variations:

Jumping Jack (Jumping Jack with arms swinging laterally from down to low diagonal)

Jumping Jack with arms swinging laterally out to side from down

Jumping Jack with arms swinging laterally from down to high diagonal

Jumping Jack with bent arms swinging laterally out to side from down

Fig. 16 : Sample entry from the Aerobics Dictionary

5.1.1 Naming the Exercises

It has been shown [Bull, 1991 #1] that most commonly-occurring Aerobics exercises can be considered to consist of two basic elements. The most important element is the 'foot pattern' (which describes the movement of the feet and legs), as this most frequently determines the name given to the exercise. The second element is the 'arm gesture' (which describes the movement of the arms and upper body).

In *Fig. 16*, for example, it can be seen that the exercise known as a ‘jumping jack’ always has the same foot pattern, but has a number of common variations involving differing arm gestures.

There is usually a large set of arm gestures which could be ‘legally’ paired with any one foot pattern to form a complete exercise move, and this dramatically increases the number of possible exercises. Factors restricting the pairing of foot patterns and arm gestures include the physical possibility of the resultant move, balance considerations, and the intended speed of execution.

The names given to different exercises are usually either descriptive (e.g. ‘backward lunge’, ‘side step’) or figurative (e.g. jumping-jack, ‘bow and arrow’) with respect to the movement involved. They are designed to be concise and easily remembered so that the instructor can communicate changes in choreography quickly and without confusion.

Entries in the dictionary are ordered alphabetically by their most common names, although synonyms are listed for those which are occasionally referred to in different ways.

5.1.2 Transitions

Another important consideration dealt with by the dictionary is that of exercise transitions, i.e. the smooth movement flow from one exercise to another. It can be observed that the starting and finishing positions of the legs in most exercises can be approximated by one of the four states shown in *Fig 17*, and this knowledge can help decide which exercises will fit together well in a sequence.

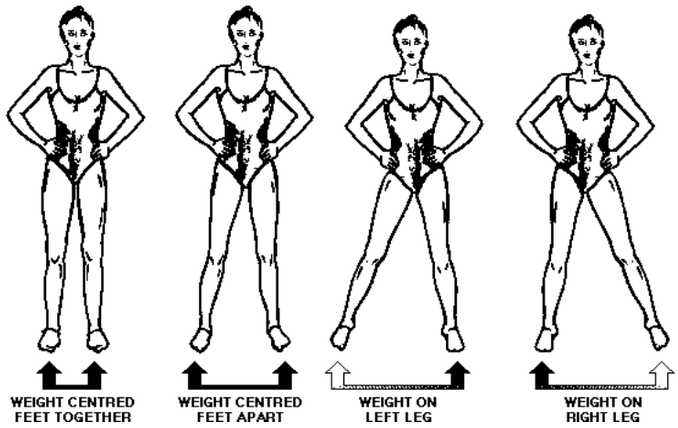

Fig. 17 : The four main start/finish states for standard Aerobics exercises

If an exercise results in the class participants having all their weight on their left legs, for example, then the exercise which follows must be able to accommodate this starting state. Failure to do so will result in the transition being awkward or even impossible to accomplish whilst keeping to the beat of the music.

A similar generalisation can be applied to the arms in order to decide which arm gestures will follow each other well in sequence. The exercise dictionary provides this information for each of the exercises it contains by means of the pictorial representations.

Please note that in the 'stick figure' pictures, the exercise is shown as a series of still frames corresponding to the position on the body on each successive musical beat (see Section 5.1.3). The first frame represents a neutral starting position and the following frames show one complete cycle of the exercise.

5.1.3 Beat Information

The performance of Aerobics Dance Exercise is always regulated by the speed of the music being used (see Section 2.1.2.1), with exercises being performed in time to the beats of the music. Every exercise requires a minimum number of beats for one cycle of its execution, depending on its complexity.

Each dictionary entry is given with its required number of beats, and this is also shown in the ‘stick figure’ diagrams which accompany the entry. For example, the ‘opposite elbow to knee’ shown in *Fig. 18* requires 2 beats to execute, i.e. from the starting position the person brings their opposite knee and elbow together on the first beat, and then returns them to the original position on the second beat.

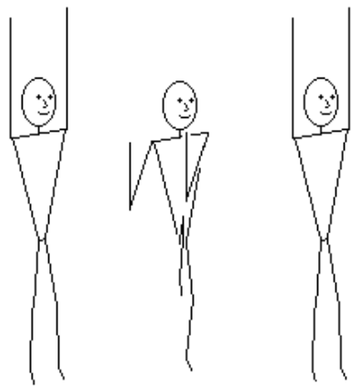

Fig. 18 : Pictorial representation of ‘opposite elbow to knee’

In the ‘shimmy jack’ shown in *Fig. 19*, four beats are required to perform the exercise. The full dictionary entries for both these exercises are given in Appendix 5.

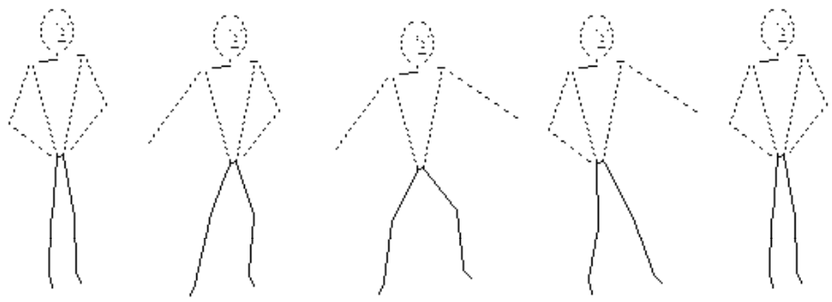

Fig. 19 : Pictorial representation of ‘shimmy jack’

5.1.4 Impact

All Aerobics moves can be given a general classification referring to the level of impact force they bring about on the joints of the lower body during execution. Exercises which

require both feet to leave the floor simultaneously are known as High Impact Aerobics moves (HIA), and these include all exercises requiring a hopping, jumping or jogging movement (e.g. ‘jumping jack’). Exercises which allow one foot to remain in contact with the floor at all times are known as Low Impact Aerobics moves (LIA), and these include most stepping or lunging movements (e.g. ‘backward lunge’).

Some exercises can be performed as either HIA or LIA moves [Egger, 1991], such as most kicking moves (e.g. ‘can-can’). The possible impact classifications for each exercise are provided in the dictionary entries.

As a general rule, HIA moves are faster and move physically intense than LIA moves, and in the early days of Aerobics the classes often consisted exclusively of HIA moves as participants were encouraged to ‘go for the burn’ [Fonda, 1981]. This was found to result in a higher risk of stress injuries [Lycholat, 1987], and most modern classes now contain a mixture of HIA and LIA exercises.

5.1.5 Travelling & Turning

Each dictionary entry contains information on how the exercises can be used for travelling or turning purposes. Some exercises (e.g. simple ‘jogging’) can be used when travelling forwards, backwards, or side to side, as well as when turning. Other exercises are more restricted, such as the ‘can-can’ which may only be performed on the spot (although it may still be used as a turning move).

5.2 The Computerised Lexicon

After the written lexicon (or Aerobics Dictionary) has been completed, it was necessary to produce a computerised representation for use in producing the formal language model of Aerobics. The computer version required a higher degree of formalism than written version, and each lexical item is described using a formalism similar to PATR

[Gazdar, 1989] because this is appropriate for representing a lexicon used with a GPSG grammar (see Chapter 8 for grammar component).

An example of an entry from the computerised Aerobics Lexicon is given in *Fig. 20* below, and the full Lexicon can be found in Appendix 7.

Exercise **HEEL_PUSH_FRONT**:
<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {dbl_push_front}
<leg modifier> = {}
<synonym> = {HEEL_DIG, HEEL_TAP}
<description> = 'Step R foot out to front so that heel taps on the floor. Both hands push forward with the heel.'

Fig. 20 : Sample entry from the Aerobics Lexicon

The name of the exercise is followed by a list of feature-value pairs which will are used for unification purposes in the full language model. It will be noted that the issue of exercise impact has been omitted, and the reasons for this are discussed in Chapter 8. The conventions used in the feature descriptions are as follows :

<cat> : The lexical category.
Values = {Ex}.

<beat> : The number of music beats required to perform the basic exercise.
Values = {1..4}.

<travel> : Possible directions of travel (relative to the class members).
Values = {place, forward, backward, left, right}.

<turn> : Degrees of turn possible whilst performing the basic exercise.
Values = {0, 90, 180, 360}.

<arm modifier> : Common adaptations to the generic exercise form for the movement of the hands and arms.
Values = {on_hips, alt_Bicep, dbl_push_side, ...}.

<leg modifier> : Common adaptations to the generic exercise form for the movement of the legs.
Values = {knees_up, heels_up_behind, ...}.

<synonym> : Common synonyms for the exercise name.
Values = {Text strings representing other names by which the exercises are known. These names do not appear as lexical items in their own right}.

<description> : Brief description of the basic generic exercise form.
Values = {A string of text, enclosed in single quotes, which describes the essential features of the exercise movement. The descriptions are not given in extreme detail, but are sufficient for exercise identification by exercise instructors. For simplicity the right foot is always assumed to go first, although this may be reversed as appropriate}.

It should be noted that the allowable values for the ‘arm modifier’ features of some lexical items do not represent a comprehensive set of all possible modifications for these exercises, but only show those observed in the Aerobics corpus. A list of all occurring ‘arm modifier’ values is provided in Appendix 7.

There are a total of 39 lexical entries (slightly more than in the written dictionary, on which the computerised lexicon is based), which give almost complete coverage of the Aerobics Corpus.

CHAPTER 6 : ACCOLADE (A Computerised Corpus of Legal Aerobic Dance Exercise)

When gathering the Aerobics routines in the national survey (see Chapter 4), no specific restrictions were placed on the format of the routines, although unofficial conventions have developed over the years which result in strong similarities between the notational styles of different teachers. For encoding and annotating purposes, however, a generalised format had to be selected to ensure consistency.

The 'raw' corpus data consists primarily of information concerning the breakdown of the music being used into logical sections such as introduction, verse, and chorus. These sections are further partitioned into groups of beats which correspond to sequences of particular exercise movements. Examples from the corpus can be found in Appendix 4.

6.1 Designing a Coding Methodology

The methodology for taking the corpus routines and coding them was based on the author's own intuitive understanding of the hierarchies apparent in Aerobic Dance choreography.

Consider the partial routine shown in *Fig. 21*, which is similar to those provided by teachers themselves, although simplified for the sake of example.

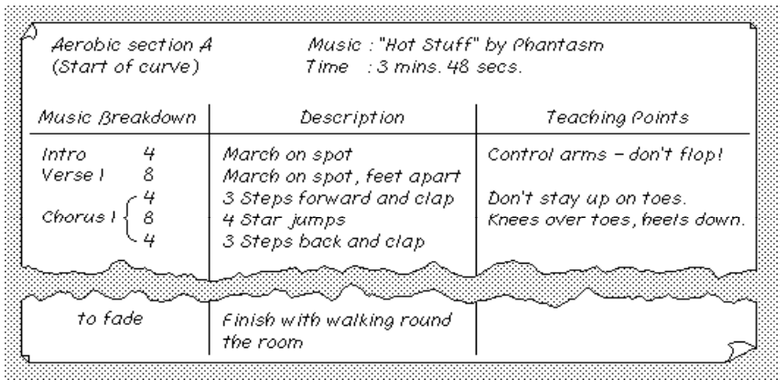

Fig. 21 : Partial hand written Aerobics routine sample

The hierarchical 'phrase structure' of this (partial) routine can be represented in a tree diagram, as shown in *Fig. 22* below. Note that the travelling phrase (i.e. the walking forwards then backwards) is discontinuous in that the return to original position does not occur directly after the forward movement, but after an intervening exercise has occurred.

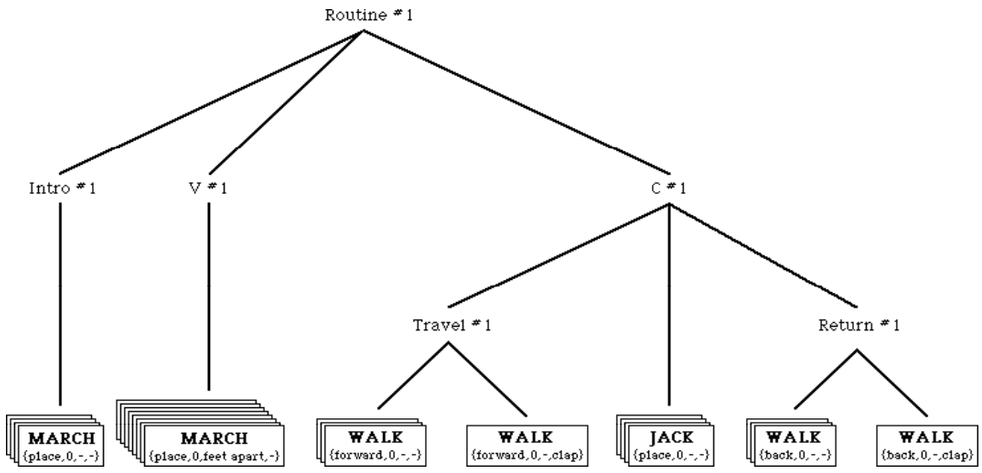

Fig. 22 : A tree diagram representing the sample Aerobics routine

This hierarchical structuring is discussed in greater depth in the chapter concerning development of the Aerobics Grammar (Chapter 8). The coded ACCOLADE version of the this sample routine is shown in *Fig. 23* below.

```
[ Routine #1 (560) [ [ Build up] [ 3.48] [ Jane Bloggs ]
                     [ “Hot Stuff” Phantasm]]
[ Intro (4)  [ Static (4) [ 2 x MARCH (2 place 0 marching low feet_apart)]]]
[ V     (8)  [ Static (8) [ 4 x MARCH (2 place 0 marching low -)]]]
[ C     (16) [ Lin_Travel (4) [ Move   (4) [ 2 x MARCH (2 forward 0 end_clap mid -)]]
                              [ Static (8) [ 4 x JUMPING_JACK (2 place 0 - mid -)]]
                              [ Return (4) [ 2 x MARCH (2 backward 0 end_clap mid -)]]]]
                                        .
                                        .
                                        .
```

Fig. 23 : ACCOLADE representation of the sample Aerobics routine

The underlying ‘phrase structure’ of the routine is captured by using nested lists. The first two lines of the ACCOLADE entry hold general indexing information concerning the routine, as follows:

Routine #1	:	Routine number (arbitrary).
(560)	:	Total number of music beats in routine.
`[ Build up ]`	:	Type of routine (related to intensity and position within the whole class).
`[ 3.48 ]`	:	Routine duration in minutes and seconds.
`[ Jane Bloggs ]`	:	Name of instructor supplying the routine.
`[ ‘Hot Stuff’ Phantasm ]`	:	Name and performer of the music.

The remainder of the entry represents the actual routine itself, broken down into its hierarchical form (similar to that shown in *Fig. 22*). For example, the chorus consists of a linear travelling phrase made up of a forward movement, a static (on-the-spot) exercise, and a return movement. The individual exercises (i.e. the ‘terminal symbols’) are held with feature values corresponding to those in the Aerobics Lexicon (see Section 5.2).

Thus the terminal symbol:

```
MARCH (2 place 0 marching low feet_apart)
```

is equivalent to an instantiation of the lexeme:

Exercise **MARCH**:
<cat> = Ex
<beat> = **2**
<travel> = {**place**, forward, backward, left, right}
<turn> = {**0**, 90}
<arm modifier> = {**marching**}
<leg modifier> = {**feet_apart**}
<synonym> = {WALK}
<description> = 'March R then L foot.'

Some of the information from the lexeme is not coded in the ACCOLADE entry (i.e. the synonyms, description and lexical category), but the terminal symbol in the ACCOLADE entry contains an additional feature value (in this case 'low') which is essentially a modifier of the arm gesture. In the example above this is used to record the fact that the arm gesture during the marching exercise is a standard 'marching arms' movement with the arms kept relatively low to reduce the overall intensity of the exercise.

6.2 Effects on the Development of the Aerobics Grammar

The development of the methodology used in coding ACCOLADE entries occurred in parallel with the writing of the initial Aerobics grammar; as one evolved, so the other was modified accordingly until working versions of each had been generated in an incremental manner.

Samples from the ACCOLADE corpus can be found in Appendix 6, and development of the Aerobics grammar is discussed in Chapter 8.

CHAPTER 7 : Adding Human Figure Animation

This chapter discusses the role of human figure animation in the Bodytronix Project, and explains how the NUDES system (see Section 2.2.2.2) was investigated with this need in mind.

7.1 The Need for Visual 4D Representation

The pictorial representations included in the dictionary of Aerobic Dance exercises (sees Section 5.1), together with the written exercise descriptions, are sufficient to convey the meaning of the exercise names to most experienced fitness leaders. New instructors, who may not have gained a very wide repertoire of moves, may still experience confusion in some cases, as would members of the public unfamiliar with Aerobics.

Practical demonstration is by far the most effective means of conveying the essential features of an exercise, and this is how instructors teach their class participants. The potential for ambiguity or misunderstanding is greatly reduced if the exercise can actually be seen.

It is clear, therefore, that animated sequences would be of considerable use in the Aerobics Lexicon when bound to the exercises as (visual) features. Such animations could be used to show individual exercises, and could be displayed in sequence to show a whole Aerobics routine.

Although the necessary time was not available to complete figure animation sequences for the lexicon, an investigation was carried out into how it might be achieved in the future. An animation package was selected and tested with the application in mind, showing that the task could be achieved using available technology.

7.2 Using NUDES for Aerobic Dance Exercise Representation

Of all the systems available for the representation of human motion, the NUDES package appeared to offer the most appropriate means of animating Aerobic Dance Exercise (see Section 2.2.2). It was designed specifically with the representation of dance in mind, and its use is relatively intuitive to those with a knowledge of human kinesiology.

Perhaps the best-known use of the NUDES system was the production of the 'Digital Duet' [Herbison-Evans, 1989 #2] for the 10th Australian Computer Conference (ACC10), where a Pas de Deux between the projection of a computer NUDES figure and a live dancer was produced [Haywood, 1983].

The NUDES system was used to create an animated version of the Aerobics exercise known as a 'jumping-jack'. A 'stick figure' version of the 'jumping jack is shown in *Fig. 24* below, and a frame from the corresponding NUDES animation sequence is given in *Fig. 25*.

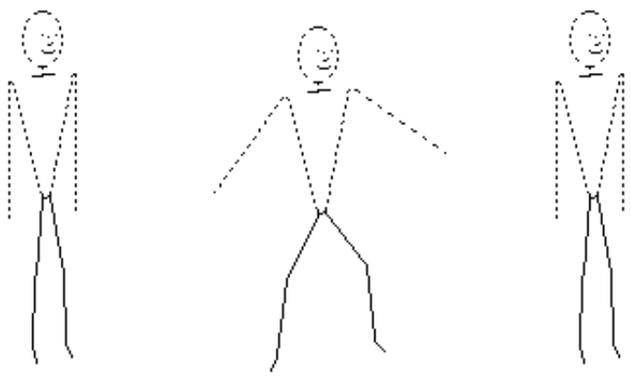

Fig. 24 : 'Stick figure' representation of a 'jumping jack'

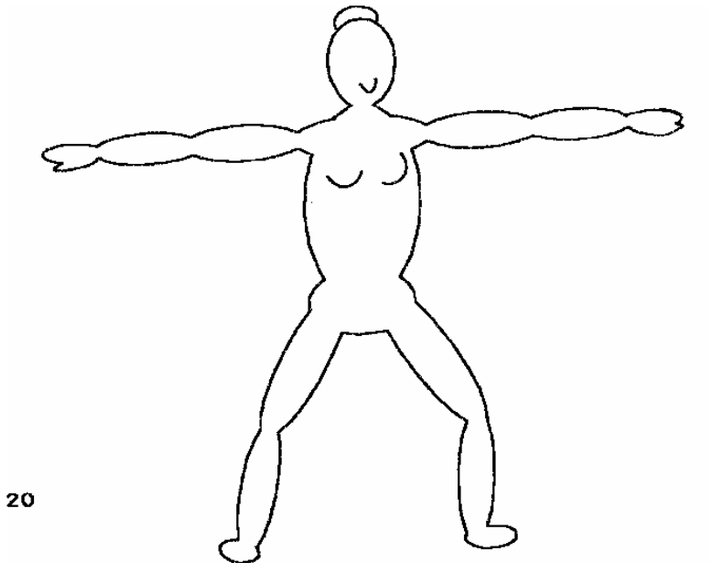

Fig. 25 : NUDES figure performing a ‘jumping jack’

It was therefore demonstrated that NUDES could in fact be used to provide the necessary animation sequences for the Aerobics Lexicon, although such a task would take a considerable number of man hours, and was beyond the scope of the Bodytronix Project.

For use in the lexicon, the animated sequences generated by NUDES would be stored in bit-map form for re-playing with the aid of a suitable software utility, such as the ‘Quicktime’ facility available on Apple Macintosh computers [Williams, 1991] [Apple, 1992].

7.2.1 Collaboration with Sydney University

The investigation and use of the NUDES software was only possible with collaboration from the Basser Department of Computer Science, University of Sydney. A grant was awarded under the “Australian Bicentennial Scholarships and Fellowships Scheme” by the Sir Robert Menzies Centre for Australian Studies, London university, allowing the author to travel to Sydney and work for 4 months in the department, under the supervision of the creator of NUDES [Herbison-Evans, 1982].

Full details of the grant, and the research trip itself, can be found in the report by the author [Bull, 1990 #3].

CHAPTER 8 : Building the Aerobics Grammar

The following chapter describes the formation of the Aerobics Grammar, based on existing Computational Linguistic theories.

8.1 An Analogy Between Aerobic Dance & Natural Language

Strong analogies can be drawn between structures found in Aerobics routines, and those in natural languages such as English. Building up exercise routines which adhere to the many constraints of safe practice can be likened to the construction of sentences in the field of NLP. The constraints can be thought of as a set of grammar rules, and the individual movements can be likened to the terminal symbols (i.e. the individual words in a natural language) to which the rules are applied when generating such routines.

The similarity between language and dance has already been explored to a certain extent, and it has already been demonstrated that Aerobics can be thought of as a form of dance. In her definitive book on Labanotation [Guest, 1984], Ann Hutchinson Guest proposes that :

> "Dance is a 'language' of expressive gestures through which non-verbal communication can be achieved. Like verbal language, it has basic 'parts of speech'. There is a clearly constructed grammar which defines the relationship of the movement 'words' to each other, and their given function in the movement 'sentence' as a whole. The basic elements in this language of movement fall into the categories of nouns, verbs, and adverbs. Adjectives occur only rarely..."

Although she fails to describe the 'clearly constructed grammar' further, she provides a family tree showing the elements of movement and how they are connected. A simplified version of this tree can be seen in *Fig. 26.*

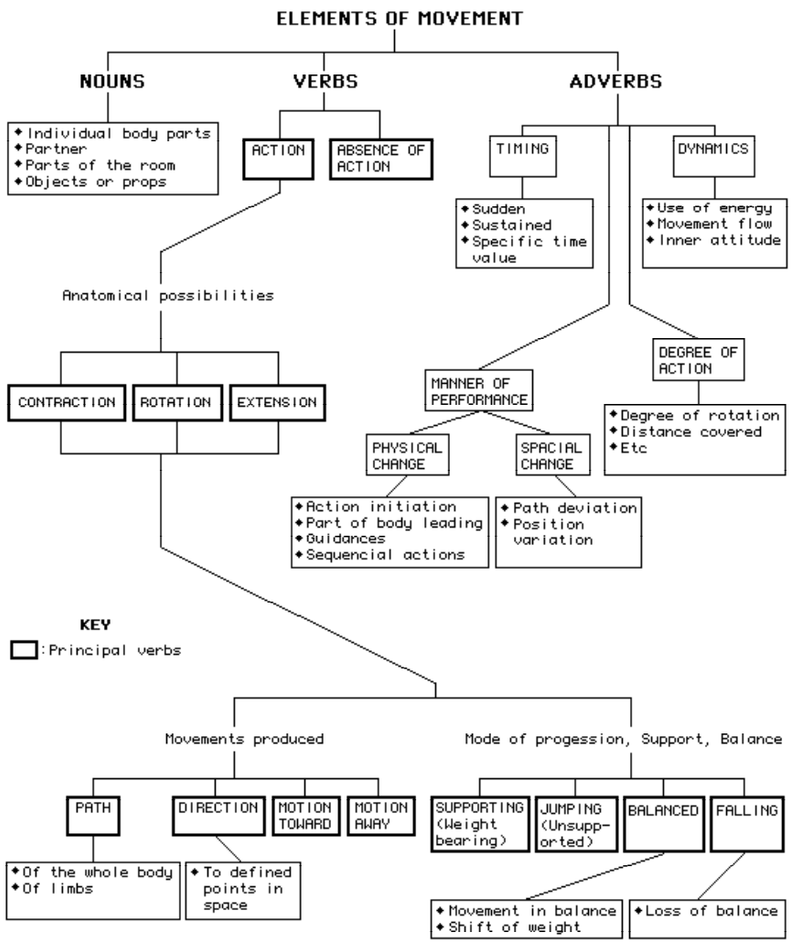

Fig. 26 : Ann Hutchinson Guest's movement family tree

8.1.1 A Grammatical Analysis of Dance

Grammatical analysis of movement is taken a step further by Don Herbison-Evans in his work on the Fox-trot [Herbison-Evans, 1989 #2]. A formal context free grammar is presented which is capable of generating valid sequences of Fox-trot dance steps. *Fig. 27* shows a sample syntax tree formed by using the grammar.

The terminal symbols at the bottom of the tree describe the steps taken by the left and right feet as the dance progresses (they are symbols 'borrowed' from the Labanotation language). A full explanation of all the symbols used can be found in the report by Herbison-Evans [Herbison-Evans, 1989 #1].

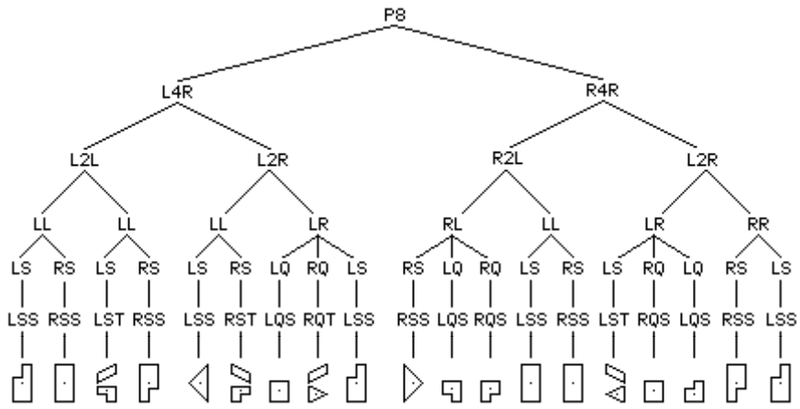

Fig. 27 : Syntax tree for a fox-trot sequence

8.1.2 Comparing Aerobics with English

The fact that others had begun to experiment with the application of grammatical techniques to movement was encouraging, and it seemed likely that this approach would be valid in the area of Aerobic Dance Exercise.

A simple analogy can immediately be drawn between the hierarchies apparent in English texts and those found in Aerobic Dance routines. This analogy is shown in *Fig. 28*, where the ‘abstracted descriptions’ represent the terms used by teachers themselves, and the ‘detailed descriptions’ represent the additional (more formal) information required by the proposed system for analysis purposes. The left-hand side of the diagram shows the natural language counterparts of the movement hierarchy.

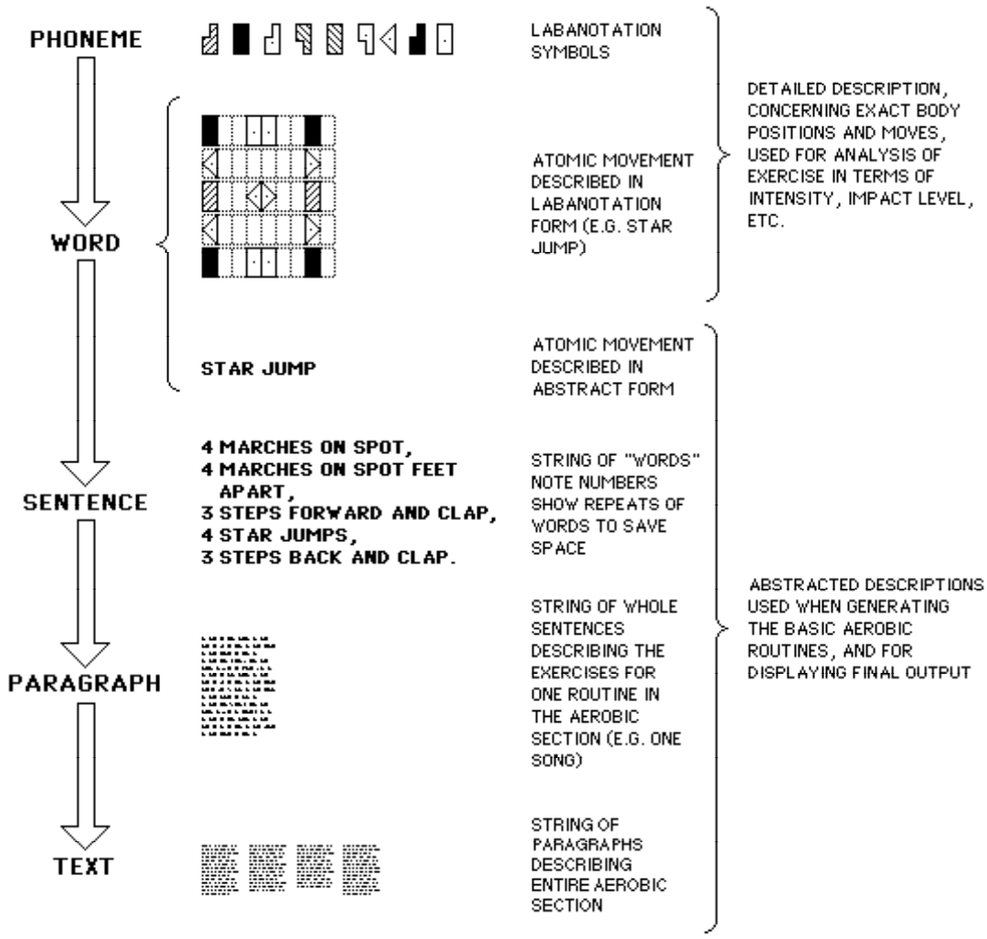

Fig. 28 : Hierarchies in English and Aerobics

8.1.3 The Final Analogy Between Natural Language and Aerobic Structures

In order to begin building a successful language model for Aerobics, final decisions had to be made concerning the best comparison between Natural Language constructs and those found in Aerobics routines. The choices were largely influenced by the ways in which Aerobics instructors themselves describe their routines to class participants and to other instructors, as discussed in the following sections; the overall aim being to develop

an analogy intuitive to both Aerobics language users (i.e. instructors) and Computational Linguists.

8.1.3.1 Lexemes & Morphemes

A lexeme, or lexical item, can be defined as:

> 'A minimal meaningful unit of language, the meaning of which cannot be understood from that of its component morphemes.' [Collins, 1987]

When Aerobics instructors teach, it is vital that they convey forthcoming exercise changes to class participants as accurately as possible in the limited time available. Since it is usually not feasible to fully describe each exercise in terms of the movements of individual body parts, exercise 'names' have evolved which are used and understood by most instructors (e.g. 'grapevine', 'star jump', etc. See Appendix 7).

These exercise names are used not only when teaching classes but also when describing routines to other instructors, both verbally and in written form. Such names can therefore be seen as lexemes, in that they are the most frequently used 'minimal' units of the Aerobics language.

Exercise names are chosen to be concise and easily remembered, and are frequently figurative rather than descriptive (See Section 5.1.1). As such, the names cannot usually by determined simply by considering the individual leg/arm/torso movements of which they are comprised. Thus, the individual leg/arm/torso movements of a named exercise can be seen as morphemes or lexical features (See [Gazdar, 1989]) in the Aerobics language.

In the example of the Foxtrot (See Section 8.1.1), the 'language' under consideration is far less complex than that of Aerobics, yet Herbison-Evans also uses what amounts to exercise names as the terminal symbols of his grammar. For example 'Left Quick Straight' (LQS) is a descriptive name representing a set of leg and body movements which would not usually be analysed in smaller units. (Note that the Labanotation

symbols are used in a non-standard manner, and as such are only pictorial representations of the step names i.e. they convey no additional underlying information concerning body movement).

8.1.3.2 Phrases and Sentences

Having decided upon the lexemes, or 'words' of the Aerobics language it was necessary to consider the higher constructs such as sentences and phrases. Once again the standard usage of the Aerobic language was considered in determining the most intuitive comparison with a Natural Language such as English.

Sentences can be defined as:

> 'A sequence of words capable of standing alone…' [Collins, 1987]

Aerobics classes usually comprise a number of exercise routines, each linked to a particular piece of music (i.e. song). Each routine is choreographed separately and is designed to be taught as a complete unit (i.e. teachers will not stop in the middle of a piece of music to move on to something else). This constraint is partly imposed by the music cassette tapes used in teaching the classes (which consist of a series of complete pieces of music), since it would be impractical to keep stopping the class in order to forward wind the tape past part of a song.

Thus an individual Aerobics routine can be seen as a sentence in that it stands alone, and must be complete for the language to be 'well formed'.

Within a complete Aerobics routine there are clear sub-divisions consisting of collections of exercises (See Fig 15), often repeated several times. These subdivisions usually correspond to repeated sections of music (e.g. verses or choruses), and can be thought of as 'phrases' given the definitions of 'lexeme' and 'sentence' already defined.

An alternative hierarchy suggested by text linguistics would be to consider the routine as a text and each individual exercise as a sentence, but this is counter-intuitive for users of

the language (i.e. instructors) where an exercise is the natural minimal unit of description (as discussed above). Furthermore they contain none of the rich recursive structures associated with generative sentence grammars.

8.2 Preliminary Attempts to Build a Language Model

Before the Aerobics corpus had been collected, preliminary investigations were made into possible representations of Aerobics routines in a phrase structural manner. Two of the many conceivable variations of a simple parse tree for the Aerobics segment shown in *Fig. 21* are shown in *Fig. 29* and *Fig. 30* below.

In *Fig. 29*, impact is considered to be a more dominant feature than travelling and a simple context free grammar capable of reproducing this tree could be created.

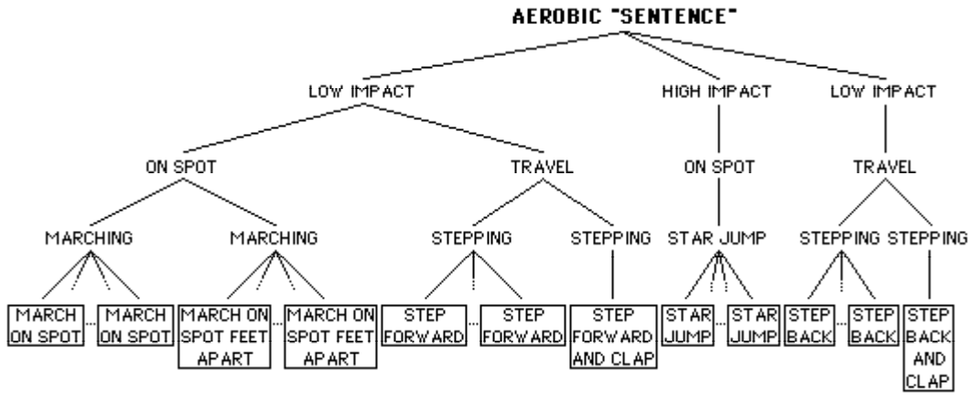

Fig. 29 : Syntax tree for an Aerobics 'Sentence' with Impact dominating

In *Fig. 30*, travelling is considered to be a more dominant feature than impact, and a discontinuity arises in one of the travelling 'phrases'. As a result, a simple context free grammar could no longer be created to reproduce this tree.

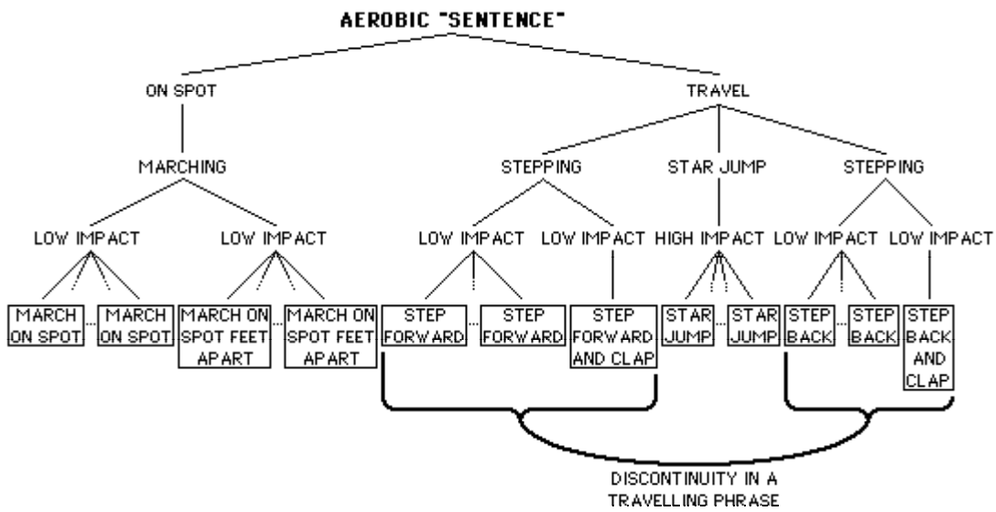

Fig. 30 : Syntax tree for an Aerobics ‘Sentence’ with Travel dominating

These brief examples served to demonstrate that the problem was definitely non-trivial. The domain of interest is, however, undoubtedly smaller and more manageable than that of a complete natural language such as English.

8.3 Requirements of the Aerobics Grammar

The language model used to represent the Aerobics Grammar and Lexicon had to be able to deal with a number of constructs not usually observed in natural languages such as English, and these are included in the list of requirements given below. Not all of these requirements were fully met, however, and this is discussed in the evaluation of the grammar in Section 8.4

- The model must be able to adequately represent expected syntactic categories, i.e. the terminal symbols (individual Aerobics exercises) and non-terminal symbols (phrasal categories such as ‘routine’, ‘introduction’, ‘verse’, ‘chorus’, ‘link’, ‘instrumental’, together with displacement, turning and static travelling phrases).

- The model must allow syntactic categories to contain feature information at all levels, and permit the passing of feature values up and down the tree structure. In particular, numerical feature unification must be permitted so that musical beat constraints may be dealt with (e.g. a chorus will consist of a fixed number of musical beats, so the sum of beats required by exercise terminals in its subtree must equal this value).

- The model must allow the representation of optionality and selection within its grammar rules (e.g. songs may or may not have any of a combination of verses, choruses, instrumental sections, etc.).

- The model must allow the repetition of categories constrained to dominate exactly identical sub-trees (e.g. exercises will often be repeated in an identical manner 4, 8 or 16 times before the routine choreography changes).

- The model must allow common ‘floor patterns’ to be represented (e.g. travelling in circles, squares, forward and backwards).

8.4 The Language Model

Having considered the alternative language models (see Section 2.2.1), it was decided that GPSG provided the best starting point for the creation of a model of Aerobic Dance Exercise. The Aerobics Grammar itself, described more fully later in this chapter, resembles GPSG except for the following details (see [Keenan, 1992] for definitions of terms used in the following section if required):

- X-bar theory has been abandoned, as has the concept of slash features and other restrictive feature propagations which were not required (e.g. Head feature propagation).

- Immediate Dominance and Linear Precedence (ID/LP) rules are not present in their usual forms, although single grammar rules can contain both ID and LP information by utilising 'selection from a set' notations, as shown in Section 8.4.1.

- Additive unification and numerical ranges for feature values are possible in the grammar rules. These are not normally required in a standard GPSG.

- (Optional) selection from a set is permitted in the grammar rules, as is the ability to specify the repetition of a lexical category *and* its sub-tree. Once again, this is a no-standard feature added to cope with the unique requirements of the language under consideration.

The notational conventions used to represent grammar rules embodying these abilities are provided in Section 8.4.1.

8.4.1 Notational Conventions

The PATR formalism [Gazdar, 1989] is used as the basis for representing the Aerobics Grammar, as well as the Aerobics Lexicon (see Section 5.2), although minor changes

and additions have been made to the notation system to allow for unusual constructs which occur regularly in Aerobics but not in natural languages such as English.

The conventions used are listed below:

$X \varnothing$ Y Z	:	Item X is re-written as item Y followed by item Z.
ΔX	:	'Delta X' represents X and the subtree dominated by X.
X^n	:	Item X is repeated n times.
ΔX^n	:	Item X is repeated n times and each occurrence must dominate an identical subtree.
$\Delta X_1..\Delta X_m$	:	Represents a set of item X's, each dominating a distinct sub-tree.
{X, Y, Z}	:	One item type from the set containing item types X, Y and Z is selected.
$\{X, Y, Z\}^n$	:	One item from the set containing items X, Y and Z is selected, and this process is repeated n times. Where n is constrained to be of the value set {0, 1}, this is equivalent to saying that selection from the set is optional.
$\{\Delta X, \Delta Y, \Delta Z\}^n$	:	One item from the set containing items ΔX, ΔY and ΔZ is selected, and this process is repeated n times. If any item is selected more than once, all its occurrences must dominate identical sub-trees. Where n is constrained to be of the value set {0, 1}, this is equivalent to saying that selection from the set is optional.
{m..n}	:	One value from the set containing values in the range m..n, where m and n are positive integers, is selected.
{m, n}	:	One value from the set containing values m and n, where m and n are positive integers, is selected.
<X y>	:	Represents the value of feature y for an item of type X.
$\sum^n$ <X y>	:	Represents the sum of values of feature y for all n occurrences of an item of type X.

The ΔX notation is required because Aerobics routines often involve repetitions of exactly the same sequences of exercise (e.g. identical exercises are often performed to each chorus of a song), or of exactly the same single exercise (e.g. exercises are usually repeated 2, 4 or 8 times before the choreography changes).

8.4.2 Explaining the Rule Structure

The general structure of a typical Aerobics Grammar rule is shown in *Fig. 31* below:

Rule {**Rule description**}
$X \varnothing W \{\Delta Y_1..\Delta Y_m\}^{n1} \Delta Z^{n2}$
n1 = {0..4}
n2 = {0, 1}
m = {1..8}
<X beat> = <W beat> + $\sum^{n1}$ <{$Y_1..Y_m$} beat> + $\sum^{n2}$ <Z beat>
<X travel> = <W travel>
<X turn> = <Z turn>
<Z turn> = 180.

Fig. 31 : General structure of an Aerobics Grammar rule

This rule states that an item X rewrites as an item W plus up to n1 different Y items, plus up to n2 duplicates of an item of type Z, given a number of constraints.

Item constraints include the facts that n1 must be in the range 0..4, n2 may be either 0 or 1, and m must be in the range 0..8. All item constraints can be considered ‘loose’ in the sense that they should theoretically apply in all cases but are sometimes broken in reality.

Item feature constraints include the facts that the ‘beat’ feature value for X must equal the sum of all the ‘beat’ feature values of its daughters, the ‘travel’ feature value of X must equal the ‘travel’ feature value of W, the ‘turn’ feature value of X must match that of Z, and the ‘turn’ feature of Z must be 180.

8.5 The Grammar Rules

The following section shows the entire Aerobics Grammar, with explanations as to the meaning and necessity of each rule. For clarity, the grammar is also shown in Appendix 8 with no additional comments.

The first rule represents the highest level of an Aerobics routine, i.e. the splitting of the routine into sections corresponding to natural divisions in the music being used (e.g. verses and choruses). It states that an Aerobics routine must consist of an optional Introduction, followed by at least one Verse, Chorus, Link or Instrumental section, and concluding with an optional Fade.

Any of the central sections may be replicated (i.e. if Verse category V_1 is repeated it will dominate an identical sub-tree). Limits are put on the allowable number of repetitions of any section in line with observations taken from the Aerobics corpus. The beat feature of the entire routine is calculated to be the sum of the beat features of all its sub-tress.

Rule {**Aerobic Routine**}
Aero $\varnothing$ Intro^{n1}
$\{\{\Delta V_1..\Delta V_{m1}\}\ \{\Delta C_1..\Delta C_{m2}\}\ \{\Delta Ins_1..\Delta Ins_{m3}\}$
$\{\Delta Link_1..\Delta Link_{m4}\}\}^{n2}$
Fade^{n3}:
n1, n3 = {0, 1}
n2 = {1..12}
m1, m2, m3, m4 = {0..2}
m1 + m2 + m3 + m4 > 0
<Aero beat> = $\sum^{n1}$ <Intro beat> +
$\sum^{n2}$ <{$\{V_1..V_{m1}\}$ $\{C_1..C_{m2}\}$ $\{Ins_1..Ins_{m3}\}$
$\{Link_1..Link_{m4}\}$} beat> +
$\sum^{n3}$ <Fade beat>.

The following rules show how the different sections of the music are broken up into various allowable travelling phrases, i.e. linear, circular or static (on-the-spot). Once again the beat features are calculated as summations of the sub-trees.

Rule {**Intro Section**}
Intro $\varnothing$ {Lin Circ Stat}:
<Intro beat> = <{Lin Circ Stat} beat>.

Rule {**Verse Section**}
V $\varnothing$ $\{\text{Lin Circ Stat}\}^{n}$:
n = {1, 2, 4, 8}
<V beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Chorus Section**}
C $\varnothing$ $\{\text{Lin Circ Stat}\}^{n}$:
n = {1, 2, 4, 8}
<C beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Instrumental Section**}
Ins ∅ {Lin Circ Stat}:
<Ins beat> = <{Lin Circ Stat} beat>.

Rule {**Link Section**}
Link ∅ {Lin Circ Stat}^{n}:
n = {1, 4}
<Link beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Fade Section**}
Fade ∅ {Lin Circ Stat}^{n}:
n = {1, 4}
<Fade beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

The following rules define travelling phrases which allow the grammar to represent movements of the class participants *relative to the room* in which they are exercising. For linear and circular travelling there are rules to allow for returning to the start point if required. It is assumed that in a return movement, the direction of travel will be reversed automatically.

Linear travelling without a return can be used in conjunction with turning or other linear travelling to obtain floor patterns such as squares.

Intermediate travelling phrases are also allowed, e.g. the class might travel forward and perform an exercise on the spot *before* returning to their start positions.

Rule {**Linear travelling with return**}
Lin ∅ Mv Int$_1$ Rt Int$_2$:
<Lin beat> = <Mv beat> + <Int$_1$ beat> + <Rt beat> + <Int$_2$ beat>
<Mv travel> = <Rt travel>.

Rule {**Linear travelling without return**}
Lin ∅ Mv:
<Lin beat> = <Mv beat>.

The term ‘facing radially’ is used to mean ‘facing inwards towards the centre of the circle’. It does not imply that the class members will necessarily travel inwards or outwards, but merely dictates the direction in which they face as they move in a circle.

Rule {**Circular travelling with return, facing radially**}
Circ ∅ Mv $\{Int_1\ Rad_1\}^{n1}$ Ret $\{Int_2\ Rad_2\}^{n2}$:
n1, n2 = {0, 1}
<Circ beat> = <Mv beat> + $\sum^{n1}$ <$\{Int_1\ Rad_1\}$> +
<Ret beat> + $\sum^{n2}$<$\{Int_2\ Rad_2\}$beat>
<Mv travel> = <Ret travel>
<Mv travel> = {left, right}.

Rule {**Circular travelling without return, facing radially**}
Circ ∅ Mv:
<Circ beat> = <Mv beat>
<Mv travel> = {left, right}.

The term ‘facing turnwise’ is used to mean ‘facing in the direction of circular travel’. It is assumed that left and right movements will cause left and right movement round the circle.

Rule {**Circular travelling with return, facing turnwise**}
Circ ∅ Mv $\{Int_1\ Rad_1\}^{n1}$ Trn Mv $\{Int_2\ Rad_2\}^{n2}$:
n1, n2 = {0, 1}
<Circ beat> = 2 x <Mv beat> + $\sum^{n1}$ <$\{Int_1\ Rad_1\}$> +
<Trn beat> + $\sum^{n2}$<$\{Int_2\ Rad_2\}$beat>
<Mv travel> = {forward}
<Trn turn> = 180.

Rule {**Circular travelling without return, facing turnwise**}
Circ ∅ Mv:
<Circ beat> = <Mv beat>
<Mv travel> = {left, right}.

Radial travelling refers to movement of the class towards or away from the centre of a circle.

Rule {**Radial travelling with return**}
Rad ∅ Mv Rt :
<Rad beat>= <Mv beat> + <Rt beat>
<Mv travel> = <Rt travel>
<Mv travel> = {forward, backward}.

An ‘intra-travelling move’ is a travelling move ‘embedded’ within another travelling move. Currently only static (on-the-spot) intra-travelling is allowed, although this could easily be extended if required.

Rule {**Intra-travelling move**}
Int ∅ {Stat}^{n}
n = {1, 2}
<Int beat> = $\sum^{n}$ <Stat beat>.

The following rules represent the level immediately dominating the terminal nodes. They specify the actual groups of exercises which form the Aerobics routines. In most cases their sub-trees consist of groups of 2, 4, 8 or 16 repetitions of (identical) exercises. An exercise will usually only ever be performed once if it required as a transitional move at the end of a longer sequence of exercises to prepare for the next sequence.

Rule {**Move from place**}
Mv ∅ ΔEx^{n}:
n = {1, 2, 4, 8}
<Mv beat> = $\sum^{n}$ <Ex beat>
<Mv travel> = <Ex travel>
<Ex travel> = {forward, backward, left, right}
<Mv turn> = <Ex turn>
<Ex turn> = 0.

Rule {**Return to place**}
Rt ∅ ΔEx^{n}:
n = {1, 2, 4, 8}
<Rt beat> = $\sum^{n}$ <Ex beat>
<Rt travel>= <Ex travel>
<Ex travel> = {forward, backward, left, right}
<Rt turn> = <Ex turn>
<Ex turn> = 0.

Rule {**Static on-the-spot exercise**}
Stat ∅ ΔEx^{n}:
n = {1, 2, 4, 8, 16}
<Stat beat>= $\sum^{n}$ <Ex beat>
<Ex travel> = place
<Ex turn> = 0.

Rule {**Turning on-the-spot exercise**}
Trn ∅ ΔEx^{n}:
n = {1, 2, 4}
<Trn beat> = $\sum^{n}$ <Ex beat>
<Ex travel> = place
<Trn turn> = <Ex turn>
<Ex turn> = {90, 180}.

There are currently 19 grammar rules, but they are complex and encapsulate a considerable amount of information. If a standard CF grammar formalism had been used, then the number of rules required to represent the same information would have been vastly greater.

8.6 An Evaluation of the Aerobics Grammar

As it stands, the grammar is able to represent a great majority of the Aerobics corpus entries. There are definite limitations, however, and the grammar is currently over-generative due to its inability to express certain pragmatic principals found in Aerobics. The key areas in which it performs less than perfectly are discussed in the following sections.

8.6.1 Class Displacement

There is currently no way to limit the total displacement of the class relative to the room in which they are exercising. Thus, the grammar *could* generate a sequence containing several travelling phrases all of which result in the class moving forward, thus crushing them against the wall of the gym!

Preventing this occurrence is not as straightforward as it first appears. Initially it was assumed that a ‘displacement’ feature could be included in the description of lexical items involving travel, such that a forward move would incur a +ve increment over the whole syntactic tree, whilst a backward move would incur a -ve increment. It would then be possible to ensure that the overall displacement at any node in the syntax structure remained below a set value.

Unfortunately this approach cannot work because of the possibility of rotational movement, when the ‘front’ of the class changes and participants face another direction. In such cases it is quite acceptable for the class to travel forwards, turn round 180 degrees and then travel forwards again back to their starting position.

Moreover, movement in a circular pattern (when the class participants form one large circle around the room) causes other problems. In these cases it is possible to travel continuously in one direction (i.e. around the circle) without restriction since the overall effect on the displacement of the entire class is zero.

Unless some means is found of keeping track of the class position relative to the room it is therefore impossible to ensure that the grammar cannot generate a technically correct but spatially impractical routine.

8.6.2 Impact Restrictions

Another problem not dealt with is that of impact restriction, i.e. the ability to constrain the routine such that sequences of HIA moves are not maintained for too long without the interspersion of LIA moves, in order to reduce the risk of stress injuries (see Section 5.1.4). Once again, it is not immediately apparent how such a restriction could be imposed simply by means of a unification strategy.

If the terminal exercises were given an impact feature, it would be possible to limit the overall amount of HIA at any intermediate node in the tree but difficult to ensure a reasonable spread of different impacts throughout the whole routine.

It should be noted that, as it was clearly not possible to deal with impact restrictions satisfactorily in the formal Aerobics Grammar, the ‘<arm position>’ feature which appears in the ACCOLADE entries was not included in the grammar rules or lexical entries (see Section 6.1).

8.6.3 Exercise Transitions

An easier enhancement to the grammar would be the addition of exercise transition restrictions, i.e. restrictions to make sure that every exercise flowed smoothly from the one before it. This could be achieved by incorporating ‘position’ features to show which

general start and finish positions (see Section 5.1.2) could be used for each exercise, and then re-working the grammar rules to ensure that adjacent exercises have at least one common position.

Exercise transition restrictions are analogous to coarticulation in spoken English. This is generally considered to be a feature dealt with at the phonemic rather than syntactic level (see Section 2.2.1.1). By analogy, it is therefore reasonable to avoid trying to deal with exercise transition in the grammar.

Whilst one of the easier ways to improve the language model, it is perhaps of least significance since instructors automatically modify the last of a sequence of exercises so that the next sequence follows on smoothly, even though this modification is never recorded in Aerobics routine plans.

8.6.4 The Exercise Intensity Curve

As mentioned in Section 2.1.2.1, Aerobics classes usually conform to a ‘single peak’ intensity pattern, i.e. the intensity of the class is increased to a peak, maintained at that level for a period and then brought back down again. This concept is difficult to reconcile with any patterns observed in natural language, and no obvious means of control is apparent using the GPSG-based grammar model.

The problem could far more easily be dealt with by applying a separate linear process to routines generated by the Aerobics Grammar. Once the grammar had generated a valid sequence of exercises it would be a relatively straightforward process to examine each exercise in turn and adjust its possible arm or leg modifications to create an appropriate intensity level.

CHAPTER 9 : Discussion

9.1 General Summary & Conclusions

The research presented in this document resulted in the development of a formal model for the language of Aerobic Dance Exercise using Computational Linguistics techniques, and explored some of its potential uses.

The following key tasks were achieved by the Bodytronix Project, and documented in this thesis:

- The collection of a representative sample of 125 Aerobics workout routines from 37 qualified and practising fitness leaders around the UK (see Chapter 4). These routines form the Aerobics corpus, which is currently the only one of its kind in the world.

  The corpus provided the basic knowledge-base from which the Aerobics Grammar and Lexicon were developed.

- The extraction of an lexicon of Aerobics exercises, annotated with formalised semantic and syntactic descriptors (see Chapter 5). A written version was produced (the Aerobics Dictionary) containing 33 base exercise moves, and then a computerised version created using PATR-based notation.

  The computerised version consisted of 39 entries and was used in conjunction with the Aerobics Grammar to form a comprehensive language model of Aerobics.

- The conversion of the written Aerobics corpus into a standardised knowledge-representation language, or tree bank, held on computer (see Chapter 6). This

also entailed a preliminary investigation of existing choreographic notation systems.

The fully tagged and annotated ACCOLADE corpus contains lexical entries including feature-based information concerning the use and form of the exercises, together with other important details such as written descriptions and commonly-occurring synonyms.

- The investigation of human figure animation techniques applicable to the research. The NUDES system was thoroughly explored, and shown to be entirely adequate in the 4D visual representation of Aerobic Dance Exercises (see Chapter 7)

- The extraction of a formalised grammar, or language model, of Aerobics. This was achieved by selecting the most applicable existing language model (GPSG) and notational formalism (PATR) adapting them to suit the specific circumstances (see Chapter 8).

  As with the production of the ACCOLADE knowledge representation language, the grammar was first written intuitively using the author's extensive knowledge of the subject domain together with data from the Aerobics Corpus. The grammar was then tested (manually) on the corpus and augmented appropriately to produce the final version discussed in Chapter 8.

  The Aerobics Grammar consists of 19 complex rules and relies heavily on feature-based unification. Novel properties, such as numerical unification, have been developed to overcome shortcomings in the original grammar model.

Work contributed by the Bodytronix Project to the fields of Computational Linguistics and Aerobics is completely original, and has great practical potential.

The Aerobics Dictionary is of immediate use to fitness leaders, students of exercise theory, or interested member of the general public, as is the Aerobics Corpus. The ACCOLADE corpus represents an interesting and unusual example of a sub-language for use in corpus linguistics research, and the Aerobics Language model is a prerequisite for the development of a number of applications which have been eagerly awaited by the fitness industry for some time (see Section 9.3).

Finally, on a personal note, the research undertaken gave me a far greater appreciation of the depth and complexity involved in the formal representation and modelling of a language. The language of Aerobic Dance Exercise, which may upon first inspection seem a relatively simple and constrained sub-language, in fact provides a highly challenging problem for Computational Linguistics research.

9.2 Work Outstanding

A small number of subsidiary tasks described in the thesis remain partially incomplete, and these are described in the following section. The fact that they remained incomplete did not affect the completion or validity of the key research goals, however, and the tasks were usually abandoned reluctantly due to time constraints.

In particular, the addition of animated sequences to the Aerobics Lexicon would have required far more man hours than were available, but it was demonstrated that the task was possible (see Chapter 7). This task is likely to completed only as a future project, and the author has no plans to complete this work personally.

The ACCOLADE corpus currently contains only a relatively small number of coded entries, although it is hoped that this will be rectified by the author in the near future. All written Aerobics Corpus entries have been manually checked, however, and the methodology for coding the entries is fully developed (see Chapter 6).

9.3 Future Projects

The results of the Bodytronix Project gives rise to a number of obvious development routes and future project ideas, and some of these are listed in the following sections.

9.3.1 An Aerobics Routine Generator

As already discussed in Section 3.3.2, a system for automatically generating safe and effective Aerobics routines is perhaps the most natural progression of the work already undertaken. Such a system would be of immediate practical value to instructors, and interest in such a project has already been demonstrated (see Section 4.2.3.2).

If the Aerobics Grammar had been a simple context free formalism, then creation of an Aerobics Generator would have been straightforward. For example, a CF grammar re-written as a PROLOG Definite Clause Grammar (DCG) [Pereira, 1986] can be run either as a parser or generator. However, the mapping of a unification-based grammar formalism onto a parser and/or generator is much less transparent [Gazdar, 1989].

Since the Aerobics Grammar employs some novel features such as additive unification (see Section 8.4), this precludes the use of a ‘standard’ unification grammar parser or generator.

9.3.2 Expansion to Cover Other Class Sections & Formats

The language model described in the thesis was created to cater for the actual sections of aerobic exercise found in standard Aerobics classes. It would be challenging to apply the same kind of techniques in the modelling of other sections of the class (e.g. ‘floor work’ or ‘warm-ups’), and of other class formats (e.g. Step Aerobics [Francis, 1990], Aqua-Aerobics [Reed, 1986], etc.).

9.3.3 Multimedia CDI Project

Computer-based multimedia teaching tools have been used with great success for a number of years, and are increasing in popularity as the price of the necessary hardware falls. Their ability to combine animated visual images with text and computer graphics makes them a powerful teaching medium well suited to the representation of complex three-dimensional data such as that associated with the theory and practice of Aerobic Dance Exercise.

The proposed Computerised Aerobics Teaching Tool would be targeted chiefly at fitness leaders still in training, but would also provide a valuable resource for those already teaching. Supplied on a CD disk, the following features would be available through a user-friendly graphical interface:

- A comprehensive 'Aerobics Dictionary' of safe and effective exercises including full colour video sequences of professional instructors performing the moves to appropriate music. Each exercise would have accompanying information concerning its physiological risks and benefits, targeted muscle groups, suggested execution speed ranges, travelling and turning potential, intensity and complexity variation potential, teaching points, history, and list of common synonyms.

  The dictionary could be browsed randomly or searched by certain exercise features such as name, target muscle groups, style, etc.

- An 'Aerobic Routine Generator Tool' capable of creating fully choreographed class sections tailored to specific target classes by using information supplied by the user. The routines generated could be viewed as video sequences formed by automatically splicing together individual exercises taken from the main dictionary. Editing would be possible before a final version would be printed out in a written format similar to that used by teachers when recording their own class choreography.

- An ‘Aerobic Sequence Development Tool’ allowing the user to enter and test their own routines by sequencing exercises from the dictionary and altering intensity, music speed, and other governing parameters. The tool would provide a constantly-updated analysis of the proposed routines comprising information such as overall complexity and intensity levels, details of muscle use/overuse, etc. Written descriptions of the finished routines could be generated as with the Aerobics routine generator.

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APPENDIX 1 : Survey Costing

During the initial planning for the survey, an estimated costing was drawn up in order to secure the necessary funds from the School of Computer Studies, University of Leeds. Full details of this costing can be found in the original survey report [Bull, 1990 #2]. The actual costs incurred, measured as accurately as possible, are shown below:

The Pilot Survey

The following figures are based on the pilot survey, described in Section 4, involving a target population of 21 teachers in the Humberside area. The regional ASSET representative, Linda Lawson, was sent 21 questionnaires (one for herself, and the rest for re-distribution).

● Production of the original questionnaire	Negligible
● Telephone costs (for contact with Linda Lawson)	£ 1.00
● Reproduction costs	£ 2.55
● Cost of envelopes	£ .65
● Postage costs (including the s.a.e.'s)	£ 10.39
Total Cost	**£ 14.59**

The Full Scale Survey

The following figures are based on the full scale national survey, during which 467 questionnaires were distributed to teachers around the country. Both ASSET and the Fitness Professionals organisation helped greatly in the distribution of the questionnaires.

● Production of the original questionnaire	Negligible
● Telephone costs	£ 15.00
● Reproduction costs	£ 7.50
● Cost of envelopes	£ 16.90
● Postage costs (including the s.a.e.'s)	£ 163.58
Total Cost	**£ 202.98**

The relatively low cost of the survey was due largely to the generous assistance given by the Fitness Professionals organisation, which offered to pay the postage costs for distributing some of the questionnaires.

APPENDIX 2 : Sample Survey Questionnaire

This appendix contains an example of the letter which was actually sent out to the aerobics teachers constituting the target population for the survey. It should be noted that the emphasis of the Bodytronix Project shifted slightly after the survey data had been collected, due to the high complexity of the language modelling problem, which had not been adequately anticipated. Thus the survey questionnaire talks of the Aerobics Routine Generator (see Section 3.3.2) as the central issue.

It also should be noted that this particular letter is geared towards members of ASSET, and those sent to members of the Fitness Professionals organisation were very slightly different, although the changes made did not affect the data received. The most noticeable change was the replacement of the first question:

Are you a Grade 1 ASSET member? YES / NO

with the following:

Have you been teaching exercise to music for more than two years? YES / NO

Grade 1 ASSET members are RSA certified teachers with at least two years experience in the field. The second version of the question, combined with knowledge of RSA certification, therefore provides the same information.

School of Computer Studies
University Of Leeds,
Leeds, LS2 9JT.

Tel. : (0532) 335 430
Fax. : (0532) 335 468

NATIONAL SURVEY OF TEACHERS OF AEROBIC DANCE EXERCISE

Dear teacher,

I am a postgraduate student at Leeds University, where I am researching into the brand new and exciting area of "Computer Generated Aerobic Dance Workouts". My aim is to create a computer program which can automatically produce safe, effective and interesting aerobic workouts for practical use by teachers of exercise to music. To achieve this goal, I am investigating methods whereby the computer will "learn" from real examples of exercise routines, and then apply its new knowledge in creating its own completely original routines.

I am not trying to replace the creativity and unique qualities of individual teachers, but merely to make a tool to help in the development of new material or to provide help when time to prepare new classes is limited. The presentation and teaching style, in any event, will always be down to the teacher concerned.

My research project is very large and complex, and I cannot hope to succeed without the help of experts in the field of exercise to music (I myself am only recently RSA qualified, and lack experience). Consequently, I am attempting to contact some of the most qualified and experienced teachers in Great Britain in order to ask for help. This letter has kindly been passed on to you by Christine North, your local ASSET representative (obviously, ASSET would not provide me directly with your addresses, as this would be unethical), in the hope that you might help.

What I would like is a copy of one of your aerobic workouts (not the warm up, LMSE or cooldown - just the actual aerobic section), written down in *as much detail as possible*. Preferably this would include the music used and length of each part of the workout, a breakdown of the music showing what exercise movements were used and how many beats they lasted, and any relevant teaching points. Stick figure drawings of unusual or complex movements would be very helpful, but don't worry if you can't spare the extra time required. A copy of the aerobic section from your RSA examination would be ideal (and presumably easier on your part).

Your routines will be treated with complete confidentiality, and will be used solely by myself for the purpose of my research in attempting to gain the following information :

- Whether there is a consistent vocabulary of exercise names and descriptions throughout the nation (e.g. everyone knows what a "star jump" is, although others prefer to call it a "jumping jack", but how many people know what a "gigolo" is?). If my program is to produce written exercise routines, it must only use terms which most teachers can understand!

- Details of specific exercise moves (*not* whole routines) for use as basic building blocks for my program to use in producing its own routines.

- Details of complete exercise routines from which my program will be able to "learn" what constitutes a valid and successful class plan. It will *not* copy existing routines, but will analyse the ways in which movements are combined and fitted to the music. The rules it learns will then help it in creating its own routines.

I know that I am asking a lot of you, especially since I can offer nothing in return except my grateful thanks and an acknowledgement in my research report. Please help if you can, or pass this letter on to someone else you think may be able to as my research grant is *very* limited and the cost of this survey is high. Please feel free to contact me if you would like to know more about this survey, or my research in general.

N.B. This survey has the complete approval of ASSET central office, and it is hoped that the findings will be included in a future edition of the ASSET journal.

Yours sincerely,

Adam Bull.

PLEASE COMPLETE THIS SLIP AND RETURN IT, WITH YOUR EXERCISE ROUTINES, IN THE PRE-PAID ENVELOPE PROVIDED

NAME: **TELEPHONE** : _____
ADDRESS : _____
_____
_____
_____

IMPORTANT NOTE : The above details are only needed in case any clarification of the routines you send me is required, and so I can tell which parts of the country are represented in the survey. They will be treated with *complete confidentiality*, and will *NOT* be passed on to anyone else under any circumstances. Unless otherwise indicated, however, I *would* like to acknowledge your help with the survey by including your name in my research paper.

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CIRCLING THE APPROPRIATE ANSWER IN EACH CASE :

Are you a Grade 1 ASSET member?	YES / NO
If not, do you have an RSA teaching qualification?	YES / NO
Do you have access to a Personal Computer at your home?	YES / NO
If you work at a sports centre or health & fitness club, is a Personal Computer available there?	YES / NO
If a computer program such as that mentioned in the letter was available, do you think exercise teachers would be willing to use it?	YES / NO

IF YOU HAVE *ANY* OTHER COMMENTS OR PIECES OF ADVICE, I WOULD BE VERY GLAD TO HEAR THEM :

_____
_____
_____
_____
_____
_____

THANKYOU VERY MUCH FOR YOUR TIME AND HELP

APPENDIX 3 : ASSET Representatives

This list of regional representatives for ASSET (The National Association for Health and Exercise Teachers) is correct for the Summer of 1990. The area codes (shown in brackets after the list of areas covered by the representative) are those used by ASSET, and some of the more densely populated areas are covered by more than one representative.

It should be noted that some regions have temporary vacancies for the post of representative. These regions, together with the Irish and Scottish regions, do not appear on the map given in Section 4.1.2.

The South

KENT (S1)
Gerry Kennedy. Tel. : (0892) 890 852
2 Down Farm Oasts, Down, Tunbridge Wells, Kent, TN3 0HF.

W. SUSSEX/E. SUSSEX (S3)
Sue Mills. Tel. : (0323) 832 020
"Touchwood", The Square, Hertsmonceux, Sussex, BN27 4LB.

DORSET (S4)
Jackie Dickson Smith. Tel. : (0305) 853 408
7 Spring Gardens, Broadmayne, Dorchester, Dorset, DT2 8PP.

AVON/BRISTOL/GLOS/SOMERSET/WILTS (S5)
Ann Beakes. Tel. : (0934) 416 699
Y Bryn, 90 Kewstoke Road, Kewstoke, Weston-Super-Mare, Avon, BS22 9YH.

OXON/BUCKS/BERKS (S6)
Robin Page. Tel. : (0295) 738 180
The Old Chapel, Main Street, Hanwell, Nr. Banbury, Oxford, OX17 1HW.

SURREY (S7)
Miranda Llewellyn. Tel. : (081) 977 0108
1 Ingram House, Park Road, Hampton Wick, Surrey, KT1 4BA.

GLOUSTERSHIRE (S8)
Helen Chidgey. Tel. : (0452) 714 611
Petaluma, Brookfield Road, Churchdown, Glos., GL3 2NZ.

LONDON (S9)
Jennie Tarsnane. Tel. : (081) 349 1449
20 Manor View, Finchley, London, N3 2SS.

LONDON (SOUTH) (S9)
Jean Krzysiak. Tel. : (081) 390 4329
78 St. James Road, Surbiton, Surrey, KT6 4QN.

DEVON (?)
Suzi Heilbrunn. Tel. : (0804) 266 635
Paignton, S. Devon, TQ3 2NS.

WILTSHIRE (?)
Salli Grant. Tel. : (0722) 790 439
Southview, Mount Pleasant State, Stoford, Nr. Salisbury, Wiltshire, SP2 0PP.

HANTS (?) - Vacant.

The Midlands

ESSEX/SUFFOLK/HERTS (M1)
Julie McCracken. Tel. : (0376) 561 867
8 Windmill Fields, Coggershall, Essex, CO6 1PJ.

DERBYSHIRE/LEICESTERSHIRE/NOTTS (M2)
Rachel Holmes. Tel. : (0773) 714 682
"Birchwood", High Street, Loscoe, Derbyshire, DE7 7LE.

BIRMINGHAM/WARWICKS/MIDLANDS (M3)
Michelle Hammond. Tel. : (021) 472 5858
9 Kingfisher Way, Bournville, Birmingham, B30.

CHESHIRE/STAFFS/SHROPS (M5)
Linzi Cockayne. Tel. : (0543) 370 883
17 Wallheath Lane, Stonnall, Staffs., WS9 9HP.

NORFOLK/CAMBS (M7)
Gillian Pearce. Tel. : (0553) 691 856
1b Tower Place, Kings Lynn, Norfolk.

NORFOLK (?)
Jan Pickering. Tel. : (0493) 658 817
62 Albermarle Road, Corleston-on-Sea, Norfolk, NR31 2AS.

HEREFORD/WORCS (M6) - Vacant.

HERTS/LUTON/BEDS (M4) - Vacant.

ISLE OF MAN (M1) - Vacant.

The North

TYNE & WEAR (N1)
Carol Harrison. Tel. : (091) 482 5122
4 Red Lion Cottage, Eighton Banks, Gateshead, Tyne & Wear.

W. YORKSHIRE/LANCASHIRE (N3)
Sharon Clough. Tel. : (0282) 412 742
Grapevine Fitness Centre, King Street, Burnley, Lancaster.

HUMBERSIDE/LINCS (N5)
Linda Lawson. Tel. : (0482) 652 915
11 Bessacar Ave., The Parkway, Willerby, Hull, HU10 6JA.

LEEDS/YORK/HARROGATE (N6)
Christine North. Tel. : (0943) 798 16
9 Cleasby Road, Menston, Nr. Ilkley, W. Yorkshire, LS29 6JW.

MERSEYSIDE (N7)
Chris Hodgson. Tel. : (0704) 879 516
20 Longfield, Formby, Merseyside, L37 3LD.

CUMBRIA (N8)
Sue Schofield. Tel. : (0229) 88 703
5 Lands Close, Newbiggin, Ulverston, Cumbria, LA12 0TY.

YORKSHIRE (?)
Sally Latimer. Tel. : (0909) 563 528
17 Crowgate, S. Anston, Nr. Sheffield, Yorkshire, S31 7AL.

MANCHESTER (N4) - Vacant.

N. YORKSHIRE/CLEVELAND/CO. DURHAM (N2) - Vacant.

Ireland

NORTHERN IRELAND/DUBLIN (I1)
Aine McCarthy. Tel. : (0001) 335 020
15 Seapark Drive, Clontarf, Dublin 3, Eire.

Wales

S. WALES/GLAMORGAN/DYFED/GWENT (W2)
Fiona J. Taylor. Tel. : (0443) 451 688
Pen Beili Cottage, Ty Du Road, Llanfabon, Nelson, Treharris, Mid Glamorgan, CF46 6PH.

Scotland

GLASGOW/STRATHCLYDE/DUMFRIES (SC2)
Elle Gordon. Tel. : (041) 644 4491
Gordons Thornton, Thornton Road, Thornton Hall, Glasgow, G74 5AL.

EDINBURGH (SC3) - Vacant.

Channel Islands

CHANNEL ISLANDS (CH1) - Vacant.

APPENDIX 4 : Sample Routines from the Aerobics Corpus

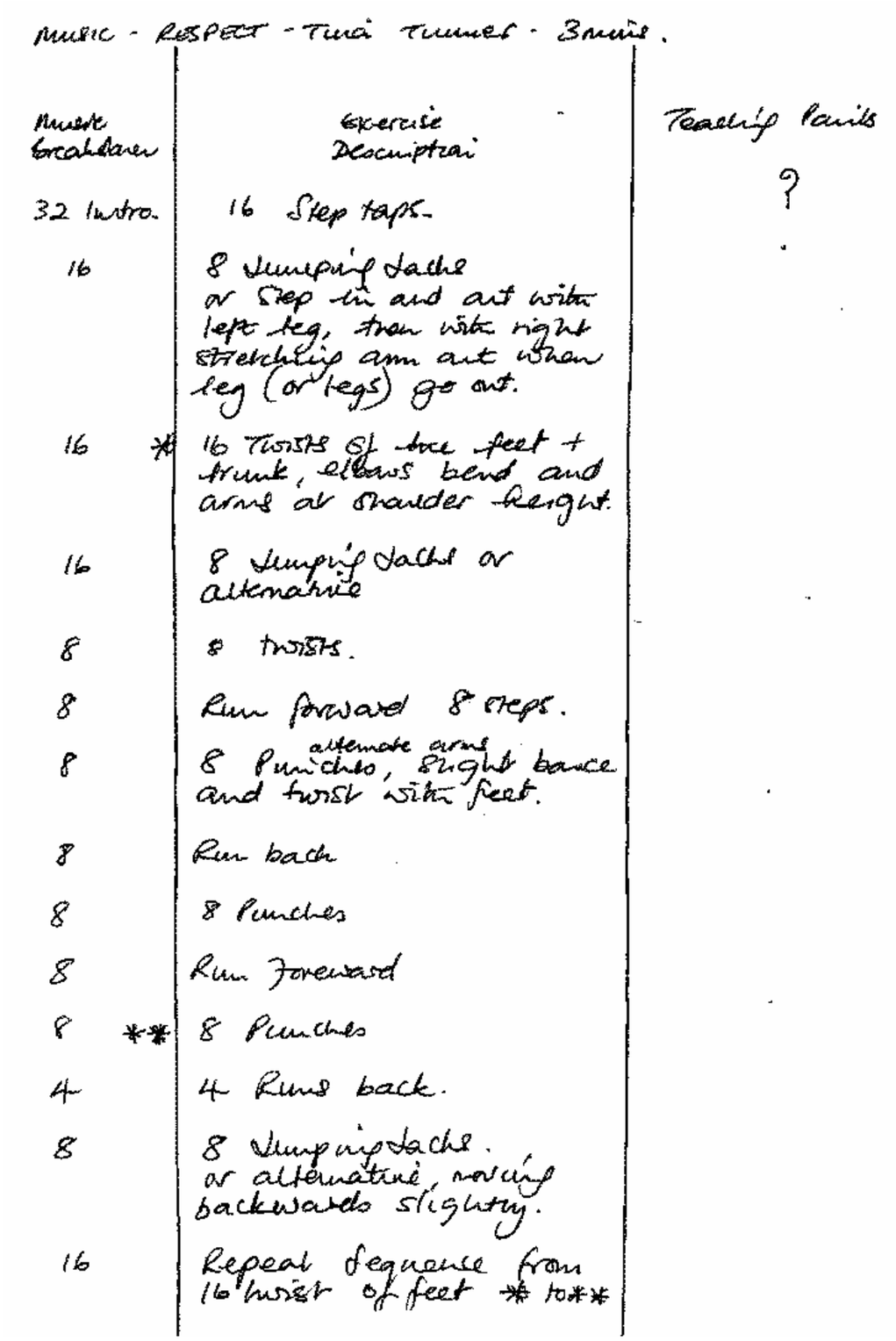
The following appendix contains six examples of actual Aerobics routines sent by fitness leaders in response to the national survey (see Chapter 4).

AEROBICS - HARD

MUSIC: Jimmy Sommerville 'You make me feel (Mightly real)' from 'The Singles Collection 1984/1990'

DURATION: 3.35 minutes AIM: To maintain heart rate in training zone, increase coordination and endurance

ANALYSIS		DESCRIPTION	TEACHING POINTS
Intro	2x8	march on the spot	
	2x8	box step	weight slightly forward, step wide
Verse 1	3x8	travelling pendulum legs (x4), heel/toe (x4) repeat x3	side step as alternative low impact to pendulum heels must go down, supporting knee soft on heel/toe
Chorus 1	2x8	walk/jog forward + arms (x4), 4 half stars	stride out using heel/toe action if walking forward, pump arms above in controlled way
		walk/jog back, 4 half stars	full stars as alternative to fitter participants
Verse 2	3x8	as verse 1	really flex and point foot and bend knee
Chorus 2	4x8	as chorus 2 (x2)	travel!
Instrum	8	march on the spot	back straight, knees up high, no stamping
	2	turn 45 degrees	
	2x8	stationary twists	make sure heels go down, feet parallel,
	4	march on the spot	arms controlled
Chorus 3	2x8	as chorus 1	if tired walk rather than jog, half stars - extend leg out to increase intensity control arms
Verse	4x8	as verse 1	side step if tired
Chorus 4	4x8	as chorus 1	
	2x8	twist until music fades	heels down, back straight



MUSIC - RESPECT - Tina Turner - 3mins.

Music breakdown		Exercise Description	Teaching Points
32 Intro.		16 Step taps.	?
16		8 Jumping Jacks or Step in and out with left leg, then with right stretching arm out when leg (or legs) go out.	
16	*	16 Twists of toes feet + trunk, elbows bend and arms at shoulder height.	
16		8 Jumping Jacks or alternate	
8		8 twists.	
8		Run forward 8 steps.	
8		8 Punches, alternate arms slight bounce and twist with feet.	
8		Run back	
8		8 Punches	
8		Run Forward	
8	**	8 Punches	
4		4 Runs back.	
8		8 Jumping Jacks. or alternate, moving backwards slightly.	
16		Repeat sequence from 16 twists of feet * to **	

Liz Jordan

AEROBICS — HARD AEROBIC — THE HEAT IS ON

3mins 45sec

BEGINNERS

		TEACHING POINTS
88 intro	Heels to bottom	Don't lean forward
88 A	Kick forward 8 use arms add a hop 8 arms not so high	Back nice straight
88	Foot out to side use arms 8 add hop	Arms shoulder height
8 8 sax	March	Use whole of the foot Back straight Relax the shoulders down
884 D	knee Lifts 12 Alternate Right 4 Left 4 pull arms down	Bring knee to chest not chest to knee Relax shoulders down
882 Ch	Foot out to side 4 Jumping jacks 4 1/4 turn Jumping jacks 4 foot to side	
888 E inst	Squats 4 arms Right 4 Left side Alternate 8	Tummy in Bottom in back back straight Knees over toes
884 D	Knee lifts 12 Alternate 4 Right 4 Left pull arms down	Keep back straight Bring knees to chest not chest to knees
882 Ch	Alternate foot out to side 4 Jumping Jacks 4 1/4 turn 4 Jumping Jacks 4 foot outside	Push heels down on Jumping jacks
8 A1	Squats reach arms up 4 Right 4 Left	Knees over toes Tummy in Bottom in Keep back straight
88 A1	Kick forward 8 use arms big movements Kick forward 8 co hop use arms arms lower	Keep back straight
88	Out to side 8 use arms Out to side 8 co hop use arms not so much now	Heels to floor
8 6	Sax March use arms	Relax the shoulders down usethe whole of the foot
88 Ch Rep 88	Foot out to side 4 Jumping Jacks 4 1/4 turn 4 more	Push feet down on Jumping jacks
8	Rep	

TEACH — 1/2 TURN

NAME: JULIANNE DAVIES LESSON PLAN: FIRST AEROBIC ROUTINE INDEX: 5 page 4

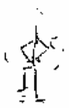
Music & Music Breakdown		Description of Exercise	Diagram	Teaching Points / Observations
3.00 mins (slow and fast count)				
3 X 8	A	STEP TAP		TEACHING RHYTHYM AND SPEED OF ROUTINE
4 X 8	B	STEP FORWARD, STEP BACK THEN REPEAT A		REPITITIVE MOVEMENTS WITH PROGRESSIVE THEME IN THE HOPE THAT BEGINNERS WILL PICK UP ON WITHOUT TOO MUCH TROUBLE.
4 X 8	B	STEP FORWARD 2 MARCH BACK 4 REPEAT A	PROGRESSION ON B	ALL ABOVE STEPS CAN BE PROGRESSED AGAIN INTO A HIGH INTENSITY AEROBIC ROUTINE.
4 X 8	B	REPEAT PROGRESSION B WITH	PROGRESSION ON A	TEACHING KNEE FORWARD ALIGNMENT ON MARCHES FOR POSTURE AND PREVENTION OF MISALIGNMENT OF HIPS ALSO CORRECTIVE FOR BAD HABITS.
4 X 8	REPEAT	ALL ABOVE MOVEMENTS WITH LEFT LEG LEAD.		
3 X 8	A	STEP TAP ARM SWINGS		CUE CLASS FOR DIAGONAL WORK.
7 X 8	A,B	PROGRESSING WITH WIDER STEPS	AND DIRECTIONAL CHANGES.	
12 X 8		ALL ABOVE STEPS WITH EVERYTHING INCORPOTATED.	PROGRESSION 16 JOGGING MOVES	THESE JOGGING MOVES WILL BE LOW IMPACT I.E TOES ON GROUND BACKWARDS MOVEMENTS 12 HIGH IMPACT LOW INTENSITY JOGS, BACKWARDS MOVEMENTS
SONG: TWIST AND SHOUT (SALT + PEPPER.)				END OF ROUTINE WITH MARCHES, INTO NEXT PACE

Cath Turrell
Time 3 mins

2/

Peak Aerobic (Low & High Intensity)

WILD ONE

Music Breakdown	Diagrams	Exercise Description	Reps. & Sets	Muscle Groups & Joints	Teaching Points
Intro 32 8888		Get into circle Jog on spot facing in various arms.	8 reps x 4 sets	Most muscles working Cardiovascular system doing a lot of work.	Heels well down, steady breathing, talking about intensities, and remind to work to own ability. Also take chance to discuss next part of routine.
Chorus 1		x 4 small jacks x 4 " lunge to side, left then right repeat, x 2 runs into centre circule.	4 reps 1 set " " " 8 reps 2 sets		
Verse A1		Step touch on spot x 8 Left Shoulder into circle . Step touch moving circle around, face in again and step touch on spot x 8	8 reps 1 set 8 reps 1 set 8 reps 1 set		Soft Knees while doing jacks not taking legs too far apart. Don't twist from waist in lunge, take it steady and just mark time intensity is too high. In the twists take it very gentle again Knees soft and heels down. In step touch don't stamp foot just touch in front.
Chorus 2		x 4 twists with legs closed x 4 twists legs open. x 4 small kicks into circle centre x 4 small knee lifts out x 2 runs into centre	4 reps 1 set 4 reps 1 set 4 reps 1 set 4 reps 1 set 8 reps 2 sets		
Verse A2		REPEAT. Chorus 2 Repeat			
Chorus 1		REPEAT. Verse A3 until end repeat.			
Verse A3		REPEAT.			

HARD
2nd AEROBIC - INCREASING THE INTENSITY - MIXING HIGH & LOW IMPACT
music - 'Sabrina - Boys, Boys, Boys'

	MUSIC	CONTENT	REPS	TEACHING POINTS
INTRO	88	jogs on spot	2x8	THROUGH THE FOOT
B	8888	4 gallop, 2 star jumps	x4 L&R	HEELS DOWN
C	8888	raise knee & kick	x8 L&R	YOU DONT HAVE TO JUMP
A	8888	double skips on spot	2x8	HEEL DOWN
	8888	flex foot & elbows	2x8 L&R	TIME TO CATCH YOUR BREATH
B	8888	4 gallop, 2 star jumps	x4 L&R	CAN DO HALF STAR JUMP
C	88	raise knee & kick	x4 L&R	CATCH YOUR BREATH
A	8888	double skips on spot	2x8	PRETEND TO SKIP ROPE
	8888	flex foot & elbows	2x8 L&R	FLEX TO THE SIDE
B	8888	4 gallop, 2 star jumps	x4 L&R	CAN JUMP LOW
C	88	raise knee & kick	x4 L&R	POINT TOE DOWN
A	88	double skips on spot	2x8	MAKE SURE HEEL TOUCHE DOWN
	88	flex foot & elbows	2x8 L&R	
B	8888	4 gallop, 2 star jumps	x4 L&R	CAN TAKE THE IMPACT DOWN
A	8888	double skips on spot flex foot & elbows	x8 x8	PRETEND TO USE ROPE
B	8888 884	4 gallop, 2 star jupms repeat	x4 L&R	SLOW DOWN IF YOU BECOME BREATHLESS

APPENDIX 5 : The Written Aerobics Dictionary

The following appendix contains copies of the entries in the written Aerobics lexicon, i.e. the Aerobics Dictionary (see Chapter 5). It should be noted that some of the 'Commonly Occurring Variations' sections are incomplete.

APPENDIX 6 : Sample ACCOLADE Entries

The following appendix contains sample entries from ACCOLADE (A Computerised Corpus of Legal Aerobic Dance Exercise). See Chapter 6 for further details.

```
[ Routine #44.1 (392) [ [ Build up ] [ 3.05 ] [ Victoria Burley ]
                        [ “Happenin all over again” Lonnie Gordon “Now 17” 1990 ]]
  [ Intro  (40) [ Static (32) [ 16 x ALTERNATING_TOE_TAP ( 2 place 0 on_hips - - ) ]
                  Static (8)  [ 4  x MARCH               ( 2 place 0 marching low - ) ]]]
  [ V      (80) [ Static (16) [ 8 x SIDE_LUNGE ( 2 place 0 marching low - ) ]
                  Static (16) [ 8 x MARCH      ( 2 place 0 marching low - ) ]
                  Static (16) [ 8 x SIDE_LUNGE ( 2 place 0 sgl_push_across low - ) ]
                  Static (16) [ 8 x MARCH      ( 2 place 0 marching mid - ) ]
                  Static (16) [ 8 x SIDE_LUNGE ( 2 place 0 sgl_push_across mid - ) ]]]
  [ C      (32) [ Lin_Travel (32) [ Move   (8) [ 4 x SIDE_STEP  ( 2 left 0 side_arm_lift low - ) ]
                                    Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]
                                    Return (8) [ 4 x SIDE_STEP  ( 2 right 0 side_arm_lift low - ) ]
                                    Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]]]]
  [ V      (48) [ Static (16) [ 8 x SIDE_LUNGE ( 2 place 0 sgl_push_across mid - ] ]
                  Static (16) [ 8 x MARCH      (2 place 0 marching mid - ] ]
                  Static (16) [ 8 x SIDE_LUNGE ( 2 place 0 sgl_push_across high - ] ]]]
  [ C      (64) [ 2 x Lin_Travel (32) [ Move   (8) [ 4 x SIDE_STEP  ( 2 left 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]
                                        Return (8) [ 4 x SIDE_STEP  ( 2 right 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]]]]
  [ Link   (48) [ Static (16) [ 8 x SQUAT ( 2 place 0 - - - - ) ]
                  Static (16) [ 8 x SQUAT ( 2 place 0 dbl_push_front mid - ) ]
                  Static (16) [ 8 x SQUAT ( 2 place 0 dbl_push_front high - ) ]]]
  [ C      (80) [ 2 x Lin_Travel (32) [ Move   (8) [ 4 x SIDE_STEP  ( 2 left 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]
                                        Return (8) [ 4 x SIDE_STEP  ( 2 right 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]]
                  Lin_Travel     (16) [ Move   (8) [ 4 x SIDE_STEP  ( 2 left 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x LUNGE_BACK ( 2 place 0 dbl_push_front mid - ) ]]]]]
```

```
[ Routine #44.2 (508) [ [ Peak ] [ 3.35 ] [ Victoria Burley ]
                        [ “You Make Me Feel (Mighty Real)” Jimmie Sommerville “The Singles Collection 1984/90” 1990 ]]
  [ Intro  (64) [ Static [ 16 x MARCH    (2 place 0 marching mid - ) ]
                  Static [ 8  x BOX_STEP (4 place 0 marching mid - ) ]]]
  [ V      (48) [ Lin_Travel (32) [ Move   (8) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                    Static (8) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]
                                    Return (8) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                    Static (8) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]]
                  Lin_Travel (16) [ Move   (4) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                    Static (4) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]]]]
  [ C      (32) [ Lin_Travel     (32) [ Move   (8) [ 4 x JOG       (2 forward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]
                                        Move   (8) [ 4 x JOG       (2 forward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]]]
  [ V      (48) [ Lin_Travel (32) [ Move   (8) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                    Static (8) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]
                                    Return (8) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                    Static (8) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]]
                  Lin_Travel (16) [ Move   (4) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                    Static (4) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]]]]
  [ C      (64) [ 2 x Lin_Travel (32) [ Move   (8) [ 4 x JOG       (2 forward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]
                                        Return (8) [ 4 x JOG       (2 backward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]]]]
  [ Ins    (60) [ Static (16) [ 8  x MARCH (2 place 0 marching mid - ) ]
                  Turn   (4)  [ 2  x MARCH (2 place 180 marching mid - ) ]
                  Static (32) [ 16 x TWIST (2 place 0 alt_tricep_ext_front mid - ) ]
                  Static (8)  [ 4  x MARCH (2 place 0 marching mid - ) ]]]
  [ C      (32) [ Lin_Travel     (32) [ Move   (8) [ 4 x JOG       (2 forward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]
                                        Return (8) [ 4 x JOG       (2 backward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]]]]
  [ V      (64) [ 2 x Lin_Travel (32) [ Move   (8) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]
                                        Return (8) [ 4 x PENDULUM  (2 left 0 side_arm_lift mid - ) ]
                                        Static (8) [ 4 x HEEL_TOE (2 place 0 alt_bicep_front low - ) ]]
  [ C      (64) [ 2 x Lin_Travel (32) [ Move   (8) [ 4 x JOG       (2 forward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]
                                        Return (8) [ 4 x JOG       (2 backward 0 marching mid - ) ]
                                        Static (8) [ 4 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]]]]
  [ Fade   (32) [ Static (32) [ 16 x TWIST (2 place 0 alt_tricep_ext_front mid - ) ]]]]
```

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[ Routine #44.3 (496) [ [ Cool down ] [ 4.05 ] [ Victoria Burley ]
                        [ “Save Me” Fleetwood Mac “Behind the Mask” 1990 ]]
  [ Intro  (32) [ Static [ 8 x MARCH    (2 place 0 marching mid - ) ]
                  Static [ 8 x BOX_STEP (4 place 0 marching mid - ) ]]]
  [ V      (64) [ 4 x Lin_Travel (16) [ Move   (8) [ 4 x DIPS   (2 forward 0 scoop mid - ) ]
                                        Return (8) [ 4 x TWIST  (2 backward 0 alt_tricep_ext_front mid - ) ]]]]
  [ C      (64) [ Static (16) [ 8 x HEEL_PUSH_FRONT (2 place 0 dbl_push_front mid - ) ]
                  Static (16) [ 8 x HEEL_PUSH_SIDE  (2 place 0 dbl_push_side mid - ) ]
                  Static (16) [ 8 x HALF_STAR (2 place 0 side_arm_lift mid - ) ]
                  Static (16) [ 8 x KNEE_LIFT (2 place 0 pull_down high - ) ]]]
  [ V      (64) [ 2 x Lin_Travel (16) [ Move   (8) [ 4 x DIPS   (2 forward 0 scoop mid - ) ]
                                        Return (8) [ 4 x TWIST  (2 backward 0 alt_tricep_ext_front mid - ) ]]
                  2 x Lin_Travel (16) [ Move   (8) [ 4 x DIPS   (2 forward 0 scoop mid - ) ]
                                        Return (8) [ 4 x MARCH  (2 backward 0 marching mid - ) ]]]]
  [ C      (64) [ Static (16) [ 8 x HEEL_PUSH_FRONT (2 place 0 dbl_push_front low - ) ]
                  Static (16) [ 8 x HEEL_PUSH_SIDE  (2 place 0 dbl_push_side low - ) ]
                  Static (16) [ 8 x HALF_STAR (2 place 0 side_arm_lift low - ) ]
                  Static (16) [ 8 x KNEE_LIFT (2 place 0 pull_down mid - ) ]]]
  [ Link   (16) [ Turn   (16) [ 8 x MARCH     (2 place 180 marching mid - ) ]]]
  [ Ins    (64) [ 4 x Lin_Travel (16) [ Move   (8) [ 4 x DIPS   (2 forward 0 scoop low - ) ]
                                        Return (8) [ 4 x MARCH  (2 backward 0 marching mid - ) ]]]]
  [ C      (96) [ Static (16) [ 8 x HEEL_PUSH_FRONT (2 place 0 dbl_push_front low - ) ]
                  Static (16) [ 8 x HEEL_PUSH_SIDE  (2 place 0 dbl_push_side low - ) ]
                  Static (16) [ 8 x HALF_STAR (2 place 0 side_arm_lift low - ) ]
                  Static (16) [ 8 x KNEE_LIFT (2 place 0 pull_down mid - ) ]]
                  Static (16) [ 8 x HALF_STAR (2 place 0 side_arm_lift low - ) ]
                  Static (16) [ 8 x KNEE_LIFT (2 place 0 on_hips - - ) ]]]
  [ Ins    (32) [ 2 x Lin_Travel (16) [ Move   (8) [ 4 x DIPS   (2 forward 0 scoop low - ) ]
                                        Return (8) [ 4 x MARCH  (2 backward 0 marching mid - ) ]]]]]
```

APPENDIX 7 : The Aerobics Lexicon

The following appendix contains the full Aerobics Lexicon. It should be noted that the allowable values for the 'arm modifier' features of some lexical items do not represent a comprehensive set of all possible modifications for these exercises, but only show those observed in the Aerobics corpus.

Lexical Item Features

<cat> : The lexical category.
Values = {Ex}.

<beat> : The number of music beats required to perform the basic exercise.
Values = {1..4}.

<travel> : Possible directions of travel (relative to the class members).
Values = {place, forward, backward, left, right}.

<turn> : Degrees of turn possible whilst performing the basic exercise.
Values = {0, 90, 180, 360}.

<arm modifier> : Common adaptations to the generic exercise form for the movement of the hands and arms.
Values = {see list below…}.

<leg modifier> : Common adaptations to the generic exercise form for the movement of the legs.
Values = {knees_up, heels_up_behind, ...}

<synonym> : Common synonyms for the exercise name.
Values = {Text strings representing other names by which the exercises are known. These names do not appear as lexical items in their own right}.

<description> : Brief description of the basic generic exercise form.
Values = {A string of text, enclosed in single quotes, which describes the essential features of the exercise movement. The descriptions are not given in extreme detail, but are sufficient for exercise identification by exercise instructors. For simplicity the right foot is always assumed to go first, although this may be reversed as appropriate}.

Arm Modification Features

The following list indicates the values of the '<arm modifier>' feature which were observed in the Aerobics Corpus. Other variations are possible, but did not occur in the data.

dbl_bicep_curl
dbl_pec_press
dbl_pull_back
dbl_pull_down
dbl_punch_up
dbl_push_front
dbl_push_side
dbl_reach_out_diag
dbl_side_raise
dbl_side_to_side
dbl_swing_forward
dbl_swing_same_side
dbl_swing_side

sgl_reach_out_diag
sgl_punch_up

alt_bicep_curl
alt_punch_up
alt_swing_forward

marching
on_hips
out_out_in_in
scoop

The Aerobics Lexicon

Exercise **ALTERNATING_TOE_TAP**:
<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {marching, alt_bicep_curl}
<leg modifier> = {}
<synonym> = {}
<description> = 'Tap R toe, L toe. Hands on hips.'

Exercise **BACKWARD_LUNGE**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {dbl_swing_forward}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step R foot out to back and the return, keeping weight on L foot.’

Exercise **BOW_AND_ARROW**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Hop on L leg whilst tapping heel of R leg to the side and bringing arms out to R at shoulder level. Hop again on L leg whilst bringing R leg back to starting position and mimicking the action of drawing a bow with the arms.’

Exercise **BOX_STEP**:

<cat> = Ex
<beat> = 4
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {marching, on_hips, out_out_in_in}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step R leg out diagonally to R, L leg out diagonally to L, R leg back to place, L leg back to place. Corresponding hands punch out with legs and back in with legs.’

Exercise **BREAKAWAY**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {sgl_reach_out_diag, dbl_reach_out_diag}
<leg modifier> = {}
<synonym> = {JOHN_TRAVOLTA}
<description> = ‘Step to R, anchoring L foot in place. Step back to position.’

Exercise **CAN_CAN**:

<cat> = Ex
<beat> = 4
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {dbl_bicep_curl, dbl_swing_forward}
<leg modifier> = {}
<synonym> = {JOHN_TRAVOLTA}
<description> = 'Hop on L leg whilst lifting R knee. Hop on L leg whilst returning R leg to floor. Hop on L leg whilst kicking R leg to front. Hop on L leg whilst returning R leg to floor.'

Exercise **CHASSE**:

<cat> = Ex
<beat> = 3
<travel> = {left, right}
<turn> = {0}
<arm modifier> = {}
<leg modifier> = {}
<synonym> = {STEP_CLOSE_STEP}
<description> = 'Side step R once quickly, then once slowly such that the sequence last 3 beats instead of the usual 4.'

Exercise **DIP**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, left, right}
<turn> = {0}
<arm modifier> = {on_hips, scoop}
<leg modifier> = {}
<synonym> = {}
<description> = 'Step, together, with hands scooping in direction of step.'

Exercise **DOUBLE_PENDULUM**:

<cat> = Ex
<beat> = 4
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {dbl_swing_same_side}
<leg modifier> = {}
<synonym> = {}
<description> = 'Swing R leg out to side, hop in position, swing L leg out to side as R leg returns, hop in position.'

Exercise **DOUBLE_TWIST**:

<cat> = Ex
<beat> = 4
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {dbl_side_to_side}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Jump to position with legs and hips rotated to R and trunk to L, jump in place, jump to opposite position, jump in place.’

Exercise **FLUTTER_KICK**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0, 90}
<arm modifier> = {dbl_push_front, dbl_punch_up, alt_punch_up}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Kick R leg diagonally R, return R leg whilst kicking L leg out diagonally L.’

Exercise **GRAPEVINE**:

<cat> = Ex
<beat> = 4
<travel> = {left, right}
<turn> = {0, 90}
<arm modifier> = {dbl_swing_side}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step R leg to R side, step L leg behind R leg to R side, step R leg past L leg to R side, close L foot.’

Exercise **HEEL_PUSH_FRONT**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {dbl_push_front}
<leg modifier> = {}
<synonym> = {HEEL_DIG, HEEL_TAP}
<description> = ‘Step R foot out to front so that heel taps on the floor. Both hands push forward with the heel.’

Exercise **HEEL_AND_TOE**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0, 90}
<arm modifier> = {alt_bicep_curl}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Hop on L leg whilst flexing R foot and tapping heel on floor, hop on L leg whilst pointing R foot and tapping toe on floor.’

Exercise **HEEL_PUSH_FRONT**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {dbl_push_front, dbl_push_side}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step R foot out to side so that heel taps on the floor. Hands push out to either side.’

Exercise **HEEL_PUSH_SIDE**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {dbl_push_front, dbl_push_side}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step R foot out to side so that heel taps on the floor, return to start position.’

Exercise **HEEL_TOUCH_BEHIND**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0}
<arm modifier> = {}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step on L leg whilst bringing R heel up behind body and L hand down to meet it, return to starting position.’

Exercise **HEEL_TOUCH_FRONT**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0}
<arm modifier> = {}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step on L leg whilst bringing R foot up in front of body and L hand down to meet it, return to starting position.’

Exercise **HIGH_KICK**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0}
<arm modifier> = {dbl_bicep_curl}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Hop on L leg whilst kicking R leg up in front of body, hop on L leg whilst returning R leg to start position.’

Exercise **HOP_SCOTCH**:

<cat> = Ex
<beat> = 4
<travel> = {place, forward, backward}
<turn> = {0, 90, 180}
<arm modifier> = {dbl_pull_back}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Jump feet apart, hop onto L leg, jump feet apart, jump to start position.’

Exercise **JOG**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward, left, right}
<turn> = {0, 90, 180}
<arm modifier> = {marching, dbl_punch_up, sgl_punch_up}
<leg modifier> = {}
<synonym> = {RUN}
<description> = ‘Jog on R then L foot.’

Exercise **JOG_HEELS_UP**:
<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward, left, right}
<turn> = {0, 90, 180}
<arm modifier> = {marching, dbl_punch_up, sgl_punch_up}
<leg modifier> = {}
<synonym> = {RUN_HEELS_UP}
<description> = 'Jog on R then L foot, brining heels up behind body.'

Exercise **JOG_KNEES_UP**:
<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward, left, right}
<turn> = {0, 90, 180}
<arm modifier> = {marching, dbl_punch_up, sgl_punch_up}
<leg modifier> = {}
<synonym> = {RUN_KNEES_UP}
<description> = 'Jog on R then L foot, brining knees up in front of body.'

Exercise **JUMPING_JACK**:
<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0, 90, 180}
<arm modifier> = {dbl_swing_side}
<leg modifier> = {}
<synonym> = {ASTRIDE_JUMP, ASRIDE_LATERAL_JUMP, JACK, STAR_JUMP}
<description> = 'Jump feet apart, jump back to start position.'

Exercise **KICK_SIDE**:
<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0, 90}
<arm modifier> = {dbl_push_side, dbl_swing_side}
<leg modifier> = {}
<synonym> = {SIDE_KICK}
<description> = 'Kick R leg to R side, return to start position.'

Exercise **KICK_FRONT**:
<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0, 90}
<arm modifier> = {dbl_push_front}
<leg modifier> = {}
<synonym> = {FRONT_KICK, KICK}
<description> = 'Kick R leg forward, return to start position.'

Exercise **MARCH**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward, left, right}
<turn> = {0, 90}
<arm modifier> = {marching}
<leg modifier> = {feet_apart}
<synonym> = {MARK_TIME, WALK}
<description> = ‘March R then L foot.’

Exercise **OPPOSITE_ELBOW_TO_KNEE**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward}
<turn> = {0, 90}
<arm modifier> = {}
<leg modifier> = {}
<synonym> = {ELBOW_TO_KNEE, PULL_DOWN}
<description> = ‘Hop on L leg whilst lifting R knee and bringing opposite elbow down to meet knee, hop on L leg whilst returning to start position.’

Exercise **PENDULUM**:

<cat> = Ex
<beat> = 2
<travel> = {place, left, right}
<turn> = {0, 90}
<arm modifier> = {dbl_swing_same_side}
<leg modifier> = {}
<synonym> = {ROCK}
<description> = ‘Swing R leg out to side, swing L leg out to side as R leg returns.’

Exercise **SHIMMY_JACK**:

<cat> = Ex
<beat> = 4
<travel> = {place}
<turn> = {0}
<arm modifier> = {out_out_in_in}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Step R foot out to side, step L foot out to side, step R foot back to start position, step L foot back to start position.’

Exercise **SIDE_LUNGE**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {sgl_punch_up, dbl_punch_up}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Lunge R leg out to side, return to start position.’

Exercise **SIDE_STEP**:

<cat> = Ex
<beat> = 2
<travel> = {left, right}
<turn> = {0, 90}
<arm modifier> = {dbl_side_raise}
<leg modifier> = {}
<synonym> = {STEP_CLOSE, STEP_TOGETHER}
<description> = ‘Step R leg to R, close with L leg.’

Exercise **SIDE_SWING**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {dbl_swing_side}
<leg modifier> = {}
<synonym> = {SHIFT_WEIGHT, SWING}
<description> = ‘Start feet apart. Bend knees, straighten up shifting weight to R side.’

Exercise **SPOTTY_DOG**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {alt_swing_forward, dbl_push_front, dbl_punch_up}
<leg modifier> = {}
<synonym> = {SHUFFLE, SHUFFLE_JUMP}
<description> = ‘Jump to position with R leg in front and L leg behind, jump to opposite position.’

Exercise **SPRING_KICK_FRONT**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {on_hips, dbl_swing_side}
<leg modifier> = {}
<synonym> = {SPRING_KICK, FLICK_KICK}
<description> = ‘Hop on L leg whilst bringing R leg back in preparation for kick, hop on L leg whilst kicking R leg to front.’

Exercise **SPRING_KICK_SIDE**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {on_hips, dbl_swing_side}
<leg modifier> = {}
<synonym> = {FLICK_KICK_SIDE}
<description> = ‘Hop on L leg whilst bringing R leg back in preparation for kick, hop on L leg whilst kicking R leg to side.’

Exercise **SQUAT**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0}
<arm modifier> = {on_hips, dbl_pull_down, dbl_pec_press}
<leg modifier> = {}
<synonym> = {KNEE_BENDS}
<description> = ‘Start with feet wide apart. Bend the knees, return to start position.’

Exercise **STEPPING_JACK**:

<cat> = Ex
<beat> = 2
<travel> = {place}
<turn> = {0, 90}
<arm modifier> = {dbl_swing_side}
<leg modifier> = {}
<synonym> = {HEEL_JACK, HEEL_TAP_SIDE, LIA_ASTRIDE_JUMP, LIA_JACK, LIA_STAR_JUMP}
<description> = ‘Step R foot out to side so heel taps on ground, step R foot back to start position.’

Exercise **TWIST**:

<cat> = Ex
<beat> = 2
<travel> = {place, forward, backward, left, right}
<turn> = {0, 90}
<arm modifier> = {dbl_side_to_side}
<leg modifier> = {}
<synonym> = {}
<description> = ‘Jump to position with legs and hips rotated to R and trunk to L, jump to opposite position.’

APPENDIX 8 : The Aerobics Grammar

This appendix contains the full Aerobics Grammar, as described in Chapter 8.

Notational Conventions

$X \varnothing$ Y Z	:	Item X is re-written as item Y followed by item Z.
ΔX	:	'Delta X' represents X and the subtree dominated by X.
X^n	:	Item X is repeated n times.
ΔX^n	:	Item X is repeated n times and each occurrence must dominate an identical subtree.
$\Delta X_1..\Delta X_m$	:	Represents a set of item X's, each dominating a distinct sub-tree.
{X, Y, Z}	:	One item type from the set containing item types X, Y and Z is selected.
$\{X, Y, Z\}^n$	:	One item from the set containing items X, Y and Z is selected, and this process is repeated n times. Where n is constrained to be of the value set {0, 1}, this is equivalent to saying that selection from the set is optional.
$\{\Delta X, \Delta Y, \Delta Z\}^n$	:	One item from the set containing items ΔX, ΔY and ΔZ is selected, and this process is repeated n times. If any item is selected more than once, all its occurrences must dominate identical sub-trees. Where n is constrained to be of the value set {0, 1}, this is equivalent to saying that selection from the set is optional.
{m..n}	:	One value from the set containing values in the range m..n, where m and n are positive integers, is selected.
{m, n}	:	One value from the set containing values m and n, where m and n are positive integers, is selected.
<X y>	:	Represents the value of feature y for an item of type X.
$\sum^n$ <X y>	:	Represents the sum of values of feature y for all n occurrences of an item of type X.

Rule Structure Explanation

Rule {**Rule description**}
X ∅ W $\{\Delta Y_1..\Delta Y_m\}^{n1}$ ΔZ^{n2}
n1 = {0..4}
n2 = {0, 1}
m = {1..8}
<X beat> = <W beat> + $\sum^{n1}$ <$\{Y_1..Y_m\}$ beat> + $\sum^{n2}$ <Z beat>
<X travel> = <W travel>
<X turn> = <Z turn>
<Z turn> = 180.

This rule states that an item X rewrites as an item W plus up to n1 different Y items, plus up to n2 duplicates of an item of type Z, given a number of constraints.

Item constraints include the facts that n1 must be in the range 0..4, n2 may be either 0 or 1, and m must be in the range 0..8. All item constraints can be considered 'loose' in the sense that they should theoretically apply in all cases but are sometimes broken in reality.

Item feature constraints include the facts that the 'beat' feature value for X must equal the sum of all the 'beat' feature values of its daughters, the 'travel' feature value of X must equal the 'travel' feature value of W, the 'turn' feature value of X must match that of Z, and the 'turn' feature of Z must be 180.

The Grammar Rules

Rule {**Aerobic Routine**}
Aero ∅ $Intro^{n1}$
$\{\{\Delta V_1..\Delta V_{m1}\}\ \{\Delta C_1..\Delta C_{m2}\}\ \{\Delta Ins_1..\Delta Ins_{m3}\}\ \{\Delta Link_1..\Delta Link_{m4}\}\}^{n2}$
$Fade^{n3}$:
n1, n3 = {0, 1}
n2 = {1..12}
m1, m2, m3, m4 = {0..2}
m1 + m2 + m3 + m4 > 0
<Aero beat> = $\sum^{n1}$ <Intro beat> +
$\sum^{n2}$ <$\{\{V_1..V_{m1}\}\ \{C_1..C_{m2}\}\ \{Ins_1..Ins_{m3}\}$
$\{Link_1..Link_{m4}\}\}$ beat> +
$\sum^{n3}$ <Fade beat>.

Rule {**Intro Section**}
Intro ∅ {Lin Circ Stat}:
<Intro beat> = <{Lin Circ Stat} beat>.

Rule {**Verse Section**}
V ∅ {Lin Circ Stat}^{n}:
n = {1, 2, 4, 8}
<V beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Chorus Section**}
C ∅ {Lin Circ Stat}^{n}:
n = {1, 2, 4, 8}
<C beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Instrumental Section**}
Ins ∅ {Lin Circ Stat}:
<Ins beat> = <{Lin Circ Stat} beat>.

Rule {**Link Section**}
Link ∅ {Lin Circ Stat}^{n}:
n = {1, 4}
<Link beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Fade Section**}
Fade ∅ {Lin Circ Stat}^{n}:
n = {1, 4}
<Fade beat> = $\sum^{n}$ <{Lin Circ Stat} beat>.

Rule {**Linear travelling with return**}
Lin ∅ Mv Int_1 Rt Int_2:
<Lin beat> = <Mv beat> + <Int_1 beat> + <Rt beat> + <Int_2 beat>
<Mv travel> = <Rt travel>.

Rule {**Linear travelling without return**}
Lin ∅ Mv:
<Lin beat> = <Mv beat>.

Rule {**Circular travelling with return, facing radially**}
Circ ∅ Mv {Int_1 Rad_1}^{n1} Ret {Int_2 Rad_2}^{n2}:
n1, n2 = {0, 1}
<Circ beat> = <Mv beat> + $\sum^{n1}$ <{Int_1 Rad_1}> +
<Ret beat> + $\sum^{n2}$<{Int_2 Rad_2}beat>
<Mv travel> = <Ret travel>
<Mv travel> = {left, right}.

Rule {**Circular travelling without return, facing radially**}
Circ ∅ Mv:
<Circ beat> = <Mv beat>
<Mv travel> = {left, right}.

Rule {**Circular travelling with return, facing turnwise**}
Circ ∅ Mv $\{Int_1\ Rad_1\}^{n1}$ Trn Mv $\{Int_2\ Rad_2\}^{n2}$:
n1, n2 = {0, 1}
<Circ beat> = 2 x <Mv beat> + $\sum^{n1}$ <$\{Int_1\ Rad_1\}$> +
<Trn beat> + $\sum^{n2}$<$\{Int_2\ Rad_2\}$beat>
<Mv travel> = {forward}
<Trn turn> = 180.

Rule {**Circular travelling without return, facing turnwise**}
Circ ∅ Mv:
<Circ beat> = <Mv beat>
<Mv travel> = {left, right}.

Rule {**Radial travelling with return**}
Rad ∅ Mv Rt :
<Rad beat>= <Mv beat> + <Rt beat>
<Mv travel> = <Rt travel>
<Mv travel> = {forward, backward}.

Rule {**Intra-travelling move**}
Int ∅ $\{Stat\}^{n}$
n = {1, 2}
<Int beat> = $\sum^{n}$ <Stat beat>.

Rule {**Move from place**}
Mv ∅ ΔEx^{n}:
n = {1, 2, 4, 8}
<Mv beat> = $\sum^{n}$ <Ex beat>
<Mv travel> = <Ex travel>
<Ex travel> = {forward, backward, left, right}
<Mv turn> = <Ex turn>
<Ex turn> = 0.

Rule {**Return to place**}
Rt ∅ ΔEx^{n}:
n = {1, 2, 4, 8}
<Rt beat> = $\sum^{n}$ <Ex beat>
<Rt travel>= <Ex travel>
<Ex travel> = {forward, backward, left, right}
<Rt turn> = <Ex turn>
<Ex turn> = 0.

Rule {**Static on-the-spot exercise**}
Stat ∅ ΔEx^{n}:
n = {1, 2, 4, 8, 16}
<Stat beat>= $\sum^{n}$ <Ex beat>
<Ex travel> = place
<Ex turn> = 0.

Rule {**Turning on-the-spot exercise**}
Trn ∅ ΔEx^{n}:
n = {1, 2, 4}
<Trn beat> = $\sum^{n}$ <Ex beat>
<Ex travel> = place
<Trn turn> = <Ex turn>
<Ex turn> = {90, 180}.