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INTRODUCTION

1.1 Music analysis and musicology

Since Italian scholars began studying musical style during the early years of the seventeenth century, music analysis has become the backbone of musical study of many different kinds. Guido Adler (1855 - 1941) formulated the modern idea of style analysis about 100 years ago and it has become an integrated part of most branches of musicology. Analysis is an invaluable tool by means of which music can be assimilated, stylistically classified and identified, learned, and its techniques understood. The results of analytical studies are the subject of countless books on harmony, form, interpretation, composition, and music history. In more recent times music analysis has also become an important aspect of comparative musicology. It is an effective method of learning and describing the style and characteristics of one musical tradition by comparing it with another. Most people will be able to recognise that there is a difference between a composition by Bach and Mozart, or between a work by Schoenberg and a Zulu song, but to describe such differences it is necessary to use a process of analysis, even if this is done mentally.

The *Harvard Dictionary of Music* defines musical style as follows:

> In a musical composition, 'style' refers to the methods of treating all the elements — form, melody, rhythm, etc. In practice, the term may be applied to single works; ... to composers; ... to types of compositions; ... to media; ... to methods of composition; ... (Apel: 1983, pp. 811-12)

The products of musical analysis are those measurable elements that contribute to the specific characteristics of musical style. For many years most stylistic analyses have been analogous, which means that descriptive models are established that in turn may be used for rough comparisons and to develop a descriptive terminology to label the results of subsequent analyses. The use of models and vague terminology (usually idiosyncratic to music) often leads to misuse or is often inadequate. The results of such research is sometimes vague and misleading, especially when applied to contemporary music. To overcome these problems various researchers have endeavoured to devise and develop new methods, of which the Schenkerian system of analysis and Hindemith's classification of chords are only two examples. Some of these attempts were more successful than others but all pale by the progress made in other fields of scientific research with the help of modern technology.

1.1.1 The role of technology in music analysis

During the last twenty years electronic technology has forged ahead at an intimidating pace. It seems that mainly creative musicians were able to keep up — and only just — by incorporating the most up to date technology in the creative process. Many composers and performers have at their disposal all the benefits of the increasing powers of synthesisers and computers and the music industry has thrived equally. It therefore seems peculiar that analytical musicologists seemingly have progressed little further than the use of recording equipment and word processors, and continue to rely exclusively on traditional, and often archaic, methods of stylistic analysis. Except a handful of progressive researchers — who are often regarded with some degree of suspicion — musicology has virtually been left behind. This is, however, not always due to a lack of interest among researchers but is mostly the result of a lack of training in newly established and innovative avenues of research. Very often, institutions that train musicologists and researchers, are themselves not properly equipped, or lack the necessary trained personnel to broaden the horizons of research methodology.

In those cases where computer technology is being used for research in stylistic analysis, there is a tendency to base the research on established traditional methods. Computers are merely applied as an aid and for the sake of expediency. As a result, those aspects of analysis that may still benefit from a degree of subjective interpretation — for the purpose of scholarly discourse — become devoid of any interpretation. Obviously, a degree of subjective interpretation can be incorporated by the programmer which would provide a degree of predetermined subjectivity to the results.

Some experiments that involve music have been done to make better use of the computer's ability to process information very rapidly and effectively. These include the application of fractal principles, and several statistically derived calculations, all with varying degrees of potential for practical application. Although these experiments have shown varied results most of them have not found any real, substantial or wide, acceptance, mainly because of the lack of co-operation between musicologists and technologists. Since the first generations of personal computers were mainly graphically or text

orientated rather than sound orientated (most are unable to produce more than a basic beep), music applications require that the elements of music (pitch, rhythm, etc.) are first translated into graphical symbols or numbers. This requires a sound knowledge of the intricacies of computer graphics. Many of the more innovative music applications therefore require a good knowledge of music as well as proficiency in computer programming. More recently computer designers and software developers have begun to integrate extensive sound and graphical capabilities as basic components of standard computer equipment and at prices that are within the reach of most musicians. The improved accessibility of computers, in both a technical and material sense, now allows for increased research and applications of computers to music.

1.1.2 Information Theory

The essential assumption of Information Theory, as applied to Communication Science, is that it provides statistical information about recurring structural elements in any form of communication. In most forms of communication as well as other applications, the application of Information Theory has become a very complex but effective tool with many uses.

Information Theory has been applied to many different fields of study and, as shall be shown in the following chapters, it has also been applied to music. However, during the 1950s to 1970s, when most of the experiments with music were done, only mainframe computers had the computational power required for the calculations, and only a few researchers had access to these — many with a limited background in music. As a result the research was time-consuming and often costly and could hardly be pursued extensively. With the event of the greatly improved and faster personal computers and simplified computer languages, the possibility has arisen for non-computer specialists to make use of these facilities to a greater extent. Most personal computers today have a greater capacity and operate faster than earlier mainframe computers. Because they are also relatively inexpensive most serious researchers now have computers at their disposal.

Early experiments with Information Theory and music were limited to using single elements such as pitch counts or rhythmic values. These elements are the most obvious and may readily be counted manually. However, calculations done by hand with hand-held calculators are time consuming and prone to errors. To apply Information Theory most effectively and to obtain more interesting and significant results, it is desirable to apply it extensively to as many structures of music as possible. As an analogy of this process the following example may be used: counting single notes in a melody exclusively and establishing the stochastic processes involved will give only a limited amount of information about the melody. Alternatively, if ever increasing groups of notes (melodic units, semi-phrases, phrases and periods) are statistically compared, the outcome will provide much more information about the music. Furthermore, it is also important that the collection of information and

subsequent calculations are as accurate as possible, as even slight errors will produce erroneous results.

1.2 Aims of this study

With this research the candidate aims to show that, by means of specifically developed computer programmes, the principles of Information Theory may be applied to elements of music that were not previously included in research with Information Theory. Most of the research done in the past was limited to single dimensions of music, such as pitch or rhythm. In this dissertation, the analysis is extended to include interval sequences, rhythmic sequences and a variety of multi-dimensional combinations. Due to computational limitations of the past, analyses of subsequent structural elements were usually limited to the second or third order[1]. With the computer programmes developed for this research all the possible orders may theoretically be generated.

The information obtained by the analyses are combined in graphs to show that it is possible to produce models of particular music styles or characteristics. Using models of music analysed in this manner the proposed hypothesis is that particular music or music that exhibits specific characteristics should therefore also generate similar results or that the results should at least be confined to specific limits.

Furthermore, the results of the analyses are used to establish whether the information content of music has a possible bearing on its popularity with the listening public. The candidate's hypothesis is that there is a direct link between the propensity of music to become generally popular and the entropy (information content) of the music. As the entropy of music increases, its general popularity or tendency to become generally popular should therefore decrease. Conversely, this implies that repetitious music with regular and repeated rhythms and within conventional tonal harmonic constraints would be less entropic (more redundant or predictable) and will therefore produce higher order values and should therefore be more popular or should at least have a greater propensity to become popular.

Intuitively most people would agree that certain types of music are more accessible or more popular than others. For example, why would Beethoven's Symphony No. 5 be singled out for popularisation above any of his other compositions, by adding rock beats and other devices to it? Similarly many listeners would prefer to repeatedly listen to an aria of a 17th century opera, than to a recitative. Why is it that certain composers are more popular amongst the general public than others (e.g. Tchaikovsky vs. Stravinsky). Often ardent lovers of 'classical' music argue that J. S. Bach's music is too 'heavy' while they would endlessly listen to the ballet music of Tchaikovsky. The most obvious elements that may be an indication of relative popularity are the repetitious quality of certain elements, such as motives and phrases. Rock musicians of the last thirty to forty years have extensively ex-

[1] The term 'order' refers to the length of the structural elements. For example, a rhythmic sequence comprising 5 note values is of the 5th order.

ploited the element of repetition to popularise their music. Certain melodic phrases ('hooks'), are repeated endlessly, over a basic and standard harmonic pattern, very often with little or no variation and often with even less lyrical content. Added to this is the steady, rhythmical drumbeat, emphasised by the bass guitar. This is only interrupted by 'breaks', usually between repeats or at the end of major phrases.

Record producers who know what ingredients are necessary to make a record 'successful', will consciously or subconsciously, select those 'songs' which will appeal most to their purchasing public. Admittedly, there are probably many factors that influence the success of a 'hit', including promotional finesse, a group's image and fame, current public preferences, and other socio-economic factors. This candidate's argument is, however, that their selection is to a large extent based on the information content of such a piece of music.

This study will attempt to show that the information content of music, with specific reference to melody, is an important underlying factor in the popularity of music.

1.3 Research methods

The first four chapters of this dissertation deal with the methods, history and background of Information Theory. These chapters provide a background to the second half of the thesis that contains detailed descriptions and interpretations of the analyses. Chapter five is a technical discussion of the computer programmes developed for the analyses of the music in this dissertation. Chapter six is a detailed discussion of the results of the analyses of the music selected for this research. The latter is summarised and interpreted in Chapter seven while the final conclusions are made in Chapter 8. All the data values obtained with the analyses are collected in the appendices at the end of this volume and are presented in tabular as well as in graph format.

Research for this dissertation began with research in the principles, history and methods of Information Theory. This was followed by investigating the applications of Information Theory, not only as it had been applied to music but also how it is currently applied to a variety of sciences and fields of research. In the process of this research three basic hypotheses were formulated. These are:

1. Information Theory allows for the generation of statistical models that reflect the characteristics of specific elements of music.

2. The general popularity of music directly relates to its redundancy (predictability) and is reflected by the amount of information as reflected in the statistical models.

3. Statistical models of music may be used as basic criteria for the selection of music that needs to be applied for specific purposes or is required to conform to typical characteristics.

Twenty-two songs, in three categories, were selected to form the basis for the analyses. For the purpose of comparison the songs had to be of different character, style, and composed during differ-

ent periods. One set of songs was selected from the modern popular repertoire and the criteria for their selection was consistent popularity; the number of recordings that were made of them over a period of twenty years, and whether they were published as scores. The second group of songs were selected from the Art song tradition of the Classical period. Again the songs' popularity was decisive in their selection and the eight most frequently recorded songs (obtained from recording catalogues) were chosen. To provide adequate contrast, the third group of songs were selected from the twentieth century Art song repertoire and the criterion for their selection was that they had little or no proven record of general popularity. There is a detailed list of all the individual songs in Chapter 6 and a complete set of the scores of the melodies of the songs in Appendix I.

To obtain the desired data to confirm (or negate) the hypotheses discussed above, a number of computer programmes were developed by the candidate to generate the entropy values for a variety of musical aspects. They are: the entropy values for the melodic elements, pitch, intervals, rhythm, and a combination of pitch and rhythm. Due to the complexities involved the development and testing of the software proved to be rather time consuming. To keep up with improved hardware and software the programmes required continuous upgrading to suit the more powerful processors and expanded memory capabilities of the computers applied for this research. Since the actual calculation of the entropy uses extensive processing time, it was deemed preferable to regularly upgrade the programmes to faster machines as they became available.

After extensive testing of the programmes for accuracy and efficiency, the information of the selected music was fed into the database. The results were compiled and subsequently interpreted.

As a final note it should be mentioned that there is an abundance of current sources available about Information Theory as a statistical method. There are also many books and articles about the application of Information Theory to a large variety of other sciences. However, published results of research done with music dried up during the late 1970s. Although aspects of Information Theory are taught at some Universities in the USA and Great Britain, it would seem that little if any progress has been made to expand the application of Information Theory to music. This would explain why so little has been written about the subject during the last 20 years.