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Teaching pre-school children to perform from conventional music notation: an exploration of different methods

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For pre-school children everywhere

Teaching Pre-School Children to Perform from Conventional Music Notation: An Exploration of Different Methods

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Finally, an apology. To my own children, Llywela and Alastair, I would like to say 'sorry' for all the times I was a few minutes late collecting you from school. Perhaps one day you'll read this thesis and discover why.

Summary

The overall aim of this thesis was to investigate whether 3 – 4-year-old children can be successfully taught music literacy skills, and demonstrate practical applications of the skill by performing simple melodies and rhythms from conventional music notation. Rhythm and pitch were investigated separately, therefore the thesis is likewise divided into two sections: rhythm and pitch. Three groups of children participated in each section, with ten children in each group. Each child received 20 ten-minute individual teaching sessions. The children who participated in the rhythm studies successfully learned to perform, from conventional rhythm notation, previously unseen phrases comprised of semibreves, minims, crotchets, and quavers. The first rhythm study was based on a simple counting teaching methodology. The second used a Dual Task teaching methodology in which rhythm performance was broken down into the component parts of maintaining a constant pulse, and learning the relationship between different note values. The final rhythm group was taught using a method based on connectionist principles. The children were simply exposed to written training rhythms and their correct performance, and were given no rules or syllables from which to work. The children who participated in the pitch studies successfully learned to perform, from conventional notation, melodies comprised of Middle C and the four notes above. Rather than using letter names to describe the notes in the conventional manner, they were described in such a way as to help the children remember their location on the stave and also on the instrument, or, in one of the studies, by the use of contextual information. Two main conclusions were drawn: that 3 – 4-year-olds both easily manage and enjoy learning to read music, and that investigating learning and performance in other areas can lead to the discovery of new approaches that may facilitate the learning of music reading.

Chapter One

Introduction

Aims of the research

In 1978 John Sloboda identified music literacy skills as an area in which there was a significant lack of research. As he said:

> "The ability to read in one's native tongue is, in most cultures, an almost essential qualification for full membership of society. Accordingly, the attention devoted to the reading process by educationalists and psychologists has been immense. The ability to read music is, if not essential, an irreplaceable asset to anyone who indulges in musical activity. Yet the amount of attention devoted to music reading by teachers, educationalists and psychologists has, on the whole, been very small."
>
> *Psychology of Music (1978a),* 6, page 3

It is difficult to believe that 23 years have elapsed since Sloboda made that statement as the situation appears not to have improved, with investigations into the music reading process remaining sparse. Meanwhile research by psychologists and educationalists into the language reading process has continued, and a wealth of information on spoken and written language acquisition, both normal and abnormal, is available. This research-based information ensures that any child learning to read does so with a great deal of direct and indirect support. The professionals responsible for teaching reading can draw on years of research concerning the effectiveness of different teaching methods, and the diagnosis and treatment of problems such as dyslexia. In contrast to this is the situation faced by a child learning to read music; here the choice of teaching method will almost certainly be based on tradition and the preferences of the individual teacher, rather than on research findings.

The overall aim of this thesis was therefore to provide research-based information which would contribute to our understanding of how children learn to read music, the effectiveness of different teaching methodologies, and the nature of any problems encountered together with the most efficient ways of overcoming them. In Britain, children are taught to read language in their first year of school at age 4 - 5, and, increasingly, at age 3 - 4 in the nursery or playgroup setting. It was therefore a further aim to ascertain whether children at these ages are also capable of learning to read music. In support of the above aims the thesis investigates the literature concerning skill acquisition and children's learning in other areas, in order to use established, relevant knowledge to understand the processes involved in learning to read music.

It is recognised that different cultures adopt diverse approaches to the introduction of both music and written language skills. This thesis is concerned only with the cultures of Britain and America, and recognises that it may not be relevant to other cultures.

Background

There are both similarities and differences between reading language and reading music. Both tasks involve the interpretation of symbols, but in a practical situation reading music also involves physical action. The task of deciding the appropriate physical response to a written note must be carried out concurrently with the reading task, thus increasing the complexity of the task. In this respect the music reading task is more difficult than the language reading task. However, this increase in difficulty is balanced by there being immeasurably more words than there are notes in music. Therefore whilst children learning to read language are faced with an apparently overwhelming number of words to learn, children learning to read music are faced with the additional task of deciding where each note is on the instrument, and overcoming any physical problems connected with actually playing it. Thus, both language and music reading tasks are difficult, requiring many hours of practice. Society though, reacts to them in different ways, presumably because of the uses to which the two skills can be put.

Language reading is fundamentally important in many areas of human activity, whereas music reading is only important for a musical activity such as playing an instrument. A person who cannot read language is disadvantaged across many areas of learning as even straightforward everyday tasks such as shopping and travelling become more difficult. Inevitably such individuals will also suffer restricted employment opportunities. On the other hand, a person who cannot read music is not disadvantaged unless they are engaged in specific music based activities. Certainly, their everyday functioning as a member of society is not affected.

The widespread use of written language means that its importance is never questioned. No one ever queries why young children are taught to read, because reading language is considered essential. They are not taught to read with a specific application of the skill as the ultimate goal. Children are not taught to read in order to study textbooks, or to read novels, or to read the latest gossip in the tabloid newspapers. Put simply, they are taught to read in order that they *can* read. The initial teacher is not focussing on the development of reading for a specific, limited purpose such as the reading of complicated scientific text, or travel brochures, or television programme listings. Because the skill is recognised as being essential for satisfactory functioning in society the final use to which it will be put is not of concern to the child's first teacher, who simply wants the child to succeed in a way appropriate to their age. The focus of attention is therefore the task itself - learning to read, rather than the end uses of the task.

Conversely, the ability to read music is not essential for satisfactory functioning in society and is therefore considered optional. A child is normally taught to read music by their first instrumental teacher, and the task of learning to read music is presented at the same time as the end use of the task - learning to play the instrument. The focus of the attention of both the child and the teacher will therefore most likely be on the end use - playing the instrument. The music reading task will be assigned secondary importance as the reason the child is receiving tuition is to learn how to play the instrument, not to learn how to read music. This situation would be paralleled in a language reading situation where a child is not taught how to read until they *need* to do so, in order to learn history, or science, for example. In that situation the focus of attention would likewise be on history or science, rather than learning to read, and one of the tasks might be expected to be adversely affected.

It is this author's opinion, assuming that young children are found to be capable of reading music, that the only way for music reading to move forward is for the importance of the task to be recognised in its own right. For music reading to advance it needs to be taught in a similar way to language reading, with children first learning to read music at a young age, and then going on to learn to play an instrument of their choice later. The first instrument learned would therefore be one that is physically straightforward to play, thus allowing the young child to concentrate on the music reading task whilst still enjoying a practical application of it.

Young children and music reading

Some researchers have stressed the importance of exposing young children to written music. Andress (1986) identified that between the ages of 3 to 6 there is a rapid increase in vocabulary, an increase that she believed should be matched in music:

> "During such rapid growth in language, the child should also be acquiring a music vocabulary with an inherent understanding of the symbols."
>
> *Bulletin of the Council for Research in Music Education (1986),* 86, page 14

Elsewhere (Andress, 1989) she outlined an early years curriculum model, but did not present any research findings to support the proposal.

Anecdotal evidence, and further support for teaching 3- to 6-year-old children how to read music, came from Shor in 1989. She again identified the years between the ages of 3 and 6 as being important, and, in particular, as being a time when a child is capable of learning many languages simultaneously, including music. She did not go on to present research-based evidence of the standard achieved by her pupils, presenting instead diary extracts that referred to individual piano lessons given to pupils age 4 or 5. The extracts reported children as young as 4½ being able to play simple pieces using both the bass and treble clefs. Pitch was taught, with the help of very large print and games, in the conventional way through the use of letter names. There was no reference to the teaching of rhythm. Shor stated that by their third year of lessons the children's progress was faster than normal. She concluded: "My experience shows that the earlier one starts teaching notation, the better the results." (page 23).

The situation predicted by Collins (1985a), that the average age of beginners would, by this time, have dropped from 7 to 4, has not yet arrived. She extolled the virtues and benefits of starting to teach the piano to very young children, but again presented no research findings (Collins, 1985a & Collins, 1985b). She also used a method based on the teaching of pitch via letter names, and did not explain how rhythm was taught. Once again the exact teaching method and level of achievement reached by the children were not reported.

Extensive literature searches have found only one experimental study concerned with the music reading abilities of very young children, further indicating the need for the present study. Oropeza-Tena and Ayala-Velazquez (1997) taught 4 to 5-year-olds the letter names of notes through the use of reinforcement procedures. The children successfully learned the letter names, but, surprisingly, it was not part of the experimental design for them to progress to actually playing the notes on an instrument. Whether or not they could have done so is therefore unknown. Even when the reading process is assigned priority it is still necessary to demonstrate a practical application of the ability before success can be claimed, as merely knowing the letter names cannot be judged to be 'reading' music. The view taken here is that children can only be said to be capable of reading music if they can perform from written notation.

The situation has arisen where some educators have expressed the opinion that teaching pre-school children to read music is a logical and worthwhile thing to do, and some musicians have reported favourably on the experience of teaching pre-school children the piano. However research-based evaluation in the area has proved extremely difficult, if not impossible, to find. This lack of structured research means that no reliable knowledge base exists. Although reports claiming to have successfully taught young children the piano have been published, the lack of precise methodologies means that the studies cannot be replicated, and the lack of clear research questions means that precise conclusions cannot be drawn. Furthermore, the published reports do not draw on new theories and methodologies, but merely adapt existing methods to make them more suitable for use with very young children. If music reading research is to progress in a cohesive way this situation must clearly be rectified. With older children more structured research has been carried out, particularly with regard to rhythm reading.

Rhythm reading

The problems caused by rhythm performance from notation have been frequently acknowledged. Shehan (1987) suggested that the cause of the problem is that the 'answer' only exists in the mind of the performer. It is not possible to play the crotchet key, or pluck the 2quavers string. If the rhythm  is seen,

the correct response lies somewhere within the brain of the performer. To further complicate the matter the crotchet could last 1 second or more, or 0.5 second or less, or any value in between. These problems have resulted in investigations with older children into the effectiveness of differing teaching methods. In countries other than the UK rhythm is taught by a variety of methods: French time names, the Kodaly and Gordon methods, together with syllabic methods based on words taken from the English language (USA). These have all been used in an attempt to facilitate rhythm learning. However, studies comparing their relative effectiveness have been inconclusive, and studies considering the learning needs of pre-school children non-existent.

Relevant developmental theories

Andress (1986, 1989) and Shor (1989) both identified the ages 3 to 6 as being important for the acquisition of language. Historically developmentalists and educationalists have stressed the importance of this age for language acquisition. Piaget, (see for instance, Crain, 1992) for example, in his description of the stages of child development identified the years between the ages of 2 and 7 as being those in which a child becomes able to use symbols, including words. In particular, he identified the ages from 2 to 4 as being those where language is rapidly acquired.

Central to Montessori's theory (see for instance, Crain, 1992) is the idea that children progress through the effective use of *sensitive* *periods*. These are times when a child is developmentally ready to learn certain tasks. Her view was that if the tasks are not learned at the appropriate time then normal development is disrupted. She identified the ages between 3 and 6 as being those of conscious language acquisition. In her writings she suggested that children are introduced to reading and writing at the age of 4 because they will by then be ready for the conscious exploration of language that reading and writing provides. If Montessori's view of sensitive periods is correct, and the years between the ages of 3 and 6 are the critical ones for language learning, then part of the difficulty older children can have in learning how to read music can be explained. Obviously, although developmental readiness facilitates learning, language acquisition is possible at other ages, as is frequently demonstrated, but may not be as easy.

Long-term benefits of pre-school learning

The importance of the pre-school years has been recognised by practitioners in many fields. In the domain of second language learning bilingual countries have long known the advantages of introducing very young children to their second language. In French speaking Canada, English first language children are expected to learn French from early childhood (Alberta Department of Education, 1991). Likewise in Wales, Welsh is introduced to first language English children in the nursery and playgroup. (For a report see Arnberg, 1982). Furthermore, reports of the introduction of a second language are not limited to spoken language. Both hearing and deaf pre-schoolers have been taught to use sign language, and Irma, Manning, Pavur and Wagner (1998) reported that hearing children who had been taught sign language had a greater vocabulary than those who had not. Daniels (1996) also reported greater vocabulary in pre-schoolers after 2 years of sign language instruction.

The importance of pre-school education in general has been emphasised many times. For example, Daniels (1995) reported significant positive effects of pre-school education on the subsequent ability of children in reading, writing, mathematics, and science. The long-term effectiveness of early reading intervention has also been reported by Davies and Brember (1997), and Nicolson, Fawcett, Moss, Nicolson and Reason (1999).

There is some support that this long-term benefit also extends to music in a study by De Yarman (1972), who compared the rhythm performance of children who were exposed to complicated rhythmic patterns at a young age with those who were not. He reported that those subjected to early exposure to complicated patterns were better able to perform them when older. Instrumental teachers often witness rhythmic behaviour that supports De Yarman's findings. The rhythmic styles to which most children in Britain are exposed are extremely limited, and perhaps becoming increasingly so. The overwhelming majority of the music they hear is written in duple (two beats per bar) or quadruple (four beats per bar) time, usually with percussion instruments emphasising a very regular and simple accompaniment pattern. Intuitively it is not surprising that children who have only heard simple rhythm patterns when young, find difficulty with complicated patterns when older. Although no empirical evidence seemingly exists, instrumental teachers are very familiar with one effect of this emphasis on duple and quadruple time signatures: the inability of beginners to perform a piece written in triple (three beats per bar) time. Invariably in the early stages of learning the piece will be performed with an extra beat at the end of the bar, with the child being seemingly incapable of noticing the error, which is frequently counted as 'one, two, three – ee' in order to provide the necessary fourth beat.

There therefore exists much evidence in the literature, both music and non-music based, supporting the view that young children would benefit from being introduced to written music notation between the ages of 3 and 6. Paradoxically these are the ages at which a child is unlikely to be introduced to written music. There are many possible reasons for this:

i) Because of the conventional reliance on letter names for the teaching of pitch, it seems reasonable to wait until a child has firmly grasped the alphabet, and gained some fluency in written language, before introducing music notation.

ii) Children aged 7 or over have greater powers of concentration than younger children, and can therefore be taught both for more time each session, and more easily each session.

iii) Many instruments are physically too difficult for very young children to play, making it necessary to wait until the child is old enough cope with the demands of the instrument before beginning lessons.

iv) Complexity. Producing the physical actions necessary to play the instrument whilst at the same time interpreting the written symbols is a complex task for which very young children may not have the cognitive capacity.

However music *is* another language. Therefore it is logical to introduce it between the ages of 3 and 6, through the use of an instrument which is physically within young children's capabilities. Intuitively it seems reasonable to assume that if that period is one that is critical for language learning, then it is also critical for the music language learning, including written music.

However, despite the above, it was not an objective of this thesis to answer the question of whether very young children *should* be taught how to read music, only whether they *could* learn how to read music. The question of whether they should be taught to read music is a separate issue. As well as the reports advocating the early introduction of music reading to young children, there is sufficient research reporting positive effects of early learning in other areas to make a long-term positive effect of early music reading likely. Whether that actually is the case is outside the scope of this thesis.

Overview of thesis

Although the age range 3 to 6 years is most frequently referred to, it was decided to reduce that to include only 3 - 4-year-olds for two reasons. Firstly, this range is highlighted by both Montessori and Piaget in their developmental theories; and secondly, given that an aim of the research was to ascertain whether children could learn to read music at the same time as learning to read language, the 3 to 4 age group was ideal, being the earliest age at which language reading is introduced. Furthermore, many children of this age attend nursery, and the nursery chosen for the research setting introduced children to written number and language as part of their everyday activities, thereby making it the ideal setting for investigating whether children can learn to read music at the same time as language. Additionally, by school age the prior experiences of children are more widely varied. Some will have previously attended a nursery and may already be able to read simple words and numbers, whereas others may have had no contact with words and numbers at all. This difference in prior experience could affect the ease and manner in which the children learned music reading, thus making comparisons between teaching methods more difficult. At age 3 and 4, in a nursery setting, it is much more likely that the children are relatively homogeneous in relation to prior musical experience.

Some background information concerning how the project came into being may be of interest. I had taught the piano for many years, both to children and university music students, and had always been struck by the difficulties experienced by some with the music reading process. For a number of children the task of learning to read music seemed to be an extremely difficult one, and they frequently commented that it was much more difficult than their schoolwork. Even university music students were not exempt from this difficulty, as although pitch reading ability was invariably securely in place, problems with accurate rhythm reading were extremely common. As a teacher I tried different ways to help the children and students overcome their problems. For example, words and phrases were used as an aid to learning a difficult rhythm (as in 'nice cup of tea' for concurrent triplet quavers and quavers); difficult passages were practised at half speed, to the accompaniment of a metronome. With children, the usual sentences were used as aids to learning the letter names (e.g. 'Every Good Boy Deserves Football' for the lines of the treble clef); pieces were practised hands separately; rhythms clapped before being played. These and other techniques were used with only varying degrees of success; none successfully overcame the problems.

Over time it occurred to me that 'prevention was better than a cure', and that the most appropriate solution was to find a way of pre-empting problems from occurring through early intervention. I became aware that very young children were being successfully introduced to written language and number skills before starting formal education, so it seemed logical to investigate whether music literacy skills could also be introduced at the same time. Personally, I had taught myself to read music, by studying my brother's piano books, at 3 years of age. I was therefore confident that what I had achieved without guidance, others could achieve with appropriate tuition.

My role in the project was that of both teacher and researcher, and it may be thought that a potential conflict of interests could occur, as I was both teaching, and assessing the effectiveness of the teaching. However, as the assessment measures were purely objective then this conflict was less likely to arise. I would argue that any researcher-bias was offset by the quantitative nature of the data. Furthermore, in many ways the dual role was a desirable one. By being actively involved in teaching the children I was able to gain a very good understanding of how the children were coping with the tasks. I was also able to ensure that the tasks were presented in a way that respected the individuality of the children and took advantage of the observed differences in understanding. Each session was a balance between ensuring that the necessary work was covered, and responding to the needs and interests of the individual child. Pre-school children are renowned for having a short attention span, but there are large differences both between children, and also, for each child, on a day-to-day basis. For instance, for some children a short attention span was the norm, so it was necessary for 4 or 5 games to be played in each session. For others, it was usual to only play 2 or 3 games. However, both types of children would have days when their concentration was particularly good, or particularly bad, resulting in a non-typical (for that child) session. It was therefore necessary for me to be extremely flexible in my approach. Sessions began with brief revision but frequently before even that could be achieved I would have to admire a new pair of shoes, or listen to what happened on the way to the nursery. It is argued that such variety did not detract from the overall viability of the studies, as all the children in each group were presented with the same material. Care was taken to ensure that all children received exposure to all the activities. For example, one child may have played the same 4 games for two sessions, and another the first 2 games one session, and the remaining 2 the next. In such situations both children received the same exposure to the training material.

The thesis reports five studies, all of which investigate pre-school children's ability to perform from conventional music notation. Ten children participated in each study, being the maximum number that was practically possible. As the children were taught individually time constraints meant that a greater number of participants in each group would not have been achievable. Furthermore, the children all attended the same nursery, and by choosing ten children in each group the need for any child to participate in more than one study was avoided. Each child who took part in the project therefore only participated in one study. To better understand the reading process, pitch and rhythm were investigated separately, resulting in the thesis being presented in two sections.

Rhythm

The first section is concerned with rhythm, and begins with a literature review that asks the question 'Why does accurate rhythm performance from written notation cause so many problems?' The first study, reported in Chapter Three, was akin to a pilot study and was designed to ascertain whether 3 – 4-year-olds could perform from conventional rhythm notation. For this study, a teaching method adapted from the conventional counting method most commonly used in the UK, was used. However, to simplify the task, rather than the number of beats being counted cumulatively throughout the bar, each note was counted as a single unit.

The two studies that followed the pilot study are reported in Chapters Four and Five respectively. They investigated teaching methods that evolved from a combination of the theoretical review of Chapter Two, and the responses of the children in the first rhythm study. The accurate performance of rhythm is thought, by many, to depend upon the ability to maintain a constant pulse to which the rhythmic phrase is then aligned. For the dual task condition, reported in Chapter Four, the children spent half of their time on activities that were designed to increase their ability to maintain a constant pulse, and the other half learning the lengths of the various notes. The rationale was that practice on these components separately would improve performance on the complete task.

Partly because of the inconclusive nature of research into rule-based methodologies, the final study investigated a method that was not rule-based. A connectionist approach was used to investigate whether it was possible for children to learn to read and perform rhythms without the use of rules, and this study is reported in Chapter Five. Training rhythms were chosen from nursery rhymes, and the children progressed through the stages of exposure to the written training rhythms together with their correct performance, to performing the training rhythms, and finally to performing previously unseen rhythms from conventional rhythm notation. Finally in this section, Chapter Six discusses the findings of the three rhythm studies, in terms of the effectiveness of the teaching methods used, and their appropriateness for use with 3 – 4-year-olds.

Pitch

The second, shorter, section of the thesis is concerned with pitch and is presented as two stand-alone papers. The first, Chapter Seven, is again akin to a pilot study, the main aim of which was to ascertain whether it was possible for young children to learn pitch notation without the use of letter names. Letter name methods have habitually been used, seemingly without investigation into whether they actually are the most appropriate vehicle to use with all age groups, or with only some age groups, or indeed with any age group. Thus for this study the notes were referred to in such a way as to help the children remember both their location on the stave, and corresponding location on the instrument. The second paper, Chapter Eight, compares two different methods. After the first few teaching sessions the children in the pilot study displayed a tendency to prefer learning new notes by one of two different methods. These methods were linked with the reported findings of research conducted into pre-school children's learning of number and written language, together with their map reading skills, to formulate methods based on equivalence relations and contextual information. This comparative study reported in Chapter Eight stands alone as a published paper. There is therefore some overlap between it and other chapters.

Summary

The thesis addressed the following research issues:

1. Can 3 – 4-year-olds learn to perform simple rhythmic phrases from conventional rhythm notation?
2. Can 3 – 4-year-olds learn to play simple melodies from conventional pitch notation?
3. Is there a relationship between the standard achieved by the children and the teaching method used?
4. Is the exploration of non-music research literature a profitable line of enquiry?

Chapter Two

A theoretical perspective on the problems of accurate performance from rhythm notation- or -'Why is rhythm so hard?'

Music is often said to be comprised of sound and silence, and sound comprised of pitch and duration. But how are pitch and duration, and therefore music, processed by the brain? This chapter explores some relevant theories and research in an endeavour to understand the perceptual processes involved in processing duration. It is suggested that any attempt to assist music learners to overcome the many obstacles presented by performing from rhythm notation must involve an investigation of how duration is processed by the brain. Only when a clearer understanding of that process is gained, can ways be found to facilitate learning.

Firstly, a brief description of how pitch is processed, a procedure that is reasonably well understood. The inner ear contains around 23,500 hair cells, each one of which has a frequency range to which it responds, together with a frequency to which it is the most responsive. The information it receives is transmitted via the auditory portion of the VIIIth cranial nerve to the auditory cortex and secondary auditory areas of the brain, and, as it travels, the frequency range to which the neurons respond decreases. Most of the auditory nerve is involved in relaying this pitch information, but it is also involved in the communication of information such as harmonics. Also, some cells record inter-aural differences, with differences as slight as 300 millionths of a second being detected. For further information readers are referred to the relevant sections of Kolb and Whishaw (1996), and for greater detail Kingsley (1996). According to Vercoe (1997) by the time the brain receives pitch information the complexity and amount of information has been enormously reduced. In the case of speech vowels the input is reduced to just 4 categories: the perceptual fundamental, and the three resonant frequencies applicable to a particular vowel.

For most people who play an instrument the pitch processing ability of the ear and brain is far more than they actually need, especially in the early stages of learning. Initially a beginner decides which note to play according to the rules of the instrument, and, only very slowly over a number of years, learns to match the actual sound produced to that expected from the written note, and to detect an error if the two fail to match. Thus, certainly in the early stages of learning, and continually for many 'non-expert' instrumentalists, a mistake is usually only identified if it results in the music sounding 'wrong' in some way. This can itself lead to mistaken conclusions of error if the composer has written a note or chord that the player considers sounds wrong.

Contrasted to the degree of understanding of pitch processing is the apparent lack of understanding of temporal, and therefore rhythm, processing. Whilst different frequencies are known to activate different hair cells, notes of different duration are processed in a way that remains unclear. As Penhune, Zatorre, and Evans said as recently as 1998:

> "The mechanisms underlying the encoding of temporal information from sensory stimuli are poorly defined in comparison with the large body of data that exists regarding encoding of other aspects of sensory information."
>
> *Journal of Cognitive Neuroscience (1998)* 10 (6), page 752

Because the pitch processing ability of the brain far exceeds the demands made by music it is tempting to assume that the temporal processing capability is likewise, but this assumption cannot be made. It is important to know whether that is the case because of the different implications for rhythm teaching and learning. If the brain's capabilities do exceed the demands of rhythm performance, then certain ways forward can be investigated. However if the capability is only just sufficient, or not sufficient at all without training, then the very nature of the problem changes and different ways forward need to be investigated. It is therefore my intention to refer to the wealth of published literature on timing and time perception in order to examine the issues relating to rhythm performance. In particular an answer to the question 'Does human timing ability exceed the requirements of performance from rhythm notation?' will be sought.

In Britain and America rhythm is traditionally taught through the use of counting strategies. Other methods do exist, but counting remains the prime vehicle for achieving rhythmical accuracy. Is that strategy in keeping with the way time is processed, or is another approach actually more suitable? The answer to these questions will also be sought by exploring the research literature.

For convenience the term 'rhythm performance' will be used to describe performance from conventional rhythm notation. When other kinds of performance, for example from memory or by imitation, are discussed, they will be described as such.

Animal research

Whilst the precise mechanism utilised for temporal processing is not yet fully understood, it is undeniably both extremely complex and highly efficient. Although it may be thought that research investigating animal timing would be of no help when considering children, this is not actually the case. As will be described below, animals have been demonstrated to show some of the same timing characteristics as exhibited by beginning instrumentalists. Furthermore animal research is particularly useful when discussing counting procedures. Animals are not able to use external clocks (except for the rhythm of night and day), and presumably cannot count, yet despite this some animals are able to use precise judgements of time to facilitate their everyday survival. If animal timing displays the same properties as human timing, and animals are capable of precise timing judgements without having to resort to counting, then maybe so too are humans.

For example, birds who have young in the nest to feed need to optimise their foraging expeditions in order to not waste time either by travelling too far for food, or spending too much time in an area where the density of food is not sufficient. In a laboratory experiment with starlings Gibbon and Church (1990) reported that the birds perceived and remembered the time spent flying and foraging, and then used this information to calculate whether the amount of food found was worth the time and effort spent on the respective tasks.

Intriguingly both pigeons and rats have been reported to display one facet of timing behaviour, which can be found in music: error is judged proportionally, and the 'counting' of any given time interval can be stopped and re-started. In his thorough historical review of scalar timing Gibbon (1991) gives many examples of research with animals, the unifying factor being their ability to judge accurately quite complicated time intervals. Gibbon's purpose in looking at the data was to show that the animals' response displayed scalar properties: when mean time produced was plotted against target time using fractions of the longest interval as measures, the relationship was linear. In one example pigeons were placed into 3 groups and given food on the first peck after the fixed interval had elapsed (a procedure termed the Fixed Interval Reinforcement Schedule). The interval used was 30, 300, or 3,000 seconds (secs), and it might be thought that the pigeons would simply peck in a rather haphazard way. However the results showed quite conclusively that the birds were capable of judging when the required interval had elapsed. The graph plotted by Gibbon is reproduced here (Figure 2.1). The Y axis divides the response into fifths of the maximum response rate, and the

X axis the fixed time interval into fifths. It can be seen that after one fifth of the time has elapsed the birds are pecking at less than one fifth of their final rate, with the rate of pecking increasing until they reach their maximum rate at almost 'full time'. Even though the fixed time

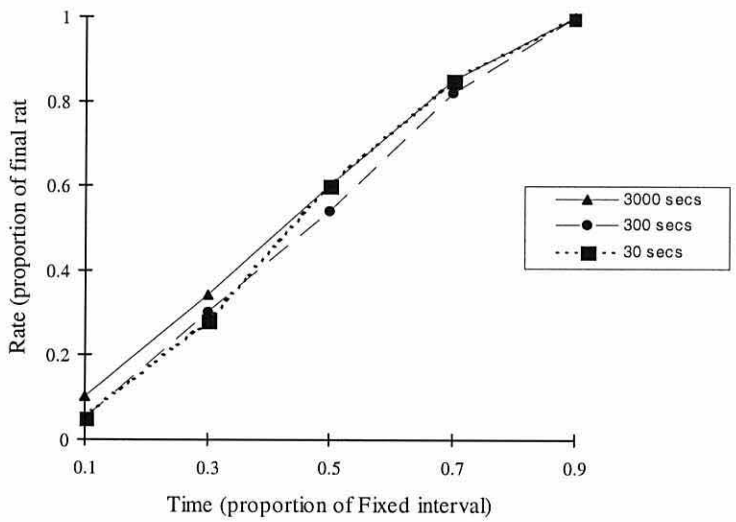

Figure 2.1: Graph of pigeons' response rate against target time.

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intervals varied considerably the variability of the birds' response was much less, with all the birds apparently knowing when the interval had elapsed. Thinking about time in terms of proportions, rather than an absolute value, is intuitively acceptable to musicians who are accustomed to thinking about duration in this way. No note value has an absolute time value, only a proportional relationship to other note values.

Researchers have proposed that animals use an internal clock to process time, even though they presumably cannot count the pulses generated by it. Roberts (1981) investigated the nature of the internal clock in rats and reported results which displayed timing behaviour very similar to that of beginning instrumentalists: both seem to form their own conclusions as to what the task is, and are capable of stopping and re-starting the clock. She demonstrated that, with food as a reward, rats were able to accurately time intervals of 20 and 40 secs. She also demonstrated that it was very easy to alter conditions so as to cause them to make errors. The animals were in light cages during the experiments but if the lights were turned out for a given interval, say 5 or 10 secs, then an amount roughly equivalent to the dark time was added on to the interval, as if the clock had been stopped and re-started. Presumably the animals were distracted from their timing task by the unexpected darkness, but were able to resume it when the distraction ceased. Also, when food was omitted at the end of a trial the rats seemingly became confused and, on the next trial, only waited for a short time interval before searching for food. This implies that they had an idea of what the task involved was, waiting for food.

Rats and beginning instrumentalists would appear to share both these behaviours. Beginning instrumentalists are frequently distracted from their timing, perhaps by having to find a difficult note, and apparently stop the clock and stop counting when the distraction begins. They then re-start it and resume counting once the distraction has finished. Beginning instrumentalists also frequently formulate their own erroneous view of what the task is, and consider it to be 'the bar' or 'the line', rather than the complete piece of music. This results in a pause between the completion of one 'task' and the start of the next. Both the above behaviours result in a lack of continuity, and, to the listener, appear as errors.

Human research

Counting

There is one obvious difference in the timing processes used by animals and humans: humans are capable of overtly counting throughout the interval in question, a tactic frequently used in music. But does this counting increase accuracy? Are non-counting and/or counting humans superior timekeepers to animals, or not as efficient? This question is important, because, in Britain and America, rhythm is so often taught through the use of methods involving counting. Many beginners find counting difficult, so if it is not effective in increasing their accuracy, perhaps their efforts would be better applied elsewhere.

Wearden (1991) investigated the issue of counting versus non-counting. He compared the results obtained from three different timing experiments: one involving pigeons, another non-counting humans, and the third counting humans. Unfortunately the paper draws upon prior research, rather than original data, and so the different time intervals used make it difficult to make a direct comparison between the three groups. The pigeons were trained with intervals of 10 - 70 secs, the non-counting humans 0.5 - 1.3 secs, and the counting humans 2 - 32 secs. The results, bearing in mind the limitations described above, indicated that when asked to produce a given time interval counting humans were the most accurate, followed by non-counting humans, with the pigeons being the least accurate. For pigeons and non-counting humans the coefficient of variation remained almost the same across all time durations. However for the counting humans it changed, being higher (0.085) at shorter time durations (2 and 4 secs), and then falling and remaining constant (0.05) for values of 8 secs and more (to a maximum of 32 secs).

At 1.3 secs non-counting humans displayed a coefficient of variation of 0.145, as opposed to 0.085 at 2 seconds, suggesting that, if the durations were reduced further, there may actually be only slight differences between the counting and non-counting humans. This has strong implications for music, where there are overwhelmingly more single note durations that are less than 2 secs than there are that are more than 2 secs. Since the strategy of counting time in seconds is so commonly used, a methodological problem exists in conducting research that compares counting humans to non-counting humans:

ensuring that the non-counting participants really are *not* counting. For very short intervals this is presumably quite straightforward, but, for intervals of around one second or more the temptation for the person to count must be very strong. Conscious attempts to avoid counting would be likely to result in distorted perception, as would the use of distraction techniques. Wearden merely reports that the participants, who were also the experimenters, stated that they were not counting. Whilst acknowledging the problem he did, in effect, simply 'take their word for it'. This author is far more sceptical and does not believe that it is a simple task to avoid counting. However, my training as a musician may influence that belief. It may be that, for non-musicians, the avoidance of counting is more straightforward. The literature at present does not answer that question, but it does acknowledge that there is a problem, and that it is extremely difficult to compare the two different means of time measurement in humans.

Terms

Some clarification of terms may be useful at this point. Following the example set by the timing literature I shall use the term 'target time' to refer to the time duration of the task, e.g. the length of a note (or bar), or the time interval between stimulus presentations; 'counting' to refer to the strategy of counting up in equal increments in order to judge the target time more accurately; and 'inter-count interval' to refer to the length of time taken for each counting step. For example, if a target time of 10 secs is produced by counting up to 10, each inter-count interval will be 1 second. If it is produced by counting up to 20 each inter-count interval will be 0.5 secs.

It follows that, even if the target time is produced by counting, non-counting strategies still have to be utilised in order to calculate the inter-count interval. In the above example the 10 second target time can be counted, whilst it is not possible to count the 1 or 0.5 second inter-count interval. So how is that produced? Wearden went on to investigate whether the timing of the inter-count interval displayed scalar properties. Adult participants were asked to count a target time of 6 seconds. The target time remained constant but was subdivided into 5, 6, 8, 10, or 12 inter-count intervals. No feedback was provided for the inter-count intervals, only the target time. These subdivisions resulted in inter-count intervals at metronome (mm) speeds of 50, 60, 80, 100, and 120. When the results of the inter-count intervals were analysed Wearden reported that they did indeed follow scalar timing properties, and furthermore that the coefficient of variation was around 0.14, corresponding to that found for non-counting humans. The accurate judgement of a target time is therefore ultimately dependent on non-counting processes, as, if the inter-count interval is inaccurate, the target time will likewise be inaccurate. Because music is counted bar by bar, there will inevitably be a tendency for the bar to become the target time, and each beat the inter-count interval. The research suggests (Wearden 1991) that this in turn will mean accurate estimation of each bar (target time), but less accurate estimation of the length of each beat (inter-count interval). This situation will not result in the most accurate musical performance, but it is difficult to see how the situation can be avoided, except in slow music where the notes are of sufficient length to enable them to become the target time.

The issue of whether bar lines improve rhythm performance has been investigated in the music literature. Byo (1992) compared accuracy of performance in 2 groups of musically experienced students. One group performed from music with bar lines, and the other group performed from music without bar lines. He reported no significant difference between the groups. This finding was contrary to expectations, and he speculated that, with young players, bar lines may actually be a hindrance, causing the bar itself to be viewed as the musical entity. The timing literature (Roberts 1981) confirms this idea, and provides an explanation as to why it should be the case.

In order to ascertain whether there was an optimum inter-count interval Getty (1976) investigated the effect of subdividing target times of 5 or 10 secs into different inter-count intervals. If counting is the best means of achieving accuracy in rhythm performance then the use of an optimum inter-count interval, if it exists, would be a further aid to accuracy. He used five inter-count intervals: 300, 450, 600, 750, and 900 ms, corresponding to mm speeds of 200, 133, 100, 80, and 66 respectively. For all participants (4) the quickest and slowest counting speeds were the least accurate, with 3 of the 4 participants being the most accurate with an inter-count interval of 450ms (mm 133), and the fourth the most accurate at 600ms (mm 100). The conclusion was therefore that counting at mm speeds of 100 and 133 was the most accurate. These findings reinforce what musicians intuitively know: it is best to avoid counting at either end of the metronome scale. Thus, if a piece has a very quick pulse it is more efficient to double the length of the unit to count, and conversely, with a slow pulse, to halve it.

Duration discrimination and Weber's Law

One aspect of timing frequently investigated is discriminatory ability: what is the smallest noticeable difference between two durations? Weber's Law states that the least discriminatory difference between two time intervals can be defined as a constant fraction of the shorter interval. This is important for music because it is important to know, if two or more notes should be the same length but are not, how great the difference can be before it is noticeable. If Weber's Law gives the minimum difference, then the closer to that the requirements of music get, the greater the accuracy required by the performer, and therefore the more difficult it is to achieve it.

Experimenters have disagreed as to whether the law holds in all, or indeed in any, circumstances. However, as explained by Laming

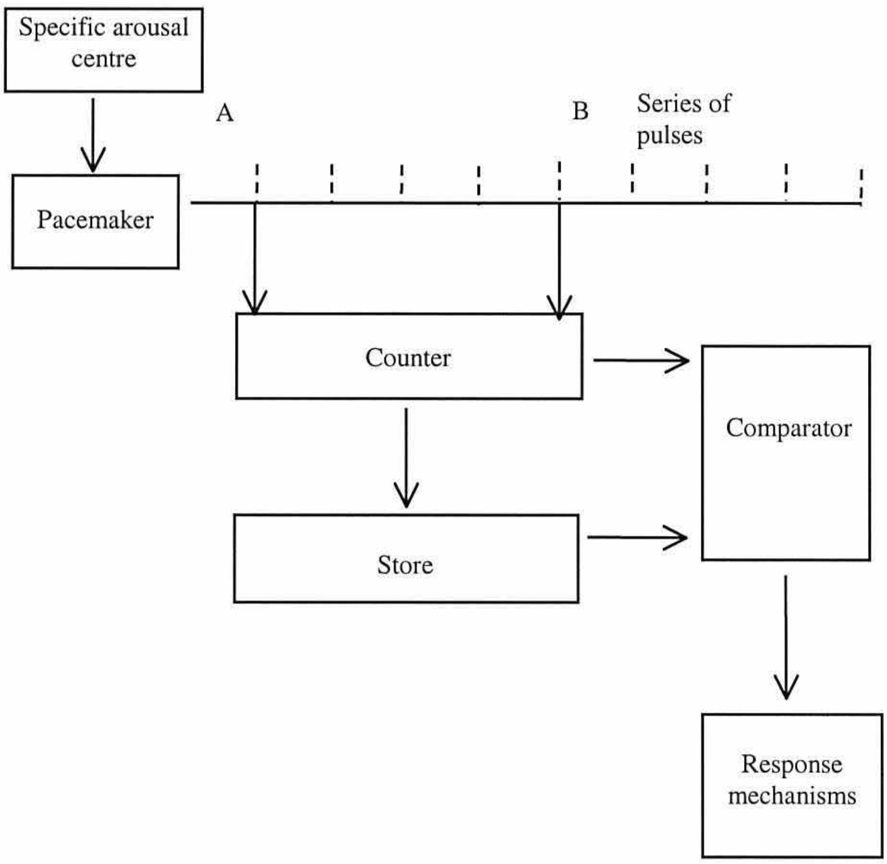
(1997) the situations where Weber's Law does not hold true are those that are dealing with a just noticeable increase to a background stimulus. As rhythm, by its nature, does not have a background stimulus it would be expected to conform to the law. The only exception would be very repetitive, 'minimalist' type pieces containing only one note value. In such cases the sheer repetition of the rhythm could cause it to take on the nature of a background stimulus, and so not conform to the law. In an investigation using adult participants who were asked to compare the duration of a pair of light stimuli Thompson, Shiffman, and Bobko (1976) reported that the law held. They calculated the value of the constant to be .056, .053, and .043 for intervals of 1, 2, and 3 secs respectively. This gives a detectable variability of between 4% and 5%. Applying this to a succession of crotchets at mm 72 for example, the metronome speed would have to increase to approximately 75.5, or decrease to approximately 68.5 in order for the difference to be noticed. This is intuitively acceptable to musicians, as slight variations in tempi of that magnitude tend not to be noticed.

The law itself is also intuitively acceptable to musicians, who are accustomed to dealing with error as a percentage of the length of the note concerned, rather than an absolute value. For example, in a passage of quick semiquavers a listener will easily notice an error on one note of 20ms, while in a slow piece an error on one note of 100ms may be only just discernible.

Kristofferson (1980) investigated Weber's Law and the effects of practice. In his study adult participants were required to discriminate between 4 time intervals of increasing length: D_1, D_2, D_3, and D_4. The mid point between D_2 and D_3 was defined at the baseline interval. The time intervals were presented as periods of silence between 2 brief auditory pulses. The participants had to respond by pressing one button if they thought the interval long, and another if they classed it as short. Thirteen stimulus sets, with baseline intervals between 100 and 1,480 ms were used. He compared results obtained before, during, and following practice, and reported that while Weber's Law held for conditions of no practice, it did not do so after practice. He reported that accuracy improved with practice, especially over the first 10 of the 20 sessions. Results obtained prior to practice followed the law and produced a straight line graph when the just noticeable difference was plotted against baseline duration; results obtained following practice did not. Practice resulted in a grouping of baseline durations, and, within each group, the just noticeable difference only increased slightly before a large increase at the start of the next group. The resulting graph of just noticeable difference against baseline duration (grouped) became stepwise in nature. He reported that the groupings resulted in doubling of baseline interval values: 100-200 ms, 200-400 ms, 400-800 ms, 800-1600 ms, but the reasons why this should be the case remain unclear. Furthermore, the increase in accuracy was not confined to the actual time intervals practised as the effect carried over to other intervals as well, suggesting that the participants were acquiring a generalisable skill. This conclusion, that practice improves ability, and that it improves ability at speeds other than those specifically practised, is in agreement with the experience of musicians who know that initial rhythmic ability can be improved, and that practice in one area results in increased accuracy on a different task.

The 'internal clock' question

Historically theories have favoured some kind of clock mechanism, although recently other ideas have also been suggested. For example, as mentioned previously, Penhune et al. (1998) do not consider the mechanism used to be one of internal clock and counter. They put forward the idea that the cerebellum merely provides the necessary structure in order for the sensory system to extract temporal information, without actually hypothesising as to what that structure might be. The use of oscillators has been suggested by some (see Church & Broadbent, 1990; Collyer & Church, 1998; and Crystal, 1999, for example). Others, such as Rosenbaum (1998) in his 'broadcast' theory of timing, have suggested that the time taken within the nervous system for signals to travel different distances is responsible for the control of timing. This idea is similar to the connectionist spreading activation models of time (see Shapiro, 1999, in Wearden, 2000, for example) which are based on the idea of a spreading activation pattern, rather like a growing pattern of ripples formed by dropping a stone in water.



Simplified from *Psychological Monographs (1963),* 77 (13), page 19

Figure 2.2: Treisman's internal clock model

An important early proponent of the internal clock was Treisman (1963), who proposed a model consisting of a pacemaker, counter, store, comparator, and response mechanism. A simplified drawing of the model is shown in Figure 2.2. In his model the pacemaker produces a series of pulses, the rate of which is determined by what Treisman referred to as the 'specific arousal centre'. When a stimulus (duration A to B above) is presented, the counter records the number of pulses present and either transfers this information directly into the store, or to the comparator. The comparator acts as a decision maker by comparing information held in the store to that being received by the counter. After comparing the two values the appropriate response is sent to the response mechanism.

Although the model is frequently quoted, experimental evidence supporting it is rather hard to come by, and, as will be seen, the addition of the comparator is a feature about which experimenters have disagreed. The use of a comparator has important implications for music, as traditional counting techniques do not use one. In fact beginners are discouraged from simply comparing the length of a note to those around it, and encouraged to ensure that all notes are correctly synchronised to the constant pulse. If Treisman's inclusion of a comparator is appropriate then the possible uses to which it can be put need to be explored.

Schulze (1978) devised an experiment to ascertain whether the time-keeping mechanism was based purely on the internal clock-counter, or whether a comparator was also utilised. As stated above, the clock-counter model is in keeping with traditional methods of ensuring rhythmic accuracy. Such methods rely on the performer creating his or her own pulse, often overtly through the use of counting, to which the music is synchronised. For example, to perform the rhythm  the performer initially places in their memory the speed of the pulse and counts 'one, two three, one two three' at that speed in order to maintain it. (Assuming the example is in triple time with 3 crotchet beats per bar). For the actual performance the notes are played on the correct count: the first note on the count of 'one', the two quavers equally spaced on the count of 'two' etc..

The use of a comparator would require a different strategy. For example, in one method the performer would compare the length of each note with the length of the one previous to it. In the above example the performer would play the first note, the crotchet, and then ensure that each of the 2 quavers occupied half the length of the crotchet. The next crotchet would be twice the length of the quaver, and the minim twice the duration of the crotchet etc.. Intuitively it would seem that this method would be very prone to accumulated error. Another possible use of the comparator would be to hold the length of one pulse in the long-term memory (or *store* in Treisman's model) and then compare the length of each note with that memory. Such a method would not require a counting process as only one pulse is stored. It is difficult to see how either of these methods could cope with more complicated rhythms, making them intuitively not a plausible explanation.

For his experiment Schulze used 4 phrases, each a succession of 7 tones, as shown below (time intervals are shown in milliseconds (ms)). The first phrase, the standard, contained intervals of all the same length, and was classed as the correct version. Participants were required to listen to the phrases and state where they thought the errors, in terms of deviations from the standard,occurred.

Standard	300	300	300	300	300	300
Condition I	300	300	300+σ	300+σ	300+σ	300+σ
Condition II	300	300	300+σ	300	300	300
Condition III	300	300	300+σ	300-σ	300	300

(Where σ is either 10 ms or 15 ms depending on the trial).

Schulze reasoned that if the timekeeper were based on comparative durations then the errors in Condition I would be the most difficult to detect, as it only contained one change; the errors in Condition II the next most difficult to detect, as it contained a change which was then reversed. Errors in Condition III should be the easiest to detect as it contained 3 changes. On the other hand, if an internal clock-counter were used then errors in Condition I would be the easiest to detect as it contained 4 intervals which were longer than the pulse. Errors in Condition III would be the most difficult to perceive as, overall, the actual 'clock' rhythm was not altered as the '+' interval and the '–' interval cancelled each other out. He further proposed that if the mechanism were an internal clock-counter then the participant's performance would improve if two further 300 ms intervals were placed at the start of each rhythm, thereby giving the clock a longer length of time in which to synchronise.

Unfortunately he only used 5 subjects, but did report errors in Condition I the easiest to detect, and errors in Condition III the most difficult. He also reported that the performance of participants improved when given 5 introductory tones instead of 3. Shulze concluded that the internal clock-counter was the most likely time-keeping mechanism used, whilst still acknowledging that some people may use other methods.

However, it is possible to explain why most participants found the errors in Condition I the easiest to detect in different ways. For example, it could be argued that, because of the short length of the phrase (6 or 8 time intervals with only the first 2 or 4 being at 300 ms), the rhythmic change was the easiest to recognise simply because it was the only example to contain 2 distinct speeds. Both the other conditions reverted back to 300 ms for the final 2 or 3 intervals. Thus, all that has really been shown is that it is easier to detect a change of pulse if there are at least 2 definite blocks of each pulse.

An indication of the disagreement about the timing mechanism is that Schulze's experiment was replicated and extended by Keele, Nicoletti, Ivry, and Pokorny (1989), with completely different conclusions being drawn. However this difference in conclusion may be partly attributable to a different interpretation of the function of the comparator. Schulze's comparator compared each note to the one previous to it. In Keele et al.'s model the perceived average of the first two intervals was stored with subsequent intervals compared to it, rather than the compared to the previous interval. They called the mechanism a 'memory-interval timer'.

Keele et al. took Schulze's original idea, but instead of the taps being presented in succession as one group, a silence was placed after the first 4 taps so that 2 groups were formed. The length of the silence was such that the pulse of the second group was out of synchronisation with the beat established by the first:

Condition I	300	300	300	silence	325	325	325
Condition II	300	300	300	silence	325	300	300
Condition III	300	300	300	silence	325	275	300

(All times in ms. The length of the silence was either 540 or 660 ms.)

Keele et al. hypothesised that the greater the number of intervals present that differed from the memorised interval, the easier it would be to detect changes. With this theory Condition I should be the easiest to detect, and they reported that it was.

They went on to suggest that if the first four initial tones set up a constant beat, as would be the case if a clock-counter were used, then the use of silences of different lengths would affect error perception. For Condition I with a silence of 540 ms, the first tone of the next group would be 60 ms early, the second 35 ms early, the third 10 ms early, and the final tone 15 ms late. Again for Condition I, but this time with a silence of 660 ms, the first tone would be 60 ms late, the second 85 ms, the third 110 ms, and the final 135 ms. Therefore, because the tones after a 660 ms silence were further away from the established beat, the differences should be easier to recognise than after 540 ms silence. This should result in a difference being found between the results obtained from a silence of 540 ms, and those obtained from a silence of 660 ms. However, Keele et al. reported that, although accuracy was less when silence was placed between the two rhythmic groups, there was no significant difference, implying that a clock-counter was not being used.

This idea that a time interval is stored in the memory and then retrieved in order to make comparisons with new intervals was an idea thought of by Schulze (1978). Similarly, Keele et al. did not completely dismiss the idea of the internal clock-counter. They suggested that sometimes the interval timer operated in such a way as to produce a series of regular beats. It would seem that neither Schulze nor Keele et al. were so convinced as to be able to dismiss the other's viewpoint entirely. Keele et al. considered an advantage of the interval timer to be that it can start measuring an interval at any point in time. It does not have to be synchronised to the pulses of an internal clock. Although in terms of general timing ability this may well be an advantage, in music it is surely a disadvantage as it is the supposed regularity of the internal clock (if it exists at all) that enables continuity.

Shaffer (1984) favoured the internal clock in his investigation of the performances of a skilled musician. He analysed the variability in repeated performances of the same phrase by a skilled pianist, and reported that, although there was high variability across performances in the duration of a half bar, there was less variation in the duration of a complete bar. He also investigated performances which contained rubato (the alteration of rhythm values for expressive purposes), and reported that there was always a unit of duration which exhibited only a small variance over multiple performances. Shaffer concluded that this lack of variability over multiple performances of the same piece was the result of a clock controlling some aspect of duration, whether a beat, part or multiple of a beat, or a whole bar. However, whilst he has shown that even in pieces played using rubato there is still a degree of regularity, the assumption that this must therefore be due to the utilisation of an internal clock is a presumptuous one. The pianist, in his experiment, could have produced some kind of 'rhythmic map' of the music that was remembered and reproduced. It may have been a clock mechanism, but it seems equally likely that, as Penhune et al. (1998) suggested, the cerebellum simply provided whatever structure was necessary for the extraction of temporal information. Although it is possible that this structure may be some kind of 'clock', it is not the only possibility. The use of oscillators suggested by researchers such as Collyer and Church (1998), and Crystal (1999); the 'broadcast' theory of timing put forward by Rosenbaum (1998); the connectionist spreading activation models of time (Shapiro, 1999, in Wearden, 2000); are all just as possible. It is tempting for us to always try to explain the workings of our own brain in ways we can easily understand, frequently with reference to external artefacts used by us. As we use clocks in order to measure time, it is convenient to use this mechanism to explain what is happening in our brain. However, we are remiss if we limit our brain to experiences of the structures and mechanisms with which we are familiar.

How long is a piece of time?

The discrepancy between perceived time and actual time has been thoroughly investigated, and it has serious implications for music. For example, on the occasions when a performer perceives the duration of a note to be correct when in fact it was not, the resulting error is extremely difficult to correct because, to the performer, it does not exist. To correct errors can be difficult enough, but the task is impossible until the error is recognised as such.

Recognition of the frailty of time perception is not limited to the research literature. We have phrases in everyday speech which acknowledge the tenuous link between actual time passing and the perception of time passing: 'a watched kettle never boils', and 'how time flies when you're having fun', are but two. We are all aware of this phenomenon in our everyday life. We know that 5 minutes spent waiting for a train which is already late will appear to be much longer than 5 minutes spent watching our favourite television programme. Mattes and Ulrich (1998) attempted to explain this phenomenon using the model of the internal clock. They assumed that the clock collects pulses that occur during an event, with the pulses then being counted. This collection needs all, or almost all, of an individual's attentional resources. If it cannot be given sufficient attention, as when watching a television programme for example, then some of the pulses are simply missed out, and therefore not counted. The less attention given to the collection of pulses then the more are missed out, and so the shorter the duration of the episode is perceived to be. This description is very appealing and provides an intuitively acceptable explanation of our everyday experiences of time. However, it could be argued that this phenomenon should not account for any variation in music timing, because when playing a rhythm we are, by the very nature of the task, concentrating on the temporal aspect; no pulses should be missed.

Unfortunately, rhythmic tasks are not the only ones facing an instrumental player. The actual notes to be played must be read and found, and the difficulties of the instrument coped with. Various researchers (Macar, Grondin, & Casini, 1994; Thomas & Cantor, 1978) have reported that time perception is more fragile than other perception tasks. In an experiment investigating the effect of asking participants to divide their attention between a timing and a non-timing task Macar et al. reported that the non-timing task was quite resilient to being allocated less attentional resources. The timing task began to suffer however, if even a small amount of attention was diverted from it.

So does that mean that if it is purely a rhythm that has to be played there will be no problems? Unfortunately not. There are many examples of such problems in the literature. Brown and Hitchcock (1965) asked participants to reproduce intervals ranging from 1 to 17 seconds. Their reproductions either consisted of two tones of alternating frequency and intensity, or one constant tone. The results reported that the duration of the interval was longer (by between 10% and 30%) with two alternating tones than it was with one constant tone. In music this cannot be allowed to happen. Two crotchets for example, must occupy the same amount of time as one minim. Craig (1973) asked subjects to arrange two identical stimuli (duration between 100 and 1,200 ms) so that the gap between them was the same duration as the length of the stimulus. He reported that when silence was used to separate the two stimuli the gap was too long, but when it was filled by white noise it was not. Again, this must not happen in music. A semibreve of silence for example, must be the same duration as a semibreve of sound.

Pokorny (1985) investigated the effect of adding extra auditory events whilst participants tapped a constant pulse. During some of the responses the interval between their taps contained tones of varying duration, volume, and pitch. The presence of these tones interfered with the participants' tapping ability, regardless of whether they were asked to actively listen to them or not. Music inevitably contains notes longer than the pulse being counted, and others that are placed in-between the pulse points. According to Pokorny the physical presence of the other sounds will in itself cause error.

The accurate playing of music requires an addition to the timing task not frequently found in the literature: for accurate playing, time estimation of a rhythm must be *prospective.* The player must know how long a note will last before it is actually played, so that the next one can be begun at the correct time. Of course it could be argued that the following note can merely be played when a sufficient amount of time has elapsed, but that is only possible if the two notes are in close physical proximity and the rhythm itself is very simple. In practice the physical requirements of moving from one note to the next, together with rhythmic complexity, means that such a strategy will not work, and prospective strategies must be adopted.

Fortin, Rousseau, Bourque, and Kirouac (1993) distinguished two kinds of interruption to the timekeeping process, and this distinction has musical implications. When the duration of the interval was outside the control of the participant then the addition of a second non-temporal task resulted in the time interval being perceived as shorter than it actually was. This is in line with Macar's conclusion that the timekeeping mechanism 'misses some beats'. However, when the participant had to actually produce the required interval, and was therefore in control of it, interruption by a concurrent task had the effect of increasing the duration of the interval. Fortin et al. (1993) suggested that the duration to be produced is placed in long-term memory, and the time-keeping mechanism starts to count this interval from its onset, signalling for production to stop once the required duration has been reached. If the mechanism is distracted by another task then it misses some counts with the result that the actual duration is longer. This argument is very persuasive and it is easy to see how it could be applied to the production of musical rhythms. The long-term memory would hold the actual pulse of the piece of music (a crotchet at mm 60 for example), and also that a minim is 2 counts, a semibreve 4 etc.. The task of short-term memory would then be to hold the durations of the actual notes of the phrase being played, so that each note followed on at the correct time. However, both the long and short-term memories also have to deal with finding the notes on the instrument. If the short-term memory is distracted from its timing task by having to perform another task, then the resulting error would be that the note is too long. Of course some division of attentional resources is possible, but once the system is overloaded it will have to choose between getting either 'the right note at the wrong time', or 'the wrong note at the right time'. As already discussed, various researchers (see Macar et al., 1994; Thomas & Cantor, 1978; for example), have reported that the timing part of the operation is more prone to error during this procedure, resulting in the 'right note at the wrong time' being the most usual result of such a conflict. Again this is in keeping with the experience of instrumental teachers who know that in a difficult passage the accuracy of the timing is more likely to suffer than the accuracy of the notes. They also know that pupils can find it difficult if they are told to 'get the wrong note at the right time', if necessary.

Children

All the research so far investigated in this chapter has dealt with the performance of adults. Our everyday experience of time and very young children may lead us to believe that they have absolutely no idea what it is, a view that is somewhat supported by the relevant literature. Piaget (1946/1969, in Block, Zakay, Hancock, 1999) in his investigations with young children concluded that they could not reliably estimate duration and understand the concept of time until around the age of eight. In one experiment children saw two cars travelling along two parallel tracks. Both cars started at the same point at the same time, and travelled for the same length of time, but because one car was moving faster it travelled further. Young children were invariably reported to state that the car that travelled further had travelled for a longer length of time; more distance meant more time. Other researchers have reported similar results in other areas suggesting that young children do indeed misinterpret 'more' of something to be 'more time'. For example, Levin and Gilat (1983) asked young children which of two bulbs was lit for the longer length of time. The bulbs were lit for the same duration but the children were reported to state that the bigger or brighter bulb had been lit for longer. Even by the age of 4 to 5 this error was reported as occurring very frequently, although rarely by age 5 - 6.

More recently Droit-Volet (1998) investigated the effect of instructing 3- and 5½-year-olds to press a button 'harder' or 'longer'. When told to press 'harder' the 3-year-olds, but not the 5½-year-olds, were reported to press for a longer duration. She concluded, in keeping with the results reported by Levin and Gilat above, that the ability to dissociate force from duration emerged between the ages of 3 and 5½. Likewise, Macar (1988), in her investigations with 3- , 4- , and 5-year-olds, reported timing accuracy to improve with age.

Subsequently, Droit-Volet (1999) compared 3- and 5½-year-olds' ability to reproduce a target time of 5 secs. For the purposes of her study durations between 4 and 6 seconds were considered accurate. She reported that the 5½-year-olds were able to reliably carry out the activity 50% of the time, and the 3-year-olds only 20% of the time. Improvement did take place over the course of the 30 trials however, with both the 5½-year-olds and 3-year-olds significantly improving their accuracy. It appears that, like the adults in Kristofferson's (1980) study, children's accuracy also improves with practice.

In work with adults, Wearden (1991) concluded that, for intervals of 5 seconds, counting humans were more accurate than non-counting. Is the same true for children? Although Droit (1994) did not train very young children to count in order to increase their accuracy, she did investigate whether using a visual external clock would enable 3-year-olds to accurately judge an interval of 5 secs. In one condition, (Differential Reinforcement of Response Duration, DRRD) the children were required to hold a button down for at least 5 secs, at the end of which time they were rewarded by being shown slides, to a musical accompaniment, of animals, toys, or a circus. In the other condition (Delayed Reinforcement of Low-Rate, DRL) they had to wait until an interval of at least 5 secs had elapsed following the presentation of the slides, and if they did so they were shown more slides. The children in both groups received eight sessions. In sessions one to four an external clock, in the form of a series of lights that illuminated in sequence, was present, but it was removed in sessions five to eight. There were two control groups, one for each condition, who were not exposed to the external clock. The results reported that the scores of the children in both experimental groups dropped when the lights were removed in session five. However, accuracy improved again, and by session eight 63% of the continuous button press responses (DRRD group) were reported to be accurate, compared with 40% of the delayed responses (DRL group, difference reported as not significant). Scores of the DRRD control group, who were not exposed to the external clock, were reported to be significantly lower with only 4% responding accurately by session five. Furthermore the children in the DRRD control group were reported to lose interest, and refused to take part in further sessions after session five. Scores of the DRL control group were lower by session eight, but not significantly so, with 24% responding accurately.

Because the lights illuminated in a predictable way, and the completion of a row signalled the end of the 5 sec period, it seems possible that the children, in the first four sessions, simply waited until the last light was illuminated before responding. Perhaps initially they did, but even though performance accuracy dropped in session five when the lights were removed, it recovered again, suggesting that the children were actually doing more than that. Droit conjectured that the external clock might have served two purposes: it may have been a source of motivation, and it may also have provided a means by which the children were able to accurately judge time. The results of this study are encouraging as they show some 3-year-olds to be capable of quite complex timing behaviour. The failure, due to lack of interest, of the DRRD control group does stress the need for the tasks to be presented in an appropriate way.

The results reported above are not overly encouraging regarding 3 – 4-year-olds' likely rhythm performance ability. They suggest that when instructed to make a note 'longer' there will be a tendency to actually make the note 'louder' rather than longer. There is also a suggestion that only a small percentage of children of that age are capable of accurate timing judgements. Even when allowed a 20% margin of error only 63% of the 3-year-olds in Droit's study (1994) were able to judge a filled interval, and a mere 40% an empty time interval. However, the interval used in this study was, in musical terms, very long. Five seconds is much longer than musical durations that children of that age encounter. It therefore does not follow that because the 3-year-olds could not manage that task they will be unable to perform rhythms. It would be interesting to replicate this study using much shorter durations, similar to those found in music, in order to investigate whether the performance of the children improved.

These studies also indicate how important it is to develop methodologies appropriate for use with very young children. The children must be made aware of exactly what is meant by 'longer' and 'shorter', and if that is beyond their capabilities then verbal descriptions avoided completely. Care must also be taken to ensure that the activities are sufficiently interesting to sustain the children's interest; 'don't want to do it' is not the same as 'can't do it'. In the experimental situation though, both would give the same result.

Although the timing literature as a whole is considerable, only a very small proportion of it is concerned with children. Because of this comparative lack of research in the area the true abilities of young children are an unknown quantity. As will now be seen, even in developmental research children under five are often excluded.

Block, Zakay, and Hancock (1999) in their meta-analytic review of the literature concerning developmental changes in timing specifically excluded children under 7 years of age. Their reasons for doing so were:

> "We did not want to distort the analyses by including highly variable data from very young children, many of whom do not yet grasp the concept of duration or know how to translate between subjective and objective duration units."
>
> *Developmental Review (1999),* 19, page 189

Although the authors' desire for accurate analysis is to be commended, it is difficult to accept that they have indeed reviewed developmental changes in timing behaviour when such a large part of the population is excluded. Major, complex, changes occur between birth and the age of 7 and these must be considered.

In a comparison of timing behaviour across the 5 – 99-year-old age group [5-year-olds, 8-year-olds, 10-year-olds, young (16-25-year-olds), young-old (63-75), and old-old (75-99)], McCormack, Brown, Maylor, Darby, and Green (1999) reported that overall the performance of young children and older adults was less accurate than that of older children and adults. The participants in their study had to perform two tasks: a generalisation task, and a temporal bisection task. Unlike Droit-Volet (1998, 1999) they used time durations that are found in music. For the generalisation task the participants were presented with a tone of duration 500 ms, which was the standard. The non-standard tones presented were between 125 and 875 ms. The participants simply had to say whether a tone they heard was the same as the standard or not. In order to make the task suitable for children a picture of an owl was used to accompany the standard tone during the practice trial, making the experimental response a simple 'owl' or 'not owl' decision. The results indicated that, on the two longest durations, 750 and 875 ms, there was no significant difference between the age groups; the 5-year-olds performed as well as adults. At shorter durations however, although no significant difference was reported between the 5- and 8-year-olds, the accuracy of the 5-year-olds was significantly worse than that of the 10-year-olds and undergraduates.

The second task, the temporal bisection task, involved the presentation of two tones, one 200 ms duration and the other 800 ms. During the training phase the short sound was accompanied by a picture of a small bird, and the long sound a picture of a large bird. During the experimental phase tones of durations 200, 300, 400, 500, 600, 700, and 800 ms were presented and the children had to point to the appropriate picture, indicating whether they thought the sound was 'big' (long), or 'small' (short). The 5-year-old children were reported to perform significantly worse than all the other age groups. They made significantly more 'long' responses to the 200 and 300 ms stimuli (which were short), and significantly fewer 'long' responses to the 800 ms stimulus (which was long).

Taking the results of the two studies together, children would appear to improve their performance between the ages of 5 and 8, and again, to a lesser extent, between the ages of 8 and 10. However, at certain time durations the 5-year-olds performed the temporal generalisation task as well as adults. The implication is therefore that some ability is in place at the age of 5, but also that it needs to be further refined before it reaches a mature level of performance at age 10.

Conclusions

So what conclusions can be drawn from the timing literature that may facilitate the understanding of rhythm performance? The first conclusion is that the literature does provide experimental evidence in accordance with the everyday experiences of instrumental players and teachers. It also suggests reasons for many of the common errors in rhythm performance, thereby suggesting likely profitable lines of research to pursue in looking for ways to overcome them. The answer to the original question of whether human timing ability exceeds the requirements of music is double sided: 'yes' - the accuracy of human timing ability exceeds the requirements of music, but 'no' - the reliability of the human timing process is far less than the requirements of music. The answer to whether the emphasis placed on counting it justified is an unsatisfactory 'don't know'; there is no consensus in the literature on that issue.

Specific issues

Accuracy

A significant fact that emerges many times in the literature is that our timing capability, both in terms of perceiving slight differences between two intervals, and in accurately reproducing intervals of a set length, actually exceeds the requirements of rhythm performance. There is a consensus that a 5% difference in time duration will be easily noticeable (Schulze, 1978, for instance, used a difference of only 3.3%), and that durations as long as 30 seconds can be reliably estimated. Music does not require these extreme parameters. As will be discussed in Chapter Three, mistakes in duration discrimination are only normally noticeable at or above the 10%-12% level, which is far greater than can actually be detected. Likewise, the longest duration likely to be found in a piece of music is a semibreve at a crotchet pulse of mm 40, a mere 6 seconds, which is much shorter than can actually be estimated. We can therefore conclude that humans are capable both of more difficult duration discrimination than required by music, and, of accurately estimating longer time intervals than required by music.

Reliability

The lack of reliability of the human timing process emerges as a root cause of many of the difficulties experienced in rhythm performance, and can be summarised in the sentence 'Life is not a timing experiment'. The research has indeed shown that humans are capable of extremely precise timing behaviour, but it has also shown that this behaviour will only be demonstrable under ideal conditions, and those conditions are simply not found in music, or indeed many places outside a laboratory setting. Accurate timing is an extremely fragile thing, very prone to disruption and distraction. Many researchers have reported results indicating that the natural human response is to *not* do what is essential for accurate rhythm reading and performance.

Counting

The use of a counting strategy is supported by some of the timing research, which concluded that timing is processed by an internal clock-counter mechanism (see Schulze 1978, for example). However there is far too much disagreement in the area to be able to state with any certainty that this conclusion is the definitive one. This disagreement is evidenced by Keele et al. (1989) who replicated Schulze's experiment, and arrived at a different conclusion. Some studies have reported that counting increases accuracy (see Wearden, 1991, for example), but also that the shorter the interval the less the increase in accuracy, to the extent that, for the majority of time durations found in music, there may be no increase in accuracy at all. The tactic of counting bar by bar has also been questioned, both by music research (Byo, 1992) and the timing research. The timing literature reports research which suggests that counting bar by bar may result in the bar becoming the target time, and therefore 'the task' (Roberts, 1981). In turn that may result in a pause between the end of one bar and the start of the next, as one task is completed and the next begun. Obviously, such a break in continuity is perceived to be an error by the listener, and must be prevented from happening. On the issue of counting no conclusions can therefore be drawn from the research. For some people utilising a clock-counter will be a successful strategy, and perhaps it is ultimately the most efficient strategy, but as an initial learning tool, it could be unsuitable.

Children

It seems likely that young children will experience the same problems in rhythm performance as older children and adults, but experience them to a greater degree. Droit-Volet (1999) reported 3-year-olds to perform less well than the 5½-year-olds. In turn McCormack et al. (1999) reported 5-year-olds to perform less well than older children. By the age of 10 children were reported to perform as well as adults. The unsurprising conclusion that timing ability develops from the ages of 3 to 10 years can therefore be drawn. The precise capabilities of 3- and 4-year-olds are an unknown quantity however as the small durations found in music have seemingly not been investigated with that age group. The question of whether the timing ability of 3- and 4-year-olds is sufficient for simple rhythm performance has not been answered in the literature.

In summary, accurate rhythm performance from written notation involves so much that is contrary to the very essence of human timing that it is not surprising it causes problems. A greater understanding of the causes of the problems should result in better solutions being found. The particular issues to be addressed in the following three chapters are those connected with the fragility of the system, and the effectiveness of counting. These issues will therefore be taken into consideration when choosing methods to use with the children. A logical starting point is to use a method similar to existing methods, but taking into consideration the age of the children. Subsequent methods will attempt to make the timing process more resilient, and investigate the efficacy of using counting strategies in the early stages.

Chapter Three

An initial investigation into pre-school children's performance from conventional rhythm notation[1]

The previous chapter explored the 'non-music' timing literature in order to identify potential causes of the acknowledged difficulty in accurate and reliable rhythm performance. In the first part of this chapter I shall consider the music based research literature, before going on to present a study which investigated pre-school children's ability to perform accurately from conventional rhythm notation.

Researchers have investigated the effectiveness of different strategies for teaching rhythm reading to school aged children, university students, and adults, without any one strategy emerging as the most efficient. As previously mentioned (Chapter Two), in Britain counting remains the usual means through which rhythm notation is taught. Researchers have questioned whether it actually is the most effective means, particularly when compared to syllabic methods. In a comparison of a traditional counting method versus a method based on speech cues and kinaesthetic movements, Bebau (1982) reported that the speech cue/kinaesthetic method resulted in significantly more accurate performances of simple rhythmic phrases. She conducted two experiments, both using the same experimental procedure. The children were given a pre-test, 18 lessons as a class, followed by post-test. In both studies the 8 – 9-year-olds in the experimental groups were taught using a combination of words and physical arm actions. The number of syllables and number of arm movements matched the length of the note, in terms of crotchets. For example, a semibreve

[1] As in the previous chapter the term *rhythm performance* will be used to describe performance from conventional rhythmic notation. When other kinds of performance are described they will be specifically described as such.

was called a 'watermelon'; therefore 4 syllables. The kinaesthetic element consisted of the hands being held together in front of the body, (in a prayer-like manner) and then moving upwards and apart to three further positions before finishing at either side of the body at waist height. The control group was taught using conventional counting methods. Bebau's results were inconclusive as, in the first of the two experiments, the difference in post-test scores between the control and the experimental group was significant, but in the second experiment the difference in scores achieved by the experimental and control groups was not. All groups significantly improved their scores from pre-test to post-test.

Colley (1987) compared the effectiveness of three syllabic (with no kinaesthetic element) methods of rhythm reading instruction: i) a method based on words: 2 quavers represented by 'Kansas', 4 semiquavers 'Mississippi', etc.; ii) a procedure based on the Kodály method: 2 quavers represented by 'Ti Ti', 4 semiquavers 'Ti Ri Ti Ri, etc.; and iii) the Gordon method: 2 quavers represented by 'Du de', 4 semiquavers 'Duta Deta', etc.. The children were aged 7 - 9 and received a pre-test, 11 weeks of class instruction, and post-test. She reported that, compared to the other 2 groups, performance was significantly more accurate in the group taught by the word method. No significant difference was reported between the Kodály and Gordon groups. However, as she herself noted, as they become more complex rhythms do not simply consist of the simple 2 quaver type patterns, and there is no evidence indicating how successful beginners are at transferring skills to longer, more complex, rhythmic patterns.

Pierce (1992) compared 4 different strategies of teaching a rhythm pattern to 10 – 13-year-olds: clapping, counting, sizzling (hissing between the teeth), and clapping and counting combined. The participants were divided into 4 groups, one for each of the teaching strategies, and were taught a rhythm pattern. Following a period of instruction this pattern was incorporated into a test melody which the children were asked to play. The results indicated that there was no significant difference in performance accuracy between the 4 learning procedures. He did, however, report significantly less accuracy if the tempo of the training rhythm did not match that of the test melody.

Ways of facilitating rhythm reading by making the rhythms visually more appealing have also been investigated. Rogers (1996) investigated the effect of using coloured notation on rhythmic accuracy. He compared two groups of beginning instrumentalists aged 7 – 8 years, one taught using rhythms notated in colour, the other taught using conventional black and white notation. He reported that the colour group gained significantly higher test scores than the black and white group when reading coloured notation, but not when reading conventional notation. Additionally, he observed that both groups expressed a preference for reading the colour notation.

Most of the relevant published research deals with school age children, or university students and adults, not pre-school children. However researchers have compared some aspects of young children's rhythmic ability to that of older children. For example, Drake (1993) investigated the reproduction (copying) of rhythms in 4 groups: 5-year-old children, 7-year-old children, non-trained adults, and musically trained adults. The children attended a school where music was taught through singing and the playing of simple instruments. The complexity of the rhythms varied from simple ones such as ♫ ♫ ♩ ♩, to more complicated examples such as ♩. ♪ ♪♩ ♪ 𝅗𝅥 . The participants heard the rhythms played on a synthesized bass drum, and had to copy them using a stick and drum. In the analyses the rhythms were grouped according to their complexity, and, when the accuracy of the reproductions was compared across groups, trained adult musicians were, not surprisingly, the most accurate. Although, when all rhythms were taken into consideration, the 5-year-olds were not as accurate as the 7-year-olds, for the simplest rhythms the differences were only slight: 82% accurate as opposed to 90% accurate. Interestingly, there was no significant difference reported between the accuracy of the 7-year-olds and the non-trained adults. This conclusion that, without specific training, there is no improvement in the ability to remember and reproduce rhythms beyond the age of 7 is counter-intuitive. Improvement from the age of 7 to adulthood would logically be expected. In Chapter One evidence was presented in support of the idea that experiences in the early years (up to age 6) are of paramount importance in learning any language, and that music is another language. These results provide further evidence to support that view. They also support the notion that, while basic music skills can be acquired simply by exposure to music, acquiring a more sophisticated ability has to be specifically developed; it will not happen purely as a result of maturation. Without musical training the performance of adults was no better than that of 7-year-olds. The non-trained adults would have been exposed to music during the intervening period, but would not have received the training necessary to cope with complicated rhythmic patterns.

Davidson and Colley (1987) investigated children's rhythmic development between the ages of 5 and 7, and concluded that 5-year-olds were better able to remember and reproduce rhythms that were accompanied by text. The text used was the words to familiar nursery rhymes, and novel songs with meaningful words. They reported that by the age of 7 this effect had diminished and the children were able to separate the rhythm from the text. In addition Davidson and Colley investigated whether the children could notate the rhythm in a meaningful way. After copying the rhythm the children were asked to write it down in any way that seemed appropriate to them, with the explanation 'so you can play it again next week' given. They were subsequently asked to play their notations, with the order of the phrases altered to exclude the possibility of the children simply remembering them. The idea of notating the pulse did not occur to either the 5- or 6-year-olds, but it did to the 7-year-olds. Davidson and Colley concluded that between the ages of 6 and 7 children realise the importance of pulse, and use it as a means of structuring rhythms. However between 10% and 40% of the 5-year-olds could still accurately play from their own notation, even though they had not used a pulse, suggesting that some children were able to effectively use alternative strategies.

A great deal of the timing literature explores the nature and properties of the internal clock. As previously discussed (Chapter Two), it is not the only likely timing mechanism, but it is one to be seriously considered. Drake and Gérard (1989) investigated, with 5- and 7-year-olds, the use of the internal clock in the form of a 'pulse train'. They used the term 'pulse train' to describe a series of pulses created by the internal clock on listening to a piece of music. Their aim was to ascertain whether young children used a pulse train in order to structure rhythms. In their study the test rhythms were divided into different groups: in the first group were simple rhythms where all taps either coincided with the beat, or were in a ratio of ½ or double it; in the second were complex rhythms where some beats were silent, some taps did not coincide with the beat, and ratios of ½, 1½, or 2 were also included as if dotted notes were being used; the third group of rhythms were described as arrhythmic, and were designed so that there was no obvious regular pulse. The predictions were that the simple rhythms would be better reproduced than the more complex ones, and that the older children would be better able to cope with the more complex rhythms than would the younger. Drake and Gérard reported that the 5-year-olds did indeed reproduce the simplest rhythms more accurately than the complex ones, and that improvement with age was greatest on the simplest rhythms.

However the 5-year-olds also reproduced the arrhythmic rhythms as well as, if not slightly better, than the complex rhythms. One problem in assessing the results reported by Drake and Gérard is that they allowed a very large margin for error, +/- 25%, when assessing accuracy. It is possible that such a large margin for error actually allowed the arrhythmic rhythms to be moved onto a pulse and still be classed as correct. Drake and Gérard thought of this possibility and analysed the error to establish whether the children did attempt to alter the rhythms in that way. This was reported to be the case, especially with the younger children. Drake and Gérard concluded that the children were attempting to make the rhythms fit a pulse train.

Drake and Gérard further explored the use of a pulse train by investigating the effect of varying the phrase length. They conjectured that, if a pulse train were being used, a greater number of pulses would make the rhythm more difficult to remember, whereas increasing the number of taps within a pulse should have no effect. (The drain on the memory resources being caused by the number of pulses, rather than the number of actual notes.) For example, if the initial rhythm ♩ ♩ ♩ ♩ is taken, then increasing the number of notes to ♩ ♫ 𝅘𝅥𝅯𝅘𝅥𝅯𝅘𝅥𝅯𝅘𝅥𝅯 ♩ will not increase the difficulty of remembering the phrase; there are still 4 crotchet beats. However altering the phrase to ♩ ♩ ♩ ♫ ♩ ♩ would make it more difficult to remember as there would then be 6 crotchet pulses. Drake and Gérard reported that with the simple and complex rhythms the number of taps within a pulse did indeed make no difference to accuracy, implying that the music was being remembered 'beat by beat', rather than 'note by note'. Their conclusion was that, by the age of 5, the use of a pulse train was very much in place, and that children structured rhythms by reference to it. This is in contrast with the findings of Davidson and Colley (1987) who reported that children were unable to utilise a pulse until age 7. However, in Davidson and Colley's study the children were asked to write down the rhythm, which is obviously a more difficult task, and the more simple use of pulse involved in merely copying a rhythm would be expected to be in place first.

The use of a large margin of error (+/-25%) caused misleading results in one part of Drake and Gérard's study. The issue of how inaccurate a rhythm has to be before it is classed as 'wrong' is one that has to be faced by researchers when investigating rhythmic responses. Unlike pitch, where on most instruments a note is either 'right' or 'wrong', rhythm has degrees of being 'right' or 'wrong'. No rhythm needs to be performed with 100% accuracy in order to be judged 'right', but the issue to be addressed is how far from 100% it has to move before it is classed as 'wrong'. Results reported in the timing literature (see for instance Kristofferson, 1980; Schulze, 1978; Thompson, Shiffman, & Bobko, 1976) suggest that a variability of 5% is readily discernible by a listener, but that is in experimental conditions. The acceptable variability in music would be expected to be greater, as rhythm is not the sole focus of attention. As long ago as 1911 Wallin investigated the question of how much error there can be before a rhythm is perceived as being wrong. He compared error in speech rhythm to error in music rhythm and reported that, for speech, the acceptable range was 7% to 15%, and for music 6.36% to 17.8%. He further subdivided the error into different grades, reflecting how the error affected the quality of the performance. Wallin concluded that, with an error of 6.36%, a performance would be judged 'excellent', with 8.53% 'good', with 12% 'medium' or 'fairly good', with 14.5% 'poor', and with 17.8% 'disrupted'. In her investigation of rhythmic reproduction Drake (1993) allowed an error of 10% to be acceptable. In the study reported in this chapter it was decided to allow an error of 12%. This is close to the 10% used by Drake, and in accordance with the 'fairly good' category of Wallin. Unfortunately most researchers do not actually state the percentage error they have allowed, presumably using the subjective judgement of the tester to score the performance.

In the previous chapter the extensive research literature on timing was investigated in order to better understand human timing capabilities. From the literature various predictions about the errors likely to occur in rhythm performance can be made, and the following sections consider these errors in more detail.

The reliability of the timing process

The previous chapter concluded that, while humans are capable of extremely accurate timing performance, the lack of reliability of the processes involved means that this accurate performance will, without training, only be found in a laboratory situation. In particular it was found that the timing mechanism is easily distracted from its task, with resulting error. It was expected that the error found in the children's performances would therefore not be that of variability caused by failing to maintain a constant value, as in a stream of crotchets for example, but would be error caused by interruptions to the time-keeping process. Rhythms containing only one note value were expected to be played more accurately as there is a minimum of disruption to the time-keeping process. As more note values are added, with more frequent changes from one value to another, the greater the disruption and complexity, and therefore the greater the number of errors. For example, in a rhythm such as ♩ ♩ ♩ ♩ there is little, if any, disruption to the timing process as all the notes are of equal value. However, in a rhythm such as ♩ ♩ 𝅗𝅥 ♫ 𝅝 the timing process is 'interrupted' three times as the note values change.

Long notes

It was anticipated that there would be two different kinds of errors associated with the long notes, particularly semibreves: one caused by difficulties in perception, and the other by interruptions to the time-keeping process.

Brown and Hitchcock (1965) reported the same target time shorter if represented by a single tone compared with two alternating tones. It was therefore predicted that 2 crotchets would occupy a greater time interval than a minim, and, more particularly, that 4 crotchets would occupy a greater time interval than a semibreve.

If a long note is at the start of a phrase, or followed by something which needs thinking about, then, according to Fortin, Rousseau, Bourque, and Kirouac (1993) there is likely to be an interruption to the timing process, which will result in the note being too long. On the other hand, if a long note is at the end of the phrase and therefore only followed by the final crotchet, it would be expected to be correct, or too short, in line with Brown and Hitchcock (1965).

Tempo

Getty (1976) reported the most accurate and preferred rate of counting to be in the range of mm 100 - 133. Fetterman and Killeen (1990), in an experiment where adult participants were asked to chose their own tapping speed as an aid to reproducing a fixed time interval, reported a very wide range of preferred speeds: mm 48 to mm 360. However, although there was a wide range of preferred speeds across individuals, there was not for each individual, who tapped close to their preferred speed regardless of the length of interval to be estimated. Conversely, Fraisse (1982) summarised the literature on spontaneous and preferred tempo and concluded that a speed of mm 100 was the most quoted figure, with a range of mm 83 to mm 120.

This difference in speeds could be a result of Fetterman and Killeen asking participants to use tapping in order to estimate a given time interval. In most of the literature the preferred tapping speed is simply that with which the participant feels most comfortable. Fraisse also acknowledged that there were differences between individuals, but not within individuals.

It was therefore predicted that although a range of speeds was likely to be chosen by the children, each child would perform at, or close to, their preferred tempo. It will be interesting to see whether their speeds lie within the mm 80 -133 range, or whether the children in this study, like the participants in Fetterman and Killeen's study, will exhibit a much wider range of preferred speeds.

The effect of experience

Kristofferson (1980) reported the adult participants in his study to improve much more over the first 10 of the 20 sessions than the final 10. The children in the study reported in this chapter were expected to display a similar pattern. It was anticipated that they would improve up to a certain performance level, but show little or no improvement subsequently. It was, however, recognised that 20 sessions may not allow sufficient time for this effect to be reliably demonstrated.

Methodological issues

Much of the published research (see Bebau, 1982; and Colley, 1987, for example) suggests that syllabic methods may be superior to the traditional counting method. However, Wearden (1991) reported counting to be an aid to accuracy, with counting humans being more accurate than non-counting humans, and in Britain rhythm reading has traditionally been taught in that manner for many years. In this study the ability of the children to count reliably up to 4 was known to be securely in place, whereas their syllabic skills were unknown, and could therefore potentially have confounded the results. It was decided to use a simple counting method for this initial investigation, as the aim of the study was to gain an answer to the question 'Can pre-school children perform accurately from conventional rhythm notation?' If the answer was 'no' then it would be in order to investigate other methods in greater detail, and if the answer was 'yes' then ways forward based on the finding of the literature, along with the children's performances here could be investigated.

Given the age of the children it was decided to count each note individually, rather than cumulatively. A crotchet was therefore 'one', a minim 'one two', a semibreve 'one two three four', and 2 quavers 'one-a'.

Another potential problem was that the actual motor skills needed for rhythm are not insignificant. Research investigating very young children's aural rhythmic skills had reported that sometimes it was not that the children could not mentally remember the rhythm they were being asked to copy, but that they could not physically reproduce it. This was particularly the case when they were asked to clap a response. Although clapping may be thought of as a straightforward task, and it is certainly one which young children enjoy, it is perhaps too difficult to enable them to concentrate concurrently on another task. Frega (1979) investigated the rhythmic development of 3- and 5-year-olds and reported that, in rhythm copying tests, the 3-year-olds found chanting the easiest followed by the use of speech patterns. Clapping was actually the most difficult means of rhythm production. It was therefore decided that the most straightforward physical action would simply be for the children to hit the table in front of them, again something that young children enjoy!

Byo (1992) questioned whether bar lines are an aid to accuracy. He compared performances of 2 groups of musically experienced students, one group performing from music with bar lines, and the other from music without bar lines. He reported no significant difference between the two groups. Furthermore he went on to suggest that bar lines may actually be a hindrance for beginners, a suggestion reinforced by the timing literature (see Chapter Two, p18). It was therefore decided to omit bar lines, as at best they would not make the task any easier, and could potentially make it more difficult.

Although Rogers (1996) reported that children prefer, and perform better from, coloured notation it was decided to use conventional black and white notation for the test material, and most of the teaching material. Again this was to avoid confounding the issue by introducing a variable of unknown effect.

The notes, in keeping with the order commonly used in children's piano tutor books were introduced in the order of crotchet, minim, semibreve, and quaver. In view of the very young age of the children, it was decided to omit dotted notes completely.

Summary

As a result of the investigation of both the timing and the music literature the following decisions as to protocol were made:

i) To make the physical performance of the rhythms as straightforward as possible the children were simply required to hit the table at which they were seated.

ii) A margin of error of +/- 12% in performance accuracy was allowed when marking the performances.

iii) A teaching method based on traditional counting methods was used. This was simplified by counting each note individually.

iv) Bar lines were omitted completely.

v) All the test material used conventional black and white notation. An element of colour was introduced in some of the teaching material.

Methodology

Participants

Ten children, 5 boys and 5 girls, all of whom attended a day nursery, took part in the study. The age range of the children at the start was 39.5 months to 50.5 months, (mean 45.65 months). The children were chosen for their age, sex and availability. Written consent was obtained from the parents, and it was verbally established that none of the children taking part was receiving private music tuition.

Resources

Teaching Materials

i) *Note Cards.* These cards were 14.5 cm high by 10 cm wide, a single note written on each card. There were 12 cards, three for each note value. (See Appendix A for an example of a card).

ii) *Practice Rhythms.* These rhythms were written in large print on A4 paper, and were of a similar difficulty to the test rhythms.

iii) *Crayons and blank paper.* The children used these to write their own rhythms.

Testing Materials

In the absence of a pre-written test for children of this age, a purpose built measurement instrument was devised. This Rhythm Performance test began with simple crotchet only rhythms and progressed in difficulty through to rhythms utilising four note values: crotchets, minims, semibreves, and quavers. In keeping with test rhythms used elsewhere, a phrase length of between 4 and 8 crotchet beats was chosen. Each rhythm was written in large print on a separate sheet of A4 paper. (See Appendix B for a copy of the test).

Procedure

All the teaching and testing sessions took place in one of the purpose built research rooms in the nursery, and were videotaped.

Teaching Sessions

The teaching sessions began within a few days of the pre-test, and each child received two individual ten-minute sessions per week. A child being absent from the nursery occasionally interrupted the routine, but the total number of sessions was twenty in each case, with no child exceeding an overall time limit of 14 weeks. The aims of the sessions were to encourage the children to learn how to keep a constant steady beat, and to teach them the lengths of the notes. This was achieved through playing various games:

i) *Walking.* The children walked across the room at a steady pace and either tapped their legs at each step, as in 'one, one, one', or every other step, as in the 'one' of 'one two, one two, one two'.

ii) *Echo sessions.* Here the children had to copy whatever I said. For example, if I said 'one, one, one two' they had to repeat it exactly, without any gaps, or slowing down, or speeding up.

iii) *Tapping.* I tapped simple rhythms on the table for the children to copy exactly.

iv) *Metronome.* The metronome was used, either overtly or in the background, to provide a steady pulse.

v) *Cuddly toys.* Sometimes, instead of tapping the table the children were given a teddy or other cuddly toy to use. The toy was then made to dance along the table in the correct rhythm, or dance on a drum, or it was given a 'drumstick' with which to play the drum.

vi) *Rhythm instruments.* Varying the rhythm instrument used introduced variety into the tapping routine. Although the table was used for the tests, during some of the teaching sessions other 'instruments' were used. These were sometimes conventional rhythm instruments such as drums, tambourines etc., but also 'instruments' such as empty egg boxes, and cardboard tubes.

As well as games based on varying the physical action used to produce the rhythm the written musical note was used in games too:

i) *Choose a card.* A simple game was for me to turn the cards face down on the table for the children to choose which one to turn over and play.

ii) *Writing their own rhythms.* The children chose, from the Note Cards, which notes to copy. The resulting rhythms were coloured in, and then played.

iii) *Listening.* Later on in the sessions I recorded the children playing their rhythms, and then let them listen to themselves.

iv) *Is it right or is it wrong.* I put a rhythm on the table in front of the children, tapped it myself, and then asked them if I had played it correctly.

The introduction of new notes followed the same pattern. Initially the new note was presented written on a Note Card; then once a child was confident and generally accurate in tapping rhythms from all the relevant Note Cards, the progression to reading the rhythms from A4 sheets was made. Initially these rhythms only used the new note value plus one other, but gradually increased in complexity until all known notes values were included.

Testing Sessions

The children received the pre-test, 20 ten-minute individual teaching sessions, and then post-test. Intermediate tests (to test for change in performance level) were administered after 7 and 14 sessions. In order check that learning had taken place a re-test was given 7 weeks after the final teaching session. As with the teaching sessions, all testing sessions were videotaped.

The test rhythms were scored from the video recordings using a stopwatch. A mark was given for each correct tap, with the exception of Question 3 and the quaver questions, where ½ a mark was allocated for each correct tap. There were 8 crotchets in Question 3 and to award 1 mark for each of them would have biased the scoring. Similarly, because the quavers appeared in pairs ½ a mark for each individual quaver was considered more appropriate. A margin of error of +/- 12% was allowed. The accuracy of the counting, in terms of applying the correct verbal label to the note, was also recorded, for example correctly saying 'one two' for a minim, or 'one' for a crotchet. Each note correctly labelled in this way was also given a mark, again with the exception of Question 3 and the quaver questions, where ½ a mark was awarded. Two sets of scores were therefore generated, one for the accuracy of the performance, and the other for the accuracy of the verbal labels used in the counting.

The metronome speed the children chose when performing the test rhythms was also noted. The children varied their speed both from one test to another, and also within a test. The speed noted is therefore the one most frequently chosen by each individual child, in each of the test situations.

Pre-test

As I was a familiar figure at the nursery, and leaving the main room to take part in research sessions was a commonplace activity for the children, no introductory activities were thought necessary. For the test children were taken individually into the research room and invited to sit at an ordinary low nursery table. The camera was *in situ* and positioned so that it focused on the tabletop and child. A very brief account is given here. Appendix C contains a detailed transcript of the explanations given to the children

First of all it was explained to the children that I was going to teach them how music is written down, just as *Stella* (one of the nursery staff) was teaching them how words and numbers are written down. The crotchet and minim note cards were then shown to the child and I explained that for each card they had to hit the table once. For the crotchet cards they were to hit the table and say 'one' at the same time, and for minims to say 'one two' and hit the table on 'one'. The names of the notes are used here for convenience. At no point were they used with the children. The children were given a short period of practice to ensure that they had understood, after which the pre-test was administered. If a child seemed reluctant because of the change from cards to paper then it was explained that they were just the same, but written on paper. Each new sheet was introduced with: *'And what about this one?'*, or *'and this one?'*, or *'We've nearly finished now, you're doing so well!'*. Any errors during the test were not corrected. After finishing the final rhythm the child was praised again and taken back to the main nursery.

Intermediate, Post and Re-tests

Intermediate tests were administered after the 7th and 14th teaching sessions. The post-test after the final teaching session, and re-test 7 weeks after the final teaching session. All the testing sessions were administered in the same way and were videotaped. The tests were scored from the recordings. In the interval between the final teaching session and re-test the children received no tuition at all.

For the intermediate, post, and re-tests the child was taken into the usual room and seated at the table. The Note Cards relevant to the notes learned were placed face down on the table and the child invited to turn them over and play them one at a time. Any mistakes at this stage were corrected. Once all the cards had been turned over they were put on the floor out of sight and I said:
'Now I've got some special rhythms for you to-day, and I can't help you with them'.
The test rhythms were then placed on the table in turn, and each one introduced with: *'Can you play this one?'*, or *'What about this one?'*, or *'You're doing really well'*, or *'Only a couple left now'*,or *'Last one!'*. Mistakes made during the test were not corrected, and at the end the child was praised again, and taken back to the main nursery.

Results

By the end of the 7th session 7 out of the 10 children had been introduced to crotchets, minims, and semibreves, and by the end of the 15th session the same 7 children had also been introduced to quavers. By the final session 8 of the 10 children could tap simple rhythms made up of crotchets, minims, semibreves, and quavers; the remaining 2 could tap rhythms made up of crotchets, minims, and semibreves.

The mean test scores and standard deviations are shown in Table 3.1. 'Accuracy of Taps' refers to the scores obtained from marking the actual duration of each note; 'Accuracy of Counting' refers to the scores obtained from marking whether a child applied the correct label to the note (e.g. said 'one two' for a minim), regardless of whether the note was performed correctly.

	Accuracy of Taps		Accuracy of Counting	
	mean (max 37.5)	SD	mean (max 49)	SD)
pre	9.30	2.18	6.1	6.69
post7	15.65	6.85	25.4	13.27
post14	21.85	8.43	36.5	10.52
post	26.20	6.94	41.7	8.63
re	21.75	7.37	35.33	9.94

Table 3.1: Mean scores from pre – re-test for Accuracy of Taps and Accuracy of Counting.

A 2x4 (sex by test) repeated measures ANOVA was employed to examine the accuracy of taps scores. The re-test scores were not used in this analysis as, due to leaving the nursery, only 6 children completed the re-test. A significant main effect was found for test [F (3,24) = 39.192; $p<0.001$]. There was no significant test by sex interaction [F (3,24) = 0.210; $p>0.8$], or main effect for sex [F (1,8) = .008; $p>0.9$]. Tukey's HSD test was used as a follow up test and significant differences were found between pre-test and post7 test, and between the post7 and post14 tests ($p<.01$). A significant difference was also found between post14 test and post-test ($p<.05$).

Because no significant effect was found for sex the analysis was repeated without sex as a variable, and similar results obtained. There was again a significant main effect found for test [F (3,27) = 42.964; $p<0.001$], with post hoc tests showing significant differences between all tests.

A paired samples t test was employed to compare post and re-test scores. No significant difference was found ($p>0.6$).

Another 2x4 (sex by test) repeated measures ANOVA was employed to examine the accuracy of counting scores. Again the re-test scores were not included. A significant main effect was found for test [F (3,24) = 56.637; p<0.001]. There was no significant test by sex interaction [F (3,24) = 1.290; p=0.3], and no significant main effect for sex [F (1,8) = 0.000; p>0.9]. Tukey's HSD follow up test revealed significant differences between pre and post7 tests, and between post7 and post14 tests (p<0.01). No significant difference was found between post14 and post test. As no significant effect was found for sex the analysis was repeated without sex as a variable and very similar results were obtained. A significant main effect was again found for test [F (3,27) = 54.868; p<0.001]. Follow up tests again revealed significant differences between all tests (p<0.01) except post14 to post-test. A paired samples t test was again employed to compare post and re-test scores. No significant difference was found (p>0.2).

A graph showing mean test scores at each of the 5 stages is shown in Figure 3.1.

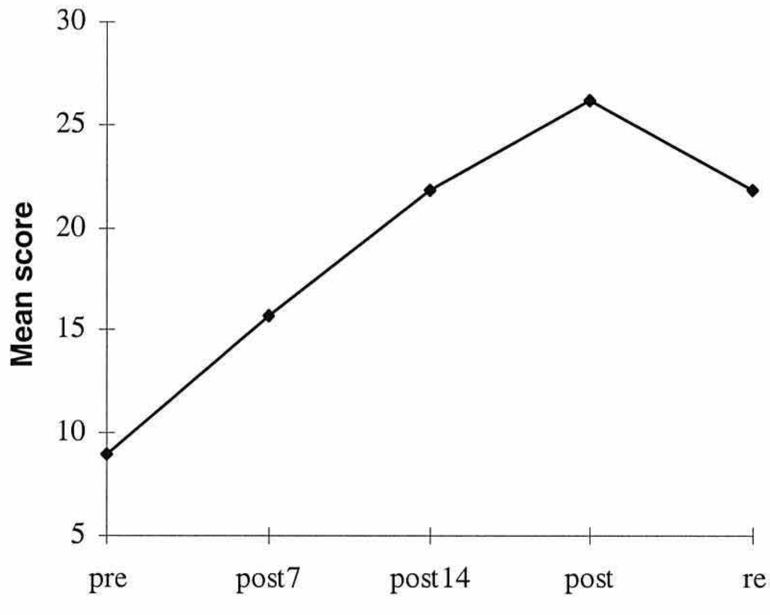


Figure 3.1: Graph of mean test scores for Accuracy of Taps

The post-test was also marked to assess whether the amount of error increased as the complexity of the rhythms increased. For this the test rhythms were divided into 3 groups: those containing only one note value, e.g. all crotchets or all minims; those containing 2 note values, e.g. crotchets and minims, or crotchets and semibreves; and those containing 3 note values, e.g. crotchets, minims, and semibreves, or crotchets, quavers, and minims. For ease of comparison the scores have been converted to a mean percentage score. The results are shown below in Table 3.2.

	mean % score	SD
Tests containing only one note value	86.60	14.8
Tests containing two note values	67.60	21.45
Tests containing three note values	48.70	28.27

Table 3.2: Percentage score (of total possible) according to the number of different note values

child	pre-test	post7	post14	post
1	105	93	100	61
2	80.5	102	106	103
3	64.5	95	92	84
4	100	73	72	84
5	72	89	90	83
6	77	70	89	86
7	80	115	110	124
8	58	164	94	102
9	95	78	55	90
10	100			100

Table 3.3: The children's favoured metronome speed at each test stage.

Table 3.3 above shows the favoured metronome speed of each child at each test stage. One child was so variable during the post7 and post14 tests that it was not possible to identify a favoured speed.

The nature of the errors occurring on the long notes was recorded, and the results shown below in Table 3.4.

child	Q5	Q6		Q8	Q9		Q12	Q13
	minim	1st minim	2nd minim	semi	semi	minim	minim	semi
1	✓	✓	✓	✓	✓	✓	✓	✓
2	X	✓	X	✓	short	✓	X	X
3	✓	✓	✓	✓	✓	✓	✓	short
4	X	X	X	X	✓	long	np	np
5	✓	✓	✓	✓	✓	✓	short	✓
6	X	✓	✓	short	✓	✓	X	X
7	X	✓	✓	X	X	✓	X	✓
8	✓	✓	✓	✓	✓	✓	short	short
9	long	X	✓	X	X	long	np	np
10	✓	X	X	X	X	X	np	np

np is not played. These children either did not learn quavers, or refused to play the questions containing them.
'✓' is correct: the note was performed to its correct duration. (+/- 12%)
'X' is wrong: the note was performed sufficiently inaccurately to become a different note value. For example a minim performed at the length of a semibreve.

Table 3.4: Long note results, indicating the nature and location of errors.

Whether a child consistently kept the same crotchet pulse, or increased speed for those questions that contained no crotchets, was noted. This information was gathered from Questions 4 and 7, as they contained only minims and semibreves respectively. The note was judged to be correct if it was within half a crotchet of the correct length. The results are shown below in Table 3.5. 'Yes' means that the note was performed to its correct duration (+/- 12%), and 'no' means that it was performed incorrectly (by more than +/- 12%). The length of the crotchet pulse was taken, for each child individually, from Questions 1 to 3.

child	question 4 minim=2 x crotchet?	question 7 semi=4 x crotchet?
1	yes	yes
2	yes	no
3	yes	yes
4	no	yes
5	yes	yes
6	yes	yes
7	no	yes
8	yes	yes
9	no	no
10	no	no

Table 3.5: Minims and semibreves as multiples of the crotchet pulse.

Pearson's correlation coefficients were calculated in order to examine possible links within test scores, and between test scores and age.

	pre	post7	post14	post	re
pre	1.000				
post7	.823**	1.000			
post14	.645*	.911**	1.000		
post	.687*	.904**	.862**	1.000	
re	.789	.887*	.855*	.916*	1.000
age	.560	.605	.699*	.616	.203

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Table 3.6: Correlation matrix of age and Accuracy of Taps test scores.

The resulting matrix is shown in Table 3.6. A positive correlation between age and Accuracy of Taps post-test score was found (r=0.616), which approached significance at the 5% level (p=0.056). A significant correlation with age (r=0.699, p<0.03) was found at the post14 test stage. As shown in the table above, there was a significant correlation between all tests, except pre-test and re-test.

A correlation matrix showing age and Accuracy of Counting test scores was also calculated and is shown in Table 3.7. No positive correlation between age and Accuracy of Counting was found at any test point. Significant correlations (p<0.01) were found between post7, post14, and post tests. Significant correlations (p<0.05) were also found between post7 and re-test, and post-test and re-test.

	pre	post7	post14	post	re
pre	1.000				
post7	.232	1.000			
post14	.172	.813**	1.000		
post	.206	.887**	.856**	1.000	
re	-.097	.881*	.616	.819*	1.000
age	.348	.581	.598	.506	.341

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Table 3.7: Correlation matrix of age and Accuracy of Counting test scores.

Discussion

The results indicate that pre-school children are capable of learning to perform simple rhythms from conventional notation. Pre to post-test gains were significant, and, despite having no rhythm reading practice in the intervening period, post to re-test changes were not significantly different, indicating that post-test performance was maintained and learning had taken place. From the analyses of the test scores it is clear that the children improved their performance steadily throughout the teaching period, with significant differences found between pre and post7, between post7 and post14, and between post14 and post-test.

Unsurprisingly, the children were more accurate in learning to label the notes correctly than learning to perform them correctly. Whereas the Accuracy of Taps scores continued to improve up to post-test stage, the Accuracy of Counting scores did not significantly improve subsequent to the post14 test. At that stage some children were scoring 100% or very close to it, indicating that a ceiling had been reached. This is in contrast to the Accuracy of Taps scores where a ceiling was not reached, and the scores were much lower. The discrepancy between the two scores suggests that it is not the actual labelling of notes that is difficult, or remembering which note is which. Rather, the difficulty lies in the problems associated with accuracy of performance. This issue will be returned to later.

Because children of this age are developing so rapidly it had been thought that ability would be linked to age, with older children performing better than younger. However, the results of the correlation analysis are inconclusive. A close to significant positive correlation between age and Accuracy of Taps post-test score was found. However, by re-test stage the correlation was no longer significant. One explanation for this could be that, because they left the nursery, the three eldest children did not take the re-test, thereby distorting the results. Furthermore no significant, or approaching significance, correlation between Accuracy of Counting and age was found. In order to make any firm conclusions concerning age differences, another study, in which none of the children are lost at re-test stage, is necessary.

A significant correlation was found between pre and post-test scores, and also between post7 and post and re-test scores. This suggests that whether a child is ready for, and interested in, rhythm reading is generally apparent early on. The scores at the post7 test stage correlated both with post-test and re-test scores. As this was an experimental situation all children received all 20 sessions. An argument could be put forward that, in a normal teaching situation if a child has not progressed after 7 sessions, the remaining sessions should be delayed.

The children had no problem at all counting the individual notes. They all knew to say 'one' in response to a crotchet, 'one two' to a minim etc., and by the post-test 4 of the children made no errors at all, indicating the knowledge to be securely in place. As the sessions progressed some children preferred to work silently, and not verbally label the notes aloud. This was only a problem in the test situation, when they were encouraged to do so. However, it is recognised that there is no guarantee that the children knew they were counting. They all produced the correct verbal response to the written notes, but they could simply have been applying the appropriate label, with the use of number being purely incidental. If this were the case then their tactic was in line with the findings of Bebau (1982); that using words aids rhythm learning. The words were meaningful, not nonsense syllables, which would, according to Colley (1987), have facilitated the task.

Pierce (1992), in his comparison of 4 different methods of rhythm reading instruction, reported that the only significant factor was that the training rhythms should be the same speed as the test melodies. The children in this study were allowed to choose their own speeds, and to change speed both within a session, and from session to session, if they wished. Each child had a preferred tempo range, and the speed they chose for their test rhythms fell within that range. This resulted in the speed of the test rhythms matching that of the training rhythms. According to Pierce allowing the children this flexibility made their task easier, and so is a good way of minimising the initial difficulties of rhythm. Imposing a specific speed on a child in the early stages is surely an unnecessary escalation of difficulty. Obviously as they become more experienced children will need to be able to play a rhythm at a given speed, but in the early stages there is a very strong argument for not imposing a speed on them.

Rogers (1996) reported that beginning instrumentalists both preferred, and performed better from, coloured notation. Certainly all the children in this study enjoyed colouring in and playing their own rhythms. Rhythm notation is still very much 'black and white' (in the visual sense). With current printing technologies it seems strange that the liking of colour by children has not been taken into consideration and utilised more. There is also an argument for involving children more, by letting them colour in the notes for example. The whole area of the use of colour could profitably be explored further, as, if nothing else, it serves to create interest and reduce boredom.

Davidson and Colley (1987) reported that between 10% and 40% of 5-year-olds could accurately re-play, from their own invented notation, rhythms they had heard. The task of inventing a means of visually representing rhythm is obviously a more difficult one than interpreting an existing system, which explains the much higher success rate of the children in this study. Even at pre-test stage the majority of the children could perform the crotchet and minim rhythms with a degree of accuracy, indicating a readiness for the task.

One purpose of Davidson and Colley's study was to ascertain whether children use pulse as an aid to structuring rhythms. They concluded that, at the age of 5, children did not utilise the pulse, but by the age of 7 they did. This finding was in conflict with that of Drake and Gérard (1989), who concluded that the 5-year-olds in their study had used a pulse train. As the children in the study reported here did not have to invent their own notation they were not able to demonstrate a use of pulse in that respect. But did they use pulse, in the form of a pulse train, in their performances? No conclusions can be drawn, and indeed it was not an aim of this study to formulate any. Nonetheless some interesting observations can be made. If a pulse train was being used then it should have been apparent in Question 3, which contained a sequence of 8 crotchets. It could be argued that the use of a pulse train would result in an accurate performance, whereas not using one would result in an uneven performance, or one which increased in speed or slowed down. Question 2 contained only 4 crotchets, and would therefore be less dependent on it. At post-test stage all the children could manage to accurately perform the 4 crotchets of Question 2, but only 60% could manage the 8 of Question 3. Does that mean that only 60% of the children were using the pulse train? Appealing though that conclusion is there is not enough evidence here to support it. The children could simply have been replicating the same interval, with no actual pulse in their head at all. In addition, some of the children simply misread the question and did not play enough notes, or played too many. Their error was not caused by the time-keeping process.

A case could also be made that the children who were utilising a pulse train would, within any given testing session, keep the same metronome pulse throughout all the test phrases. Only one child did achieve that, and kept the same strict metronome speed throughout the post-test. However, because the test phrases were all separated from each other, and written on separate sheets, then it seems reasonable for a child to choose a different pulse for each phrase if they so wished. The majority of children did manage to perform minims and semibreves at the appropriate length, even when there were no crotchets present in the phrase. Was this because they were maintaining a crotchet pulse? Again it is not possible to say. From the results of this study it is not possible to judge whether the children were using a pulse train or not. The performance of the majority is in keeping with its use, but they could still have been using different methods to achieve the same result.

A margin for error of +/- 12% was allowed when marking the tests, being the margin for a 'fairly good' performance as classed by Wallin (1911). This degree of error worked well, with performances that were subjectively acceptable falling within that figure. There was a problem with the actual timing of the performances however, as the use of a stopwatch was not practical at quicker speeds, and certainly not for quavers. The strategy of not using the subjective judgement of the tester is supported, as, after watching a number of video extracts the tester experienced 'rhythm fatigue', and it impaired judgement. The subjective element needs to be removed, but a more accurate means of physical measurement than a stopwatch is necessary.

The predictions

From the timing literature a number of predictions about the performance of the children were made. Were the results in line with these predictions? The answer is mainly 'yes'.

Complexity and reliability

As predicted, increasing the number of note values within a rhythm increased the number of errors made. As Table 3.2 shows, the mean score for the questions that contained only one note value was 87%, for those containing 2 values 68%, and for those containing 3 values 49%. This lends weight to the argument that it is the nature of rhythm timing that is so difficult. The presence of other tasks such as working out what the note is and how long it lasts have to be performed concurrently, thereby distracting the timing mechanism. That distraction leads to error, and the greater or more frequent the distraction, the greater the error. The lack of error on the actual labelling of the notes also supports this hypothesis. The children clearly knew what the notes were called; they simply could not perform them accurately in more complicated situations.

The prediction that error would not be caused by variability in the time-keeping process, which, if present, would manifest itself as a failure to maintain a constant value in single note value rhythms, was also borne out. Questions 1 - 3, which only contained crotchets, were, at post-test stage, performed with a mean accuracy of 93%. As Question 3 contained 8 crotchet pulses, if the children had been unable to maintain a regular pulse because of variability in the time-keeping process scores on this would have been low. However, the accuracy on this question was 89%, with 6 children making no errors at all.

Long notes

One child did not make any errors at all on the long notes, 2 children only made one error, and the remainder made between 2 and 5 errors. Investigating the performances of Questions 6 and 9 is interesting as both contained a long note at the end of the phrase, and a long note early on in the rhythm. It had been predicted that, in keeping with the results reported by Fortin et al. (1993), because there were factors to work out following the first long note of the rhythm, the timing process would be distracted, and the distraction would lead to error. However, as only a final crotchet followed the second long note there was not the same degree of distraction, and so the note would be more likely to be played accurately. The performances of the 7 children who completed all the questions at post-test stage did not support this. In Question 6 the first long note was performed correctly by all 7 children, and the final long note by 6, whilst in Question 9 the first was performed correctly by 5 of the children, and the second by 7. There is limited support for the idea in the performances of question 9, but none whatsoever in Question 6. In the quaver questions the long notes were accurately performed by only 2 of the 7 children. Owing to the small number of children in this study caution must be exercised in any interpretation of these results. It is nevertheless suggested that it is the overall complexity of the rhythmic phrase, rather than simply what note is next, which is the cause of distraction, and therefore error.

It was certainly the case that semibreves and minims occupied less time than the corresponding number of crotchets, as predicted by Brown and Hitchcock (1965). Of the long note errors in the rhythms containing 2 or more note values, 6 were too short, and only 3 too long (excluding errors which were so inaccurate as to be classed simply as 'wrong'). However, in the questions which consisted exclusively of long notes 6 children performed the minims correctly, and 7 the semibreve. This again suggests that complexity is the root cause of error, as, when there was nothing else to consider, the majority of the children performed long notes accurately.

Tempo

The children were allowed to choose their own speed, and the timing literature (see Fraisse, 1982; Getty, 1976) predicted that speeds between mm 83 and mm 133 would be the most popular. This was found to be the case, with all the children regularly choosing a tempo within that range. However, this range was not invariably chosen. Some children also displayed a liking for slower speeds, particularly when quavers were introduced. Generally, mm 60 was the slowest speed chosen, with speeds slower than that being rare. In keeping with results reported by Fetterman and Killeen (1990), and Fraisse (1982), there were marked differences between the speeds preferred by different children.

Effect of experience

Kristofferson (1980) reported that his participants improved very quickly over the first 10 sessions and then only a little after that. The children in this study improved extremely rapidly over the first 7 sessions, with a 68% increase in score. Over the following 7 sessions they only improved by 40%, and by 15% over the final 6, indicating very strongly that the early sessions were where most improvement in performance took place. These percentages were calculated from the mean score of the group, and investigating the scores of the individual children reveals that some did reach a plateau beyond which little improvement was made. For example, for 3 children the post-test mark was within 2 marks of their post14 test result, indicating that a plateau had been reached after 14 sessions.

The effectiveness of the teaching techniques

My role as teacher enabled me to accurately judge the suitability and effectiveness of the games used in the study. I was able to form an opinion based not only on the children's performances and verbal comments, but also on their facial expressions and general body language. In particular I observed that some of the methods used to help the children develop the concept of a constant pulse were not effective:

i) *Walking.* The children could only manage to walk and tap at the same time if the taps coincided with each footstep. They were not capable of tapping every other step as in tapping on 'one' in 'one two, one two'; the exercise was discontinued as it was also not enjoyed by the children. In hindsight it might have been beneficial to continue with simply walking and tapping on each step, as this would have reinforced the concept of a constant pulse.

ii) *Metronome.* The children were fascinated by it, but paid more attention to its visual aspect than the ticking sound, and were not capable of tapping the table in time with it.

> Leaving it ticking in the background was tried to see if the children would match their taps to it, but they did not. Again, its use was discontinued; moreover it is difficult to envisage a situation where it could be useful with such young children.

In contrast the games played were all successful, with the exception of *'Is it right or is it wrong'*. Most children found this game difficult, and were therefore reluctant to do it. They were also not usually correct in their decision, and perhaps because of that it did not increase accuracy.

The echoing and copying games, where the children had to copy what I said or tapped, were both enjoyed by the children and effective in improving performance accuracy. The children had to listen very carefully in order to match their performance to mine, and because of the imitative nature of the task they frequently heard what a correctly performed rhythm sounds like; that it is not possible to speed up or slow down, or stop. It therefore served two purposes: it helped the children develop listening skills, and exposed them to the ingredients necessary for accurate rhythm performance.

The use of a teddy and other cuddly toys was also very successful. Apart from sustaining the children's interest it also provided an opportunity to introduce a kinaesthetic element. I held one of the toys' arms whilst the child held the other, and in that way I exerted an influence over how the toy moved. Letting the child feel the correct rhythm as well as hear it provided further reinforcement, and is in keeping with the findings reported by Bebau (1982), who suggested that kinaesthetic awareness is an important part of rhythm learning.

The children enjoyed performing the rhythms by hitting the table and it presented no problems. The use of various instruments, both conventional and improvised, during some of the teaching sessions did provide variety, which was necessary in order to sustain the children's interest and prevent boredom. In the test situation the children were always happy to use the table.

The games that utilised written notes, with the exception of the previously mentioned *'Is it right or is it wrong'*, were also successful. The simple game of placing all relevant Note Cards face down on the table and allowing the children to choose which ones to turn over was surprisingly consistently enjoyable. The children were happy to play the game repeatedly without becoming bored. As more notes were learned the increase in the number of cards meant that they filled the table, or had to be spread out on the floor, something that the children greatly enjoyed.

The children also enjoyed writing their own rhythms, by choosing and copying note cards, and colouring them in. This involved them more in the written side of the process, and helped them to understand how rhythms are constructed. It also linked music to the other literacy skills that were being developed in their everyday nursery activities. In language and number work the children did not simply read numbers and letters, they also practised writing them. In that context it would be inappropriate to only provide the children with experience of reading rhythms.

Conclusion

The main question this study was designed to answer, whether 3 – 4-year-old children can learn to perform simple rhythms from conventional notation, has been answered. They can. The children also enjoyed both the teaching and testing sessions, indicating that, when presented to them in an appropriate way, rhythm reading tasks are well within their capabilities.

The validity of the predictions made from investigations of the 'non-music' timing literature is an indication of the potential benefit of further similar investigations. Rather than confining the search for answers to music-based research, there is a great deal to be gained by investigating a much wider range of relevant research literature.

The study has identified possible ways forward. As predicted, it is not the required accuracy of timing that causes error in performance, rather the nature of the rhythm performance task. The human timing mechanism is very fragile, and prone to distraction and disruption. In particular, errors were judged to be caused by children having to process information about the type and relative length of a note at the same time as estimating and performing the actual duration, with accuracy diminishing as complexity increased. This is very much a dual task problem, where one task is the accurate performance of the notes, and the other is decoding the written symbols. Hence one way forward is to approach the rhythm reading task from a dual task perspective. The next chapter reports a study based on that approach.

Another possible line of investigation is that suggested by Penhune et al. (1998). If it is accepted that the precise way in which temporal information is processed is not understood, then one way forward is to not attempt to enforce a processing method on the brain, but to let it find its own. By exposing children to the correct performance of a rhythmic phrase, and allowing them the time to learn to perform it themselves, each child should find a suitable way of linking a written note to the corresponding performed note. This is very much in line with connectionist learning principles, so by investigating the connectionist literature a way forward in that direction may be found.

Finally, the marking of the test performances needs to be more reliable. Relying on the subjective judgement of the tester is unsatisfactory, but so is the use of a stopwatch. Accordingly in the studies reported in Chapters Four and Five, rather than relying on the inherently fragile and unreliable timing mechanism of a human tester, the tests will utilise a computer and timing program. In this way any ambiguity should be removed, and a purely objective measure of duration obtained.

Chapter Four

A dual task approach to the teaching of rhythm notation[1]

The previous chapter highlighted one of the main problems connected with rhythm performance: it is not that novice performers (and others) do not know what the lengths of the notes should be, it is that they cannot accurately perform them in a 'real-music' situation where phrases are comprised of two or more different note values. Accurate performances are easier, and therefore more likely to occur, in artificial, single note value situations. For example, the rhythm ♩ ♩ ♩ ♩ will not present any problems to the novice, whereas the rhythm ♩ ♫ 𝅗𝅥 ♩ most likely will. As discussed in Chapter Three, the difficulty is caused by having to work out the length of one note whilst performing another, with no extra time available for the task. This is a dual task situation. One explanation for the problems beginning instrumentalists encounter in rhythm performance could be that the necessary dual tasking ability is not yet in place. If so, is this lack of dual task ability caused purely by lack of experience, or do young children not possess the capabilities needed to deal efficiently with a dual task situation? Is it possible for them to learn how to dual task, or is it an ability acquired purely by maturation? By referring to the published literature on dual and multi tasking I shall first of all attempt to answer that question. The remainder of the chapter describes a study that employed a dual tasking methodology to teach rhythm performance to a group of 3 – 4-

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[1] As before, the term *rhythm performance* will be used to describe performance from conventional rhythmic notation. When other kinds of performance are described they will be specifically described as such.

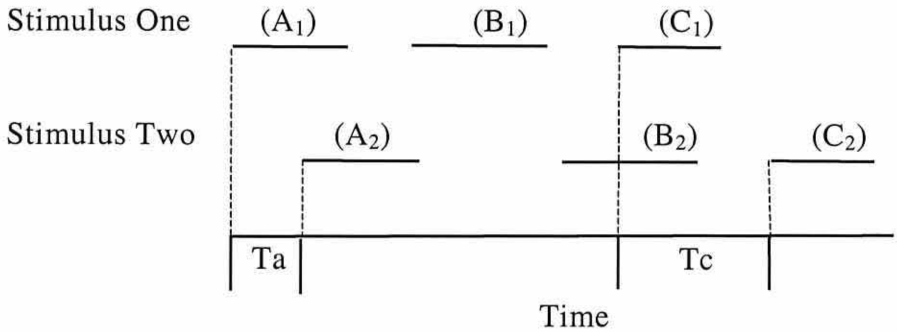
year-old children.

An investigation of the timing literature reveals that, although the problems of dual and multi-tasking have received considerable attention, the vast majority of the work has been conducted with adults, not children. As much of the research has been carried out with funds provided by the military that is not surprising. I shall therefore begin by investigating the general literature, followed by that which assesses the capabilities of children.

Dual and multi-task performance in adults

One feature of the debate is the issue of whether dual tasking is the processing and execution of two actions simultaneously, or in fact serial processing that masquerades as simultaneous execution by delaying one action until both are in a position to be performed. Although intuitively it would seem to be impossible to process the complex information contained in a piece of music without processing information in parallel, it must be remembered that intuition can be wrong.

Weldon put forward the idea of the *psychological refractory period,* or PRP, as long ago as 1952. The classic PRP experiment consists of two stimuli, both of which require a high-speed response. A time interval termed the *stimulus onset asynchrony* (SOA) separates the presentation of the stimuli. Weldon stated that reaction to the second stimulus is delayed by an interval greater than the SOA, and that the shorter the SOA the greater, proportionally, the delay. Weldon suggested that a bottleneck at the response selection phase caused the delay. He hypothesised that the two responses do not happen in parallel, but serially, and that the second response is not made until the first response has at least been chosen. This delay is shown in Figure 4.1, and, as can be seen, the delay in response execution, Tc, is much greater than the time interval between the presentation of the stimuli, Ta.

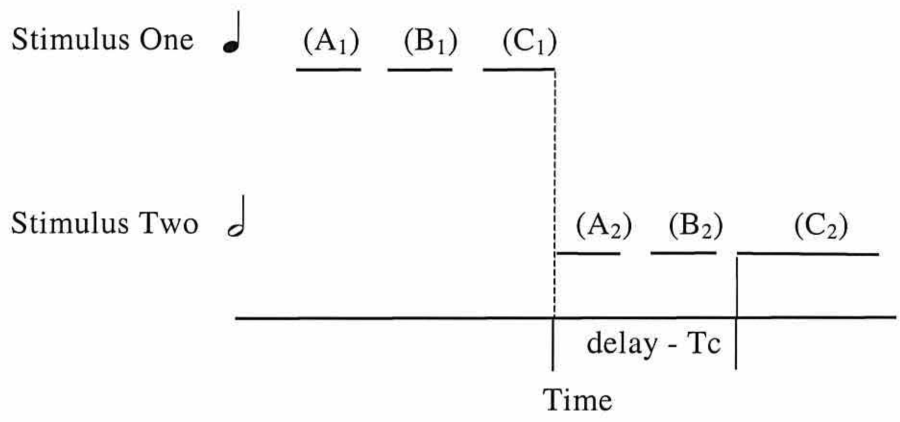


Where (A) is stimulus perception, (B) response selection, and (C) execution. Ta is the time interval between stimuli presentation, and Tc the time interval between response execution.

Figure 4.1: Delay in response execution

In the above model the response selection phase for the second stimulus (B_2) cannot be begun before that phase has been completed for the first (B_1). This is where the bottleneck in the system lies; it is not possible to perform the two operations concurrently. The delay in the response selection phase carries over to the execution phase, resulting in a longer delay, Tc, between the execution of the two stimuli than between their presentation, Ta. Much more recently Pashler (1992) looked at the issue again, and also concluded that the delay was due to a bottleneck at the response selection stage.

If the bottleneck theory is accepted, in the above example information is being processed as quickly as possible. However, rather than attempting to process information as shown above in Figure 4.1, what tends to happen in a beginner's rhythm performance is shown below in Figure 4.2. Here the stimulus perception phase for the second stimulus (B_2) is not begun until the execution phase for the first (C_1) has been completed. This occurs because the beginner is able to choose when to look at the second stimulus, rather than it being presented to them, and the easiest time to look at the second stimulus and begin phase (A_2), is when all processing and execution related to the first stimulus has been completed. With this tactic any need for dual tasking is avoided.



Where (A) is stimulus perception, i.e. reading the note, (B) is response selection, i.e. deciding how long it lasts, and (C) execution, actually playing the note.

Figure 4.2: A beginner's likely rhythm performance

Unfortunately this avoidance of dual tasking results in performance error as there is a long delay, Tc, between the completion of phase C for the first note (C_1), and the beginning of phase C for the second (C_2). As one note is supposed to follow on from the previous one without any delay at all the listener perceives this disruption as an error. Obviously this is not acceptable, so beginners are encouraged, by being told to look and think ahead, to change their behaviour to that shown below in Figure 4.3. Here there is no gap, as the execution of the second stimulus begins immediately upon completion of the first. It does require a degree of dual tasking though, as, although the response selection phase for the second note (B_2) does not begin until that phase has been completed for the first (B_1), it must occur concurrently with (C_1), playing the first note. This is in keeping with Weldon's PRP model as the two response selection phases still do not happen simultaneously. The difference between the two is the nature of the execution phase (C). In a PRP experiment the stimulus response is most likely to be simply pressing the correct button; the manner in which it is pressed is unimportant. In Figure 4.3 the execution phase (C) has to last for a specific duration, and therefore needs to be attended to throughout that time. As discussed previously (Chapter Two), as the difficulty of the (B_2) task increases so does the likelihood of errors of perception occurring in the performance of (C_1).

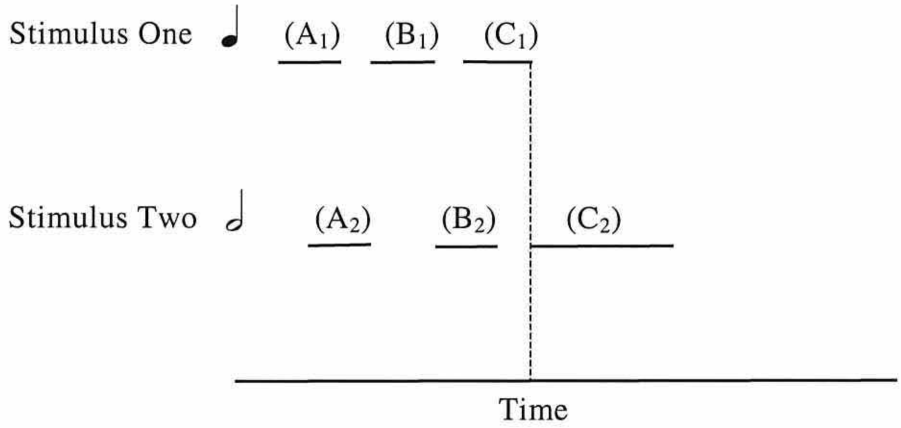
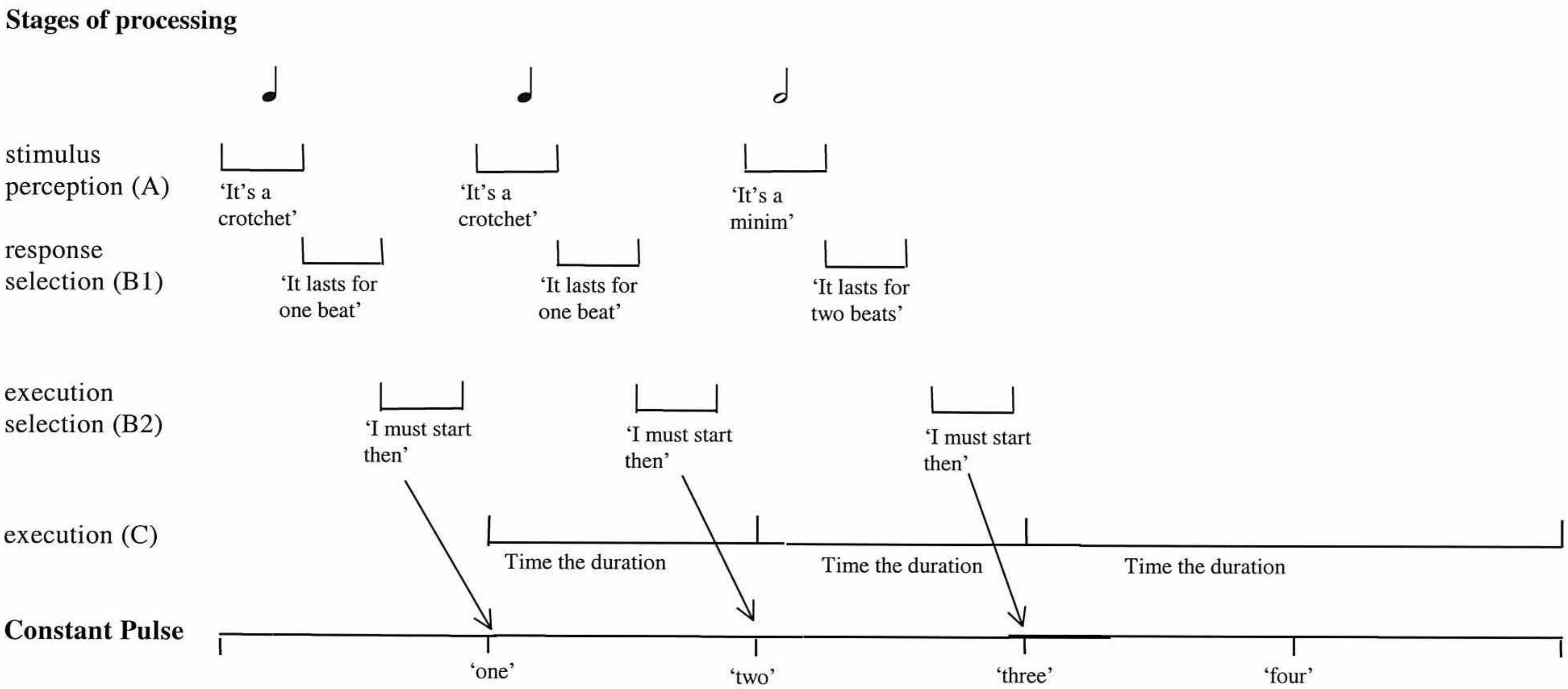


Figure 4.3: Planning ahead

For accurate rhythm performance the situation is actually more complicated than that shown in Figure 4.3. There must be a uniformity of speed throughout a piece of music and to achieve that a performer of any standard may count, or otherwise keep a steady pulse, whilst playing, and endeavour to position every note accordingly. This results in a complicated procedure where the performer has to not only process information concerning the length of the notes, but also to maintain a constant pulse and ensure that each note synchronises with it. This process is shown diagramatically in Figure 4.4. The stages of processing are shown on the left: (A), (B1), (B2), and (C), and occur in that order for each note. The constant pulse, although at the bottom of the list, is always present, not being part of the processing stages as such. Here the response selection phases still happens serially, but maintaining a constant pulse and ensuring that the notes are the correct length must happen concurrently. Therefore although simultaneous processing by the



The various processing stages are listed down the left hand side, read from top to bottom. The bottom line represents the constant pulse, which the performer must keep continuously. As can be seen, any disruption to the constant pulse will inevitably result in an error.

Figure 4.4: The processes involved in simple rhythm performance

response selection mechanism is avoided, accurate performance cannot take place without it happening elsewhere.

In Figure 4.4 the four notes are processed as four separate stimuli. With practice the stimuli can be 'chunked' so that a number of notes constitute one stimulus, thereby simplifying the task. In Figure 4.4 experience would quite quickly reduce the three stimuli to two: the 2 crotchets being the first, and the minim the second. Because this rhythm is one that is so frequently encountered, those two stimuli would then be reduced to just one. This grouping of information is an essential part of expert performance in many areas, including music, and with increasing experience and practice the amount of information that can be grouped together is increased. Sloboda (1976, 1978b) investigated the performance of expert piano sight readers, concluding that experts not only looked at more notes in each eye span, but also used contextual information more, to the extent that minor errors in the middle of phrases were not noticed. Sloboda likened this inability to notice errors in music to the difficulties of proof reading written language text. In text an experienced reader will not notice minor mistakes and read the correct word. His evidence suggests that the experienced music reader will similarly not notice minor mistakes. Therefore in music reading as in language reading: experienced readers do not read every note, unlike beginners, who initially have no alternative strategy.

However, this grouping of information does not eliminate the dual tasking problem, it merely changes its nature. It is obviously not possible for an entire piece of music to be grouped, therefore the problem of how to perform one group while processing information about the next remains at some level. Whether that group is two notes or two bars only alters the frequency and complexity of the task; it does not remove it. It is argued here that the complexity of simultaneously storing two or more beats or bars of music, whilst retrieving and performing the previous ones, and at the same time maintain a constant pulse, necessitates some simultaneous processing.

Nevertheless, many researchers have concluded that simultaneous processing is not performed, and that only serial processing occurs. Perhaps in the laboratory situation that is the case, if not in music. Weldon (1952), Fisher (1975), and Pashler (1992), all concluded that processing took place serially, not in parallel. In Fisher's experiment participants were required to respond to a five choice task by touching a disc with an electronic pen, while concurrently performing simple arithmetic addition. Although concluding that processing took place serially she did not state that parallel processing was not possible, only that serial processing occurred because it was more efficient.

Allport, Antonis, and Reynolds (1972) suggested that if, in a dual task situation, the required responses used different modalities then parallel processing could occur, whereas if a single response modality were utilised it could not. Participants in their study had to repeat a verbal message whilst at the same time being presented either with complex visual scenes that they had to remember, or, in a separate experiment, concurrently sight read a piano piece. Participants performed so well in both experiments that Allport et al. concluded it was not possible for information processing to be restricted by a limited capacity central processor, and that information could be processed in parallel in certain circumstances. McLeod (1977, 1978) also argued that if the required responses used differing processing areas then interference in the dual task situation could be greatly reduced, if not eliminated. To them the delay was a result of the same processing area being involved in the situation, not, as Pashler and Weldon believed, of the processing stage.

In rhythm performance the task of deciding what the note is and how long it lasts does not use the same processing area of the brain as timing the length of the note, and so, according to Allport et al. and McLeod it should be possible to perform the two processes simultaneously. However, the fundamental problem of maintaining a constant pulse whilst simultaneously timing individual notes, both of which use the same processing area, remains. According to Allport et al. and McLeod, this unity of processing area will result in interference between the two tasks.

Not all researchers though agree that the processing area used for the individual tasks in a dual task situation is important. Pashler (1990) investigated the response modality effect described above and identified one factor as being of primary importance: whether the participant knew in advance in which order the stimuli, and therefore the responses, would be presented. His participants had to respond to two closely timed stimuli (interval 100 - 700 ms). In one experiment the responses were both manual, and in another one of the responses was vocal and the other manual. In both situations the performance of the participants greatly improved if they knew in advance the order of stimulus presentation. Without advance knowledge the disruption caused in manual-manual tasks was about three times that caused in vocal-manual tasks. Pashler argued that failing to take into account prior knowledge of stimulus order could lead to the mistaken conclusion that utilising differing processing areas automatically resulted in improved performance. He went on to suggest that, as a result of prior knowledge, the participant prepared for the task, and, with that preparation, performed only slightly better on tasks involving different processing areas than tasks utilising just one. The slowest stimulus separation time used by Pashler corresponds to mm 86, but the reported response delay was too great for acceptable musical performance, supporting the belief that it is not possible for notes to be performed in isolation. In music there must be some degree of simultaneous processing.

Some researchers have concluded that the complicated nature of the dual task situation is such that it must be controlled by some kind of 'executive'. Posner and DiGirolamo (1998) argued in its favour, stating that executive attention must be an essential part of the process. Others however, (see Parasuraman, 1998 for example) do not support the idea of executive control, as the inevitable question that remains unanswered is 'What controls the executive?' That argument becomes never ending as at each layer something has to be put in place to control the layer below. Eventually the concept of a mental process being able to organise itself has to be accepted, so why not accept it at the first level? It is not relevant here to discuss the issue further, but interested readers are referred to the above articles, and to the work of authors such as Kelso (1995), who discuss self-organising, dynamic theories of control.

Training regimes for adults

An important question is 'can dual task performance be improved, and if so by what methods?' Despite extensive literature searches, no reference to utilising dual task training in music performance could be found. However in some areas, notably those connected with air defences, considerable attention has been given to improving multi-task performance.

The Learning Strategies Project, reported in Acta Psychologica (1989), was specifically designed to answer the question of whether multi-task performance could be improved, and by what method. The project was concerned with the training of fighter pilots, and compared different learning strategies. As reported by Donchin (1989), the belief at the time was that simply allowing trainees time in a simulator would be of as much benefit as any structured practice regime. The project was conducted on a very large scale, involving centres in America, Europe, and Israel. All centres used the same computer game, the Space Fortress, as both the basis of the training and the test task. The game itself had been designed to be interesting, challenging, and suited to the future skill requirements of the trainee pilots. Each centre used a different training method, based on their particular interests. The learning strategies used in the project broadly reflected two opposing views as to what constitutes an optimal training strategy. In one kind of experimental group the main task was broken down into smaller sub-tasks that were initially practised in isolation. In the other the participants practised switching attentional emphasis to differing task components. There was a large independent control group based in America, together with smaller, centre based control groups. The participants in the control groups were allowed an equal time of unsupervised practice as the experimental groups were of structured practice.

The results reported that the trainees in both categories of experimental groups achieved significantly higher scores than those in the control groups, indicating that complex multi-task skills are ones that can be learned. Contrary to the widely held belief at the time, unsupervised practice did not result in the same increase in skill level as did a structured practice regime. So the first part of the question 'can dual task performance be improved?' has been answered - it can. Fabiani, Buckley, Gratton, Coles, Donchin, and Logie (1989) set out to directly compare two of the most effective learning strategies: the switching attentional emphasis method of Gopher, Weil and Siegel (1989), and the hierarchical method of Frederiksen and White (1989).

In the early stages of the attention switching method (Gopher et al., 1989) the participants were instructed to ignore their total score, and just concentrate on improving their score in the desired area. The hierarchical group (Frederiksen & White, 1989) was initially trained on sub-tasks that had been identified as necessary for the overall task, and then subsequently moved on to the whole game. The results reported that the hierarchical group achieved significantly higher scores than did the attention switching group. However the attention switching group's performance was more resistant to disruption caused by having to perform another task concurrently with the Space Fortress game than was that of the hierarchical group. Fabiani et al. also investigated the effectiveness of the different strategies as a function of the participants' initial ability. They divided the participants into low, medium, and high ability groups according to how they scored on a pre-training aptitude test. Following intervention the participants in the low ability group actually scored lower than those in the control group when they undertook the attention switching training regime. Low ability participants in the hierarchical group did not, however, score less than those in the control group. The medium ability group performed best after hierarchical training, with medium ability participants in both training groups performing significantly better than the control group. The high ability group performed well regardless of the training regime used.

The results strongly suggested that there actually is no overall 'best' training strategy, thus providing the answer to the second part of the question. There is some indication though that the attention switching method may be more difficult for those who do not have a high initial level of aptitude for the task. The natural aptitude of the person for the task should be a factor in the training decision, and also the final real life situation - will the task be performed in a non-distracting environment? Music performance is a distracting environment so an argument could be made for the suitability of the attention switching method. The counter argument would be that unless a person has a high initial level of aptitude he or she may perform worse as a result of such training. What is very apparent is that, provided a suitable training method is chosen, training regimes improve performance on a complex task significantly more than does unsupervised practice.

The interest in pilot training regimes based on attention switching strategies continued, with Gopher (1992) identifying the inability of trainees to cope sufficiently well with multi-task demands as a frequent cause of failure during flight training. From his work he concluded that it is possible to improve attentional abilities, and that, with practice, the time-shared performance of a task will be approximately the same as when each of the components is performed individually. He reported his training to be very successful, with the percentage of student pilots graduating in the experimental group twice that in the control group.

Although at first sight this work might be considered not relevant to music, it is, for two important reasons: i) it shows that by the use of appropriate teaching strategies multi-task performance can be greatly improved, and ii) the ability to switch attention is an important one in many aspects of music. Even in the performance of a simple rhythm, attention needs to be switched to different components. For example, in the performance of a long note attention needs to be directed to the pulse in order to ensure that the note is performed to its correct length, while little attention is needed for the note itself (in terms of what kind of note it is, and its relative duration). Conversely, if a bar contains a complex rhythm attention also needs to be directed to decoding the notes (in terms of what they are and relative duration), as well as to the pulse. Certainly when a complete piece of music is being performed, as opposed to only a rhythm, then performers have to be constantly switching their attention to different elements. In certain passages it may be the expressive quality which is the most important, in another technical problems, and another the rhythm, and so on.

The dual task capabilities of children

Although there is a wealth of literature concerned with dual and multi tasking, only a small proportion of it is concerned with the dual task abilities of children. A frequent use of children's dual tasking is to use the dual task situation to assess the attentional demands of one of the tasks. Typically, a child's performance is measured on a task in the single task situation, and then again in the dual task situation. The amount of performance decrement is seen as indicative of the amount of attention required by the task. (See Guttentag, 1984; Halford, Maybery, & Bain, 1986; Shepp & Barrett, 1991; and Whitall, 1991; for example). Such research is of little help here as it is that very decrement which needs to be avoided, and such studies do not attempt to do that.

Given the overall development of children it might be assumed that older children would be better than younger in the dual task situation. Indeed, some researchers have reported age related effects in dual task performance, while others have reported none. Miller, Seier, Probert, and Aloise (1991) reported age differences in the decrement caused by having to perform a visual selection task concurrently with finger tapping. In their study 6-year-olds were reported to suffer a greater decrement than did 10-year-olds. However, their study also highlights an inherent problem in investigating dual task performance across age groups: younger children will find each component more difficult than older children, thereby altering the difficult level of the dual task task. For example, tapping as fast as possible with an index finger, and classifying objects as being 'household' (the tasks required in Miller et al.'s study), are both tasks that are more difficult for 6-year-olds than for 10-year-olds. This discrepancy in single task difficulty would be expected to reveal itself in the dual task situation, so unless steps are taken to counteract it any comparison across age groups is invalid.

In an attempt to overcome this difficulty Birch (1978) paired 8-year-olds with 13-year-olds and trained the 8-year-olds until their baseline performance on the tasks separately was the same as that of the 13-year-olds. Following this training she reported no difference in performance decrement caused by dual tasking. She interpreted this to mean that performance in a dual task situation is dependent on ability at the single task stage, with age not being a factor. However, although she attempted to control for baseline difficulty by training the younger children, the problem was not solved as the very act of training altered the nature of the task. The performance of the younger children may have become automated, or, even though their performance level was the same, the younger children could still have been working harder to achieve it.

Lane's (1979) solution to the problem seems one of the most appropriate. The participants in his study were 7-year-olds, 9-year-olds, and college students. They had to carry out two tasks: remembering a string of animal names, and remembering which geometric shapes had been presented during a trial. Before assessing the participants in the dual task situation, to establish each individual's criterion level they were first given 8 practice sessions on each task in isolation. Subsequently each of the two tasks was allocated a 'difficult' and 'easy' condition for each individual. A 'difficult' task was classified as the maximum number that had been remembered during the practice sessions. An 'easy' task involved remembering one less than the maximum number achieved during practice. During the experimental sessions one of tasks was classified as 'primary', and the other 'secondary'. The children were told that for correct answers they would receive a certain number of chips (counters), which could then be exchanged for a prize. The number of chips awarded for correct answers to the primary tasks was four times that awarded for the secondary task. As the difficulty level was set for each individual regardless of their age group, a valid comparison of dual task performance across age groups could be made. Lane reported that although there were significant differences between the age groups in single task performance, there was no significant main effect for age in the dual task situation. The only significant differences reported concerned the participants' ability to control attention in order to be awarded more chips. All the college students and half the 9-year-olds, but none of the 7-year-olds were able to achieve this. Lane therefore concluded that dual task ability as such is not linked to age, but that the ability to control attention is.

Lane's conclusion that dual task ability is not linked to age was supported by Guttentag (1989), who, in a thorough review of the literature concluded that, although some results seem to show that younger children perform worse than older children in dual task situations, if enough consideration is given to age related differences on the individual tasks, actual dual task ability is not linked to age.

Pearson and Lane (1991) further investigated age differences in the allocation of attentional resources. The success of such strategies with adults (Gopher et al., 1989) means that their use must be seriously considered. However, are young children capable of effectively controlling and switching attention, or is it, as implied by Lane (1979), a skill which they have yet to acquire? The participants in Pearson and Lane's study (8-year-olds, 11-year-olds, and adults) were presented with words and numbers via stereo headphones. Each ear heard different information and the participants were instructed to which ear they should attend. The results reported differences between the 8-year-olds and 11-year-olds, but not between the 11-year-olds and adults. More recently (1997), Irwin and Burns reported fifth grade children capable of controlling their allocation of attention, whereas second grade children were unable to do so. From these studies the conclusion that ability to control and switch attention does not begin to develop until around age 10 can be drawn.

Nevertheless a small number of researchers have reported younger children to be capable of effectively allocating attentional resources. Birch (1976) for example, reported 7-year-olds able to improve performance on one of their dual tasks when told it was the most important. This suggests that, with appropriate training children younger than 10 may be able to control and switch attention. Therefore although evidence for mid to late childhood acquisition of attention switching ability is strong, the possibility that it can be achieved earlier, given appropriate training, must be considered.

Training regimes for children

Earlier in this chapter ways of improving dual and multi-task performance in adults, through the utilisation of differing training regimes, were discussed. Have investigators also looked at whether children are capable of improving their dual task performance? Unfortunately the answer seems to be that they have not. Interest in the dual task situation is primarily a developmental one, and covers many aspects within that framework, but not the issue of learning. Researchers who have investigated whether children can improve their performance following instruction are apparently scarce, and in recent years extremely difficult, if not impossible, to find.

Despite extensive literature searches only the study by Birch (1976) mentioned above could be found. In her study the children could not be said to have received training as such, as the only instruction they were given was to which of the two tasks they should pay the most attention. However that in itself is the very beginnings of an attention switching strategy, and she reported that all of the children were capable of improving their performance on one task when instructed to do so.

The lack of research concerning training children in dual task performance should not be taken to mean either that such teaching should not be undertaken, or that it would not be beneficial. Numerous studies have reported no age effect in dual tasking, therefore if adults can improve their dual task performance, so presumably can children. The only negative finding reported is that the ability to control and switch attention is not in place until the age of 10, although the beginnings of it could be in place much earlier at the age of 7. This merely indicates the importance of defining the appropriate teaching method, rather than suggesting that improvements are not possible.

Methodological issues

Given that, at the age of 3 – 4, children cannot realistically be expected to have developed any attention switching strategies, a method based on breaking the task down was considered to be a more appropriate approach. In this study the constituent parts of rhythm performance were taken to be maintaining a constant pulse, and reading and understanding the rhythm values of the notes. Gopher (1992), in his work with adults, concluded that after appropriate training multi-task performance closely matched performance on each of the sub-tasks in isolation. Thus, after appropriate dual task training the performance of the children could be close to their performance on each of the above tasks in isolation. The first investigative study (see Chapter Three) found that the children were capable of learning and accurately remembering the note values, but what of the constant pulse? Are such young children capable of maintaining a constant pulse?

Moog (1976), in his thorough investigation of the capabilities of children from 0 to 6 years of age reported 40% of children aged 3½ capable of moving in time to music, and 'most' children aged 4 and 5 able to clap in time with music. Frega (1979) reported that 47% of 3-

year-olds, 93% of 4-year-olds, and 100% of 5-year-olds were able to maintain a steady beat in time with a piece of music. The figures for maintaining a steady beat in time with an existing drumbeat were 80% of 3-year-olds, 87% of 4-year-olds, and 100% of 5-year-olds. These reported findings suggest that differences will be found between the younger and older children, but that the majority will be capable of keeping a constant pulse.

A training regime to provide practice on each of the component parts was devised for the children. For learning the note values, rather than the counting method used in the previous study (Chapter Three), it was decided to use a method based on animals and syllables, in keeping with the work of Davidson and Colley (1987). They had concluded that 5-year-olds were better able to remember rhythms that were accompanied by text. The use of words is also in line with researchers (see Colley, 1987 for example) who have reported syllabic methods to be effective in rhythm learning. Animals were chosen as the majority of pre-school children are interested in looking at pictures of them, adding a further, visual dimension. The animal - note value pairs were chosen so that the number of syllables matched the length of the note, in terms of crotchet beats.

To give the children practice in maintaining a constant pulse it was decided to devote some time to tapping in time with a piece of music, and also to devise a simple computer program which would provide a visual constant pulse stimulus with which the children could keep time.

As well as the experimental rhythm performance test used in the previous study, additional tests were administered in order to assess any improvement in constant pulse ability.

In the previous study the correct verbal labelling of the notes was assessed, as well as the correct performance. Here it was decided not to do that because it was previously noticed that some children were reluctant to name the notes aloud. Also, the task was so well performed that it was not considered worth the extra possible stress caused by attempting to insist that they did so.

It was anticipated that the children would encounter no problems in learning the appropriate label for each note value, or in understanding that some notes are long and some are short. It seemed likely though that they would have problems accurately performing the test rhythms, and although their ability to maintain a constant pulse may improve in the single task situation, because of their very young age it was not known if that improvement would carry over into the dual task situation. In the reported research the youngest children were aged 6, and a great deal of development takes place between the ages of 3 and 6. However many researchers reported no age effect for dual task ability, and so a strong argument can be made to support the opinion that, if the children can perform the tasks in isolation, they will also be able to perform them concurrently, even if there is a degree of performance decrement as a result. It still must be recognised that dual task performance with such very young children is very much new territory, and so it is extremely difficult to predict outcomes with any degree of certainty.

Methodology

Participants

Ten children (5 boys and 5 girls, from the same nursery as previously) took part in the study. Their ages at the start ranged from 3 years 4 months to 4 years 6½ months (mean 3 years 8 months). Written consent was obtained from the parents and it was verbally established that none of the children was receiving private music tuition.

Resources

Computing equipment

A timing board (manufactured by Nidaq; accurate to a millisecond) installed in a PC computer was used to record test performances. Linked to the timing board was a large (1 inch square) blue button attached to the top of a wooden 5 by 4 inch block. Depressing the button produced a 'beeping' sound. The timing program recorded the length of time for which the button was depressed, and also the time interval to the next button press. The computer and button were also used during the teaching sessions, but not the timing program.

Teaching Materials - constant pulse

i) Two computer programs based around the cartoon character 'Itchy' were written. In the first the character appeared to jump from one side of the screen to the other, at mm speeds of 40, 60, or 80. The aim was for the child to press the beeper, or touch the screen, in time with Itchy's jumping. In the second, more complicated program, the screen was divided into two with one Itchy in the top half and another in the bottom. The top Itchy jumped as before, but the child controlled the bottom Itchy by pressing the space bar. The aim of this game was for the child to make the bottom Itchy jump at the same time as the top Itchy. (See the attached CD for a copy of both these programs).

ii) Short extracts from various pieces of music (See Appendix D for a complete list) were played. The child practised keeping a constant pulse either by tapping the table, pressing the beeper button, or playing various musical instruments in time with the music.

Teaching Materials - note values

i) *Animal Cards*. The animals used were:

a) A dog for a crotchet.

b) A donkey for a minim.

c) A tortoise for a semibreve.

d) A teddy bear for 2 quavers.

Each animal (taken from Microsoft Clip Art) was printed in colour on a card 6ins by 4ins. There were three cards for each animal. Rather than using an animal with four syllables for a semibreve, the tortoise was called a 'slow, slow, tortoise' in order to achieve the 4 beats. 'Teddy' was chosen for a pair of quavers as it is a two syllable word that can be said easily and quickly. (See Appendix E for examples of the cards.)

ii) *Note Cards.* These were the same as used in the previous study (see Appendix A). There were 12 cards, three for each note value.

Teaching Materials - complete rhythms

i) *Computer Practice Rhythms.* These were written, in colour, and saved as separate files so that they could be read individually from the computer screen. The rhythms relevant to the note values already learned were minimised and the child chose which ones to maximise and play. (See the attached CD for examples of these rhythms.)

ii) *Paper Practice Rhythms.* These rhythms were written on A4 sheets and of a similar difficulty to the test material. These were used in addition to the computer rhythms to accustom the children to playing from hand written music.

iii) *Writing Rhythms.* The children wrote their own rhythms by choosing which of the Note Cards to copy, and then colouring them in.

Testing Materials - constant pulse.

i) *Tapping in Time with Vivaldi.* A short extract from the first movement of the Vivaldi Lute Concerto was played through twice, once for the child to respond to at a quick (crotchet) pulse (mm 126), and again at a slow (minim) pulse (mm 63). The number of consecutive taps in time with the music was noted, up to a maximum of 10.

ii) *Tapping in Time with Itchy.* The simple Itchy program was run at each of the 3 metronome speeds (40, 60, and 80) and the number of button presses in time with Itchy noted, again up to a maximum of 10.

iii) *Pulse Continuation test.* After the post-test only, a pulse continuation test was given. Here I pressed the button at each of the metronome speeds in turn and invited the child to join in. The child was told that I was going to stop, but they were to continue at **exactly** the same speed. This was recorded by the timing program and the number of consecutive taps at the correct speed (+/- 12%) recorded. Also recorded was the greatest number of evenly psaced consecutive taps, if any, at the speed the child deviated to, up to a maximum of 10.

Testing Materials - complete rhythms.

The same Rhythm Performance test was used as in the previous study, the only difference was that the child performed the rhythms by pressing the button attached to the computer. (See Appendix B for a copy of the test).

Procedure

All the teaching and testing sessions took place in one of the purpose built research rooms in the nursery, and were videotaped. The computer was used to record the performances of all testing sessions, with the exception of the Tapping in Time with Vivaldi, and Tapping in Time with Itchy, tests.

Teaching Sessions

The teaching sessions began within a few days of the pre-test. Each child had two individual ten-minute sessions every week. A child's absence from the nursery occasionally interrupted the routine, but the total number of sessions was twenty in each case, with no child exceeding an overall time limit of 14 weeks. Each ten-minute session was divided equally between time spent working on constant pulse activities, and time spent learning and practising note values. As the sessions were divided between constant pulse training and learning the appropriate rhythm values, the following description will be divided likewise.

Constant Pulse

The following games were played in order to help the children acquire and improve their ability to keep a constant pulse.

i) 'Catching' Itchy at either side of the computer screen at speeds of mm 40, mm 60, and mm 80. As well as pressing the button in time with Itchy, sometimes they actually touched the screen to 'catch' him that way. In order to give the children something to aim for they were told 'see if you can catch him three/five times', and later, 'see if you can catch him five/ten times'.

ii) Asking the child to make their Itchy jump in time with the second Itchy by pressing the space bar at the appropriate time.

iii) I hit the table at varying metronome speeds and the child had to play in time with me. If they could not then I corrected them saying 'you beep at **exactly** the same time as me, listen carefully'. Or, 'you're going too quick/slow, listen carefully'.

iv) The child pressed the button at evenly spaced intervals and I had to hit the table in time with them. If they did not keep a constant speed then I said, 'I can't keep with you because you're speeding up/slowing down! Listen carefully'. Following this I demonstrated speeding up, slowing down, and maintaining a constant speed.

v) I pressed the button with them at various metronome speeds. They were then told that when I stopped they had to keep going at **exactly** the same speed. If they didn't they were told 'No you went quicker/slower, let's try again'.

vi) Extracts from various pieces of music (See Appendix D) were played and the children performed actions in time with them. Initially this was simply hitting the table or pressing the button. As the sessions progressed this was developed to include hitting a drum and clapping hands, as well. To help the children develop a 'feel' for when the action was correct I frequently clapped their hands for them etc., and then encouraged them to do it by themselves.

vii) Singing nursery rhymes and clapping or tapping the table in time with them.

In order to retain the children's interest, in all of the above games a teddy or a doll was frequently used to press the button or dance on the table.

Note values

Some of the games used to teach the children the different note values were very similar to those used in the previous study. Others used the computer and were therefore new.

i) *Choose a Card.* In this game the Note Cards were placed face down on the table and the child chose which one to turn over, match to the corresponding Animal Card, and then play. The opposite game of turning over the Animal Cards was also played. Sometimes instead of pressing the beeper themselves they were given a teddy or doll to use to press the button.

ii) *Practice Rhythms* were written on A4 sheets and also as coloured rhythms on the computer. These computer rhythms were minimised and the child chose which one to enlarge and play.

iii) The children wrote their own rhythms by choosing and copying, using coloured crayons, notes from the Note Cards.

Constant pulse and note values combined

From around Session 12 onwards, in order to combine both the constant pulse and the reading of note values I frequently tapped the table, using a constant crotchet pulse, while both the child and I played the phrases.

New notes were not introduced until a child could confidently and reliably play rhythms comprised of the note values that had already been learned. The new note was then introduced initially by itself, and subsequently with other values, using the Note Cards only. When a child was confident and accurate with the Note Cards then complete Practice Rhythms were played. As before the notes were introduced in the order crotchet, minim, semibreve, quaver.

Testing Sessions - Rhythm Performance tests

The children were given the pre-test, 20 ten-minute individual teaching sessions, and post-test. Intermediate tests (to test for change in performance level) were given after 7 and 14 sessions (post7 and post14 tests). To measure learning a re-test was administered 7 weeks after the final teaching session.

Pre-test

For the pre-test the children were taken individually into the experimental room and seated at their side of the table. On the table facing them was the computer monitor and the 'beeper' button. I pressed the button first, and invited them to copy me. If any child was reluctant to press the button then he or she was given extra time to become accustomed to the action. Care was taken to ensure that by the time the test itself began each child was happy and confident using the button.

I then drew their attention to the computer screen, and started the Itchy program at mm 60. I explained that we had to catch Itchy by pressing the beeper button whenever he was at the side of the screen. I demonstrated what to do before letting the children try. We then said 'goodbye' to Itchy and closed the program.

The written notes were introduced by placing a dog card on the table next to a crotchet Note Card. I explained that the two went together; for a crotchet we had to say 'dog' and press the button at the same time. I demonstrated a few times before letting the children try for themselves. I also explained that the Note Cards were a way of writing down music, and that they were going to learn how to read music, just the same as they were learning how to read words and numbers.

When the child was able to play two crotchets the donkey card was introduced, with a similar explanation. Finally, the crotchet and minim cards were mixed up and the child asked to choose a card one at a time to place with the correct animal; the resulting rhythms were then played. The pre-test itself was begun immediately, and administered as previously. (See Chapter Three.) As previously the terms crotchet, minim, etc. are used for convenience here. At no time were the terms used with the children.

After the test the Itchy program was run as before (mm 60), but this time the greatest number of accurate taps (those which synchronised with the character's 'jumping') were recorded. At the end the child was praised and taken back to the main nursery.

Intermediate, post and re-tests

The same procedure was followed for the intermediate, post, and re-tests. On entering the room the Note Cards relevant to the values learned by the child were placed face down on the table. The child then chose, one at a time, which card to turn over and play, any mistakes were corrected. The Rhythm Performance test was begun immediately, and any mistakes made during the test were not corrected. At the end the child was praised and taken back to the main nursery. In order to avoid fatigue the Constant Pulse tests were administered in a separate session, usually the following day.

The tests were marked from the computer recordings of the performances. The duration of each note was calculated, and a mark awarded for each correct note, within the +/- 12% margin of error allowed. As before, in Question 3 only ½ a mark was awarded for each note, and ½ a mark for each quaver in the quaver questions.

Testing Sessions – constant pulse

The Constant Pulse tests were given at the same time, with the exception of the Pulse Continuation test, which was given after the post-test only. Owing to time constraints and children leaving the nursery, the re-test was not administered for the Constant Pulse tests

With the exception of the Pulse Continuation test, which was marked from the computer file, the Constant Pulse tests were marked from the video recordings. Again, a mark was awarded from each correct tap, up to a maximum of 10.

Results

Table 4.1 shows the test scores the children obtained for each test, along with their age. To investigate changes in rhythm performance over time a one-way repeated measures ANOVA was employed and a significant main effect found [F (4,32) = 32.455; $p<0.001$]. Tukey's HSD follow up tests were calculated and revealed significant differences between pre – post14 (p<0.01), pre - post7 test ($p<0.01$), and post7 - post14 test ($p<0.05$). Post14 - post-test, and post-test - re-test differences were not significant ($p>0.05$). A graph of these scores is shown in Figure 4.5.

child	pre-test (max 37.5)	post7 (max 37.5)	post14 (max 37.5)	post-test (max 37.5)	re-test (max 37.5)	age (months)
1	5.5	16.50	23.50	23.50	24.50	54.50
2	8.5	12.50	18.50	14.50	14.50	49.50
3	10.5	14.00	19.50	17.50	.	53.00
4	9	14.50	24.50	27.50	24.00	47.50
5	10	19.50	22.00	19.50	18.00	47.50
6	5.5	19.00	18.00	17.00	18.50	46.00
7	5.5	16.50	23.00	25.50	24.00	44.00
8	13.5	19.00	26.50	28.50	22.50	42.50
9	6	12.00	14.50	19.50	19.50	42.00
10	11.5	11.50	14.50	22.00	23.00	40.00
Mean	8.55	15.5	20.45	21.50	20.94	46.65
SD	2.86	3.034	4.12	4.70	3.47	4.74

Table 4.1: Children's test scores and age, with group mean and SD

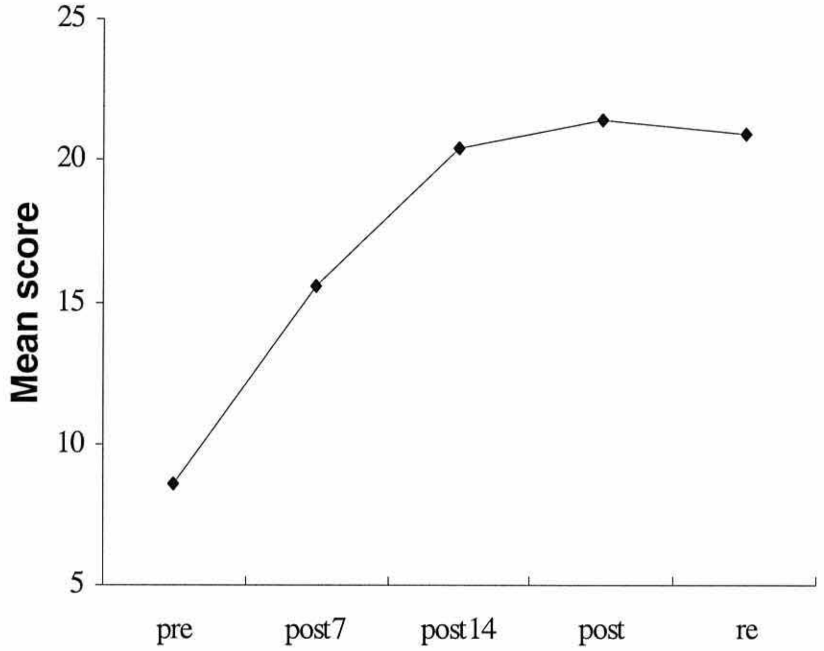


Figure 4.5: Graph of mean Rhythm Performance scores at each test point

In order to test whether the dual task training did result in the children being able to perform complicated rhythms as well as straightforward ones, the scores on the questions were grouped according to how many different note values there were in each question. To achieve this the rhythms were divided into 3 groups: those containing only one note value per rhythm, e.g. only crotchets, or only minims, or only semibreves; those containing two note values per rhythm, e.g. crotchets and minims, or crotchets and semibreves; and those containing three note values per rhythm, e.g. crotchets, minims, and semibreves, or quavers, crotchets, and minims. The mean score, as a percentage of the total possible score, was calculated. The percentage score was used in order to facilitate comparison of the scores across groups, as each group had a different maximum score. These results are shown below in Table 4.2.

Number of note values per rhythm	mean % score	SD
One note value per rhythm.	75.60	10.00
Two note values per rhythm	54.40	14.99
Three note values per rhythm	37.70	21.95

Table 4.2: Mean percentage score, indicating accuracy of Rhythm Performance relating to the number of different note values

Pearson's correlation coefficients were calculated in order to examine possible links within test scores, and between test scores and age. The results are shown in Table 4.3. No significant correlation between Rhythm Performance test scores at any stage and age was found. For each test, with the exception of the pre-test, there was a significant correlation found between it and the following test stage. For example, there was a significant correlation ($p<0.05$) between post7 and post14 scores, and between post14 and post-test scores.

	pre	post7	post14	post	re	age
pre	1.000					
post7	.003	1.000				
post14	.191	.642*	1.000			
post	.240	.255	.673*	1.000		
re	.026	.055	.420	.868**	1.000	
age	-.232	.122	.308	-.285	-.084	1.000

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.3: Correlation coefficients for age and Rhythm Performance test scores.

The children's progress in tapping in time with the cartoon character Itchy is shown in Table 4.4. There was a potential maximum score of 10 for each test. Two children, participants 2 and 3, did not enjoy the Tapping in Time with Itchy tasks at all. Although in the early stages it was possible to persuade them to carry out the tasks, by post-test stage their dislike of the activity was such that they refused to co-operate. Their scores are therefore not included in the analysis.

A 3x3 (speed by test stage) fully repeated measures ANOVA was employed to examine the scores. No significant main effect was found for speed [F (2,14) = 0.028; p >0.9], or for test stage [F (2,14) = 2.898; p >0.088], and there was no test stage by speed interaction [F (4,28) = 2.210; p >0.09].

A paired samples t test was employed to examine (at mm 60) pre to post-test stage scores. Post-test stage scores were found to be significantly higher than pre-test stage scores (p<0.05).

		pre-test stage	post7 stage	post14 stage	post-test stage
mm40	mean		2.4	4.3	6.38
	SD		2.12	3.40	3.81
mm60	mean	2.8	3.5	4.5	5.25
	SD	2.20	2.51	3.37	2.19
mm80	mean		3.1	5.9	4
	SD		2.85	4.09	3.50

Table 4.4: Number of consecutive taps in time with the cartoon character Itchy at each test stage.

The marked individual differences in the Tapping in Time with Itchy scores at mm 60 are shown below in Table 4.5

child	pre-test stage	post7 stage	post14 stage	post-test stage
1	3	1	3	3
2	1	0	5	
3	2	2	4	
4	8	9	10	10
5	4	4	5	5
6	3	4	5	3
7	3	2	1	5
8	3	4	10	5
9	1	5	2	5
10	0	4	0	6

Table 4.5: Individual children's scores on the Itchy tests at mm 60.

The progress of the children in Tapping in Time with Vivaldi is shown below in Table 4.6. A 2x3 (speed by test stage) fully repeated measures ANOVA was employed to examine the scores.

		post7 stage	post14 stage	post-test stage
slow pulse	mean	1.2	1.9	3.38
	SD	1.69	1.45	2.13
quick pulse	mean	5	6.8	7.63
	SD	3.46	3.49	2.77

Table 4.6: Mean scores, at each test stage, on the Tapping in Time with Vivaldi test. (Maximum score of 10)

Significant main effects were found for test stage [F (2,14) = 6.427; p<0.01], and speed [F (1,7) = 43.318; p<0.001]. There was no significant test stage by speed interaction [F (2,14) = 0.307; p>0.05].

Tukey's HSD follow up tests revealed no significant difference between scores obtained at post7 stage and post14 stage, or between scores obtained at post14 stage and post0test stage ($p > 0.05$). Significant differences were found between the slow and quick scores at post7, post14, and post-test stages ($p < 0.05$).

In order to test for a link between scores on the Constant Pulse tests and scores on the Rhythm Performance tests a correlation matrix showing both Constant Pulse and Rhythm Performance post-test scores was calculated, and shown in Table 4.7. The 'Itchy' column shows the number of taps in time with the cartoon character, the 'Viv' column the number of taps in time with the piece of music, and the 'cont' column the number of taps which correctly continued the given pulse. No significant correlation between any of the Constant Pulse test scores and post-test score was found. There were also no significant correlations between any of the Constant Pulse test scores

	itchy@40	itchy@60	itchy@80	vivquick	vivslow	cont@40	cont@60	cont@80	age	post
itchy@40	1.000									
itchy@60	.415	1.000								
itchy@80	.203	.447	1.000							
vivquick	.231	.324	.661	1.000						
vivslow	.191	-.054	-.382	.075	1.000					
cont@40	-.704	-.049	.329	.136	-.448	1.000				
cont@60	-.255	-.116	-.608	-.137	.693*	-.043	1.000			
cont@80	-.139	.380	.000	.052	-.322	-.107	.023	1.000		
age	-.195	-.209	.059	-.444	-.037	.223	-.337	-.625	1.000	
post-test	-.244	.408	.064	.012	.347	.400	.570	-.028	.076	1.000

* Correlation significant at the 6% level (p= 0.057).

Table 4.7: Correlation matrix of Constant Pulse scores, age, and post-test scores.

themselves. The only correlation that approached significance at the 5% level was between scores on tapping in time with Vivaldi at a slow pulse, and Pulse Continuation at mm 60 (r=.693, p <0.06).

Pulse Continuation scores are shown in Table 4.8. Here the number of consecutive taps at the correct speed, following the withdrawal of the constant pulse stimulus, is shown in the column

child	cont@40	cont@60	cont@80	own@40	own@60	own@80
1	2	1	1	2@40	2@29	5@106
4	1	0	3	2@47	9@93	6@64
5	0	1	1	7@60	8@75	8@206
6	0	0	1	5@87	3@110	2@69
7	0	4	4	10@145	5@73	4@84
8	2	4	1	3@46	10@68	10@102
9	2	0	5	5@54	6@88	5@74
10	0	2	5	4@95	2@59	5@72
Mean	.88	1.50	2.63	4.75@71.75	5.63@74.38	5.63@97.13
SD	.99	1.69	1.85	2.71@35.60	3.16@24.32	2.45@46.57

Table 4.8: Pulse Continuation scores at the three metronome speeds

'cont@40' etc., and the number of correctly spaced taps, regardless of speed, is shown in the column 'own@40' etc.. For example, participant 8 accurately tapped two taps at mm 40 (+/- 12%) and then changed speed to maintain three taps at mm 46. At mm 60 the same child managed four taps at the correct speed before playing ten taps at mm 68.

Three different types of Constant Pulse test were administered to the children: Tapping in Time with Itchy, Tapping in Time with Vivaldi, and Pulse Continuation. Each test had a potential maximum score of

10. To investigate the differences and similarities of the post-test stage scores on these Constant Pulse tasks a 3X2 (test by speed) ANOVA was employed, using the scores shown below in Table 4.9. A significant main effect was found for test [F (2,14) = 9.053; p<0.01], and a significant test by speed interaction found [F (2,14) = 8.456; p<0.01]. No significant main effect was found for speed [F (1,7) = 2.140 p>0.1]. Tukey's HSD follow up tests showed that overall the Tapping in Time with Vivaldi scores were significantly higher than the Pulse Continuation scores (p<0.05). The Tapping in Time with Itchy scores at mm 40 were significantly higher than the Pulse Continuation scores at the same speed (p<0.05). The

Test	Mean (Max 10)	S.D.
Itchy@40	6.38	3.81
Itchy@80	4.00	3.51
Vivaldi Slow	3.38	2.13
Vivaldi Quick	7.63	2.77
Pulse cont. @40	.88	.99
Pulse cont. @80	2.63	1.85

Table 4.9: Constant Pulse test scores at post-test stage.

Tapping in Time with Vivaldi Quick scores were significantly higher than both the Tapping in Time with Itchy, and the Pulse Continuation scores at the higher speed (p<0.05). The interaction effect can be seen in the graph of speed against test scores, Figure 4.6.

Scores on the Tapping in Time with Vivaldi test were significantly higher at the quick pulse than the slow (p<0.01). The differences between the Pulse Continuation scores at mm 40 and mm 80 approached significance at the 5% level (p=0.058). There was no significant difference found between the scores on the two Itchy tests.

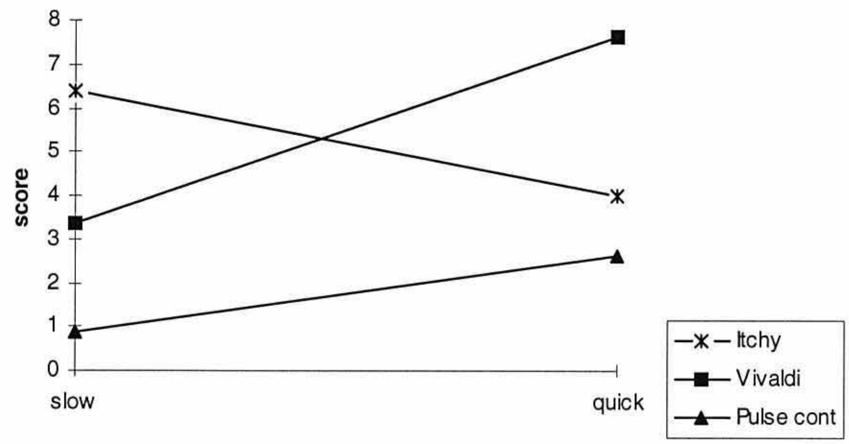


Figure 4.6: Graph showing Constant Pulse post- test stage scores at the quick (mm 80) and slow (mm40) pulse.

Discussion

These results show that once again the children who took part in the study learned how to perform simple rhythmic phrases from conventional notation. Pre to post-test gains were significant while post to re-test changes were not, indicating that learning had taken place. This replicates what had been found in the earlier study. However the purpose of this study was to investigate whether utilising part-task training would facilitate young children's accurate rhythm performance from conventional notation. It had been thought that the use of such training would facilitate the performance of rhythms containing more than one note value, as such rhythms necessitate dual task performance. However the pattern of accuracy was the same as in the previous study: rhythms containing only one note value were played more accurately than those containing two, which were in turn played more accurately than those containing three.

One half of the part-task training was to teach the children how to maintain a constant pulse, the other to teach them the note values. Of the two the constant pulse results are of particular interest, as they are most relevant to the purpose of this study. However, the conclusions that can be drawn from the analyses are far from conclusive.

Constant Pulse test results

Three tests of constant pulse ability were given: i) tapping in time with the cartoon character Itchy, ii) tapping in time with an extract from the Vivaldi Lute Concerto, and iii) continuing to tap at a given speed. For the first two, performance scores were taken both early on in practice and at the post-test stage, and for the third at post-test only.

Tapping in Time with Itchy

Significant pre to post-test gains, at mm 60, were found for this test, but the children displayed marked individual differences. At the pre-test stage eight of the children could only manage three or fewer taps, while one child managed eight consecutive taps, which is more than the remainder achieved at post-test stage. Although all the children except two improved their scores, it is interesting that, despite their improvement, they were still unable to score as high as the child who obviously had a strong initial aptitude. The conclusion drawn here is therefore that although practice can improve ability, over the time scale of this study initial aptitude is of greater importance. However, maybe the practice itself was not best suited to the children. The cartoon character had been included to maintain the interest of the children, which it did. It is possible though that the use of a visual training stimulus caused interference with the auditory, resulting in less improvement. Of course it could also be argued that the use of two different modalities reinforced the idea of a single constant pulse. A further study is therefore needed to establish whether the additional visual aspect is a help, or a hindrance.

A further study using a wider range of speeds, and with all speeds tested at all test stages is also needed. In the analysis of the test scores obtained on all 3 speeds no significant effects were found. However the speeds mm 40 and mm 80 were not tested until the post7 session, and perhaps the children had already improved by that time. No significant difference between the scores according to speed was found. A wider range, perhaps mm40 to mm120, or even quicker, is needed to investigate if there are optimum performance speeds.

Tapping in Time with Vivaldi

The separate analyses of these scores revealed a significant main effect for both speed and test stage. The children definitely preferred tapping at the quicker pulse, with some finding it extremely difficult to slow down and tap the slower pulse. By post-test stage four of the children achieved the maximum score (10) at the quick pulse, whereas none did at the slow pulse. The children's ability to keep time with a piece of music is in keeping with that reported by Moog (1976) and Frega (1979). Moog reported that 'most' 4- and 5-year-olds are capable of clapping in time to music, and Frega (1979) that 47% of 3-year-olds and 93% of 4-year-olds can do so. Because of this reported increase in ability over time, it may be thought that the increase in ability displayed by the children in this study was a result of maturational factors, rather than learning. However, the results of the correlation analysis revealed no significant correlation with age at all.

Pulse Continuation

The Pulse Continuation scores, recorded after the post-test, indicated that the children had not, in general, grasped the idea of continuing an existing pulse at exactly the same speed. Only one child, at one of the three speeds, continued the original pulse. The remainder changed speed dramatically when left to continue on their own.

The comparison of the different Constant Pulse test scores at post-test stage revealed significant differences in attainment levels on the tests. For example, the scores achieved on the Tapping in Time with

Vivaldi test were significantly higher overall than those obtained on the Pulse Continuation tests. This reflects what had been observed during the teaching sessions: the children found the Pulse Continuation task by far the most difficult of the three, and the Tapping in Time with Vivaldi task the most straightforward. However one child, who also scored the maximum score on the Tapping in time with vivaldi test at the quick pulse, could manage the Pulse Continuation task suggesting that, given further practice, more children may also have done so. The interactive effect can be explained by the nature of the tasks. Tapping in Time with Itchy required auditory and/or visual processing, and was better performed at the slower rather than the quicker pulse, possibly because of the time required to process the information. Both the Pulse Continuation and the Tapping in Time with Vivaldi tasks required only auditory processing, and were better performed at the quicker pulse. This pulse, mm80, is in keeping with that chosen by the children when performing their rhythms.

In the correlation analysis of Constant Pulse test scores, the only correlation that approached significance, at the 5% level, was between the Tapping in Time with Vivaldi test at the slow pulse and the Pulse Continuation test at mm 60. The children found both of those tasks difficult so it is tempting to assume that the correlation is a result of that difficulty. However other tasks, such as the Pulse Continuation test at mm 40 were also difficult, and no correlation at all was found for those tests. The issue is very unclear. A further study with more children, and, as already suggested, a wider range of speeds, is needed to clarify the situation.

The lack of any correlation between these Constant Pulse scores and post-test scores suggests that constant pulse ability may not be as necessary as musicians think it is. This lack of link is counter-intuitive as a pre-school child capable of tapping in time with a piece of music would be described as having a 'good sense of rhythm', and be expected to be better at learning rhythm performance. Likewise, a great deal of emphasis has traditionally been placed on the ability to overtly maintain a constant pulse, usually by counting. The ability to maintain a steady stream of taps at a given speed would, therefore, be considered an important one, and indicative of future ability. It is surprising that in this study neither of those abilities were found to be linked to accurate performance. There are a number of reasons why this could be the case:

i) These abilities are in fact linked, but at this stage pre-school children are not able to utilise constant pulse strategies in their performance.

ii) The ability to maintain a constant pulse is an ability that is acquired through experience, and is more associated with expert performance than with novice.

iii) The children did not make sufficient progress to enable them to utilise the ability. If the study had lasted longer, and the children had not been introduced to rhythm notation **until** a minimum competency in maintaining a pulse had been reached, then a link may well have been found. The children all received 20 ten-minute sessions, five minutes of which were spent on constant pulse activities. Perhaps if more time per session, or more sessions, had been spent on constant pulse activities then there would have been a greater improvement. There was an improvement, suggesting that, despite their age, very young children are capable of improvement on the tasks, but they either need more time, or the tasks need to be presented to them in a more appropriate way, in order for greater improvement to occur. In particular, it seems probable that those children who initially scored very low would benefit from more practice than those whose initial scores were high.

iv) The small number of participants prevented the link from being identified. Looking at the scores of individual children is revealing: only two children scored 10 (maximum) on the Itchy test, and the same two children gained the two highest scores on the post-test. Four children scored 10 (maximum) on the Tapping in Time with Vivaldi test at the quick pulse. Two of those children gained the highest two marks on the Rhythm Performance post-test. However the remaining two only gained the 5th and 7th highest marks. Repeating the study with a greater number of participants would reveal whether these scores were indicative of a trend, or merely isolated incidents.

The findings of this one study are of course not sufficient to state that there is no link between constant pulse ability and rhythm performance ability. As outlined above more research is needed, including a similar study with older children, to investigate whether the lack of a relationship between rhythm performance and constant pulse abilities, if present, is indicative of novice performance in general, or only of this age group.

Dual task learning

It is interesting to relate the findings of this study to those of the Learning Strategies Project. When Fabiani et al. (1989) investigated the effectiveness of different strategies as a function of initial ability they reported the appropriateness of different methods to be dependent on initial aptitude. Children who have a high initial level of constant pulse ability may benefit from a different teaching method than those who have a lower level, and, in particular, those with a lower initial ability may need extra time at the start of learning. The use here of an approach based on the hierarchical method of Frederiksen and White (1989) has displayed encouraging possibilities. It is suggested that perhaps the method needs to be even more hierarchical. Perhaps constant pulse training tasks should be introduced in a manner structured to the requirements of individual children, with easy tasks such as tapping in time with a piece of music introduced first, and more difficult ones only introduced when a required performance level performance is reached.

The findings reported in the literature (see Lane, 1979; Pearson & Lane, 1991; and Irwin & Burns, 1997; for example) that children under the age of ten are unable to utilise attention switching methods are supported here. The children's attention was directed towards playing the correct note, not to maintaining a constant pulse. As a result of this they frequently paused while deciding which note came next. If a child stopped in this way then they were instructed not to do so, and reminded that in music it is not possible to 'stop and think'. No improvement was observed as a result of this instruction. It was as if the children were genuinely unaware that were in fact stopping; their attention was elsewhere and could not be re-directed. Birch (1976) reported the 7-year-olds in her study to be capable of improving performance on one task when told that it was the most important. It would be interesting to repeat this study with 7-year-olds in order to investigate whether they were capable of responding to that instruction.

Observation of the children supports the idea of simultaneous processing. Allport et al. (1972) considered that the performance of their participants in the dual task situation was so high as to only be achievable by the use of parallel processing, an idea which is supported here. The children, when performing accurately, apparently did not process the information serially, as suggested by Weldon (1952), Fisher (1975), and Pashler (1992). On such occasions they were observed to be looking ahead and reading subsequent notes. Conversely, the children were frequently observed to be processing information serially during inaccurate performance. On these occasions a gap between consecutive notes was noticed, during which the children were observed to be looking at the next note.

The other task, that of learning the note values, was once again achieved without any problems. All the children were quickly and easily able to correctly match the animal and note value pairs. This again reinforces the idea that the difficulty with rhythm performance is not knowing how long the notes should be, but accurately performing them. Encouragingly, some of the children were on occasions observed to be looking ahead to the next note concurrently with performing another in the same manner as Sloboda (1976, 1978b) observed in expert sight readers. These children were beginning to utilise, at a very basic level, an essential component of accurate rhythm performance.

Constant pulse training activities

Once again, in my role as teacher, I was able to observe the children's behaviour closely, and in particular note the difficulty they experienced with some of the constant pulse activities. The most difficult task was continuing a pulse that I had begun (the Pulse Continuation tests). The majority of the children invariably deviated a long way from the original pulse, and even though they were told they had changed speed, and also that they should not do so but should keep **exactly** the same speed, they demonstrated little or no improvement. Because the children were so unaware of their, usually dramatic, change in speed, I considered that they perhaps did not understand the verbal instruction. I therefore spent time demonstrating slowing down and speeding up. After such examples the children could identify when I changed speed, but still not accurately assess their own performance.

Most of the children also found it difficult to tap in time with the cartoon character, much more so than had been envisaged, and were unable to perform the task very well. Simply touching the screen was much easier and better carried out. One of the planned tasks, the game in which the children made their Itchy jump in time with the one at the top of the screen, was abandoned. It was attempted once, with a child who had a high initial ability in the area, but even he found the task extremely difficult and not enjoyable, and so it was not attempted with the remainder of the children.

Either tapping the table or pressing the beeper in time with me was much easier, and therefore better performed. In that activity the children did not have to remember the pulse in order to perform the task accurately, they simply had to stay in time with me. On that task all the children could improve their performance in response to the instruction 'listen carefully, you play at exactly the same time as me, we have to sound like one person'. Later this game was extended to include both the child and myself hitting the drum at the same time, again something that they enjoyed. The opposite game, that of me having to keep time with them, was also enjoyed by the children, but not as effective as if I failed to do so they usually took great delight in thinking that I had 'got it wrong', rather than viewing their own performance as inaccurate. The ability to perform accurately when an external pulse was present, but not when it was absent, suggests that the children are actually not able to maintain a constant pulse in their head at all. However as explained earlier, one child could manage the task, so it could well be that with more practice more children would have been able to do so.

Keeping time with a piece of music was the most straightforward of the constant pulse tasks. The performance of this task did not present any problems, and was greatly enjoyed. Many different pieces of music were used (see Appendix D), and different cuddly toys were used to dance to the music. The use of toys worked well as it meant that whilst the toy was dancing I was able to hold one of its arms, and the child the other. By this means I could control the toy's movements and enable the child to experience what moving in time with music felt like, introducing the kinaesthetic element identified by Bebau (1982). Similarly, the children enjoyed clapping in time to nursery rhythms. Again, to enable the child to feel accurate clapping I initially held their hands, and gently clapped them for them.

Note reading activities

The actual learning of note values and reading the rhythms did not present any problems. As had been anticipated the children enjoyed working with the Animal Cards and found it easy to remember the cards and corresponding note values. This supports the work of researchers who have reported syllabic methods being effective in rhythm learning. (See Colley, 1987; and Davidson & Colley, 1987, for example).

The use of rhythms written on the computer also retained the children's interest, although some did initially find it difficult to realise that they were the same as those written on paper. Part of the interest was because they were written in colour, resulting in a cry of 'Oh! It's the yellow one', or whatever the child's favourite colour was. This supports the general use of colour, as suggested by Rogers (1996) and discussed in the previous chapter.

The remainder of the visual material used for learning the note values was the same as used in the previous study, and was again successful. The children once more enjoyed writing and colouring in their own rhythms, and working with the Note Cards. Once again they took great delight, when three or more note values had been learned, in there being so many Note Cards that they filled the table, or had to be spread out on the floor. In this study the games gained the additional dimension of further matching to the appropriate Animal Card. This was also enjoyed by the children, who were happy and confident to match a note card to its corresponding Animal Card, and vice versa.

Conclusion

Donchin (1989) reported that, until the Learning Strategies Project, it had been believed that simply providing trainee pilots time in a simulator would result in an increase in performance equivalent to the use of a structured practice regime. That project convincingly refuted the idea, and demonstrated that structured teaching and practice resulted in significantly better performance. Similarly, novice music performers are expected to improve their dual task performance with no more help than an instruction to 'look and think ahead'. Whilst this study does not show convincingly that dual task instruction improves performance, it does suggest that future projects, which take into account the limitations and shortcomings of this study, may well do so. It also indicates that despite their age some of the children were capable of a limited amount of dual tasking. This was most clearly evident when a child was observed looking ahead to the following notes whilst concurrently playing others.

Many researchers (see Guttentag, 1989, for example) reported that dual task ability as such was not linked with age. The performance of the children in this study was not compared against that of older children, but it would be useful to do so in order to assess developmental trends. In particular, improvement would be expected by the ages of 5 and 7.

The use of the Nidaq timing board, button, and PC proved to be successful. The children were happy to use the button, and the timing program accurately recorded the lengths of the notes, and silences. This accurate recording of note duration is seen as an essential part of test scoring as it completely removes the subjective grey area that inevitably occurs when a performance is not perfect, but is not so wrong as to be instantly classed as wrong. The removal of this subjectivity is as a step forward in reliable marking. The only decision left is the one as to what percentage of error is allowable. The figure of 12% proved to be a reliable one as when two musicians, accustomed to working with children, were asked to mark a sample of the performances their marking was in agreement with the +/- 12% figure.

However, an important and fundamental question remains: is the ability to maintain a constant pulse really that important at this stage, or is it a strategy used and needed only by more advanced performers? If it is the latter then we are at risk of overloading beginners unnecessarily by expecting them to be able to overtly maintain a constant pulse from the earliest stages.

The study reported in the next chapter may well help to answer that question; no attempt will be made to encourage the children to use a constant pulse. In addition, the children will not be taught note lengths by any conventional means, rather they will be expected to 'acquire' that knowledge purely by exposure to written rhythms and their correct performance. Intuitively the children might be expected to have difficulty learning, to not learn as well, or even not learn at all. An argument could be made that a procedure such as rhythm performance, which has traditionally been so dependent on the correct application of rules, cannot successfully be taught by any another means.

Chapter Five

A Connectionist Approach to the Teaching of Rhythm Notation[1]

At the end of the previous chapter a fundamental question was asked: is the ability to overtly maintain a constant pulse essential in the early stages of learning to perform from rhythm notation? One of the aims of this study was to investigate that question further. If the children do not receive any practice or tuition in constant pulse activities, will that make a difference to their learning? A further aim was to investigate whether the traditional dependence on rules is justified, or whether simply exposing children to complete written phrases, together with their correct performance, will enable them to formulate their own, effective, interpretation of the system.

Both of the previous studies concluded that poor performance was not attributable to a lack of understanding of the lengths of notes, or an inability to remember which written note corresponded with which length of note. Rather, poor performance was attributable to the difficulties the children experienced in accurately performing rhythms that contained more than one note value. They had learned the rules but still could not accurately apply them. Ryle (1949) first identified the distinction between these two forms of knowledge; he referred to it as the difference between 'knowing that' and 'knowing how'. Although many of Ryle's examples involved physical activities such as riding a bicycle, others were cognitive tasks such as knowing how to play chess, or how to talk grammatically. In a rule-based system the 'knowing that' is taught first, in the belief that it will provide the knowledge necessary to 'know how', and music has traditionally been taught in this way. It is expected that 'knowing that' a minim is twice

[1] As before, the term *rhythm performance* will be used to describe performance from conventional rhythm notation. When other kinds of performances are described they will be specifically described as such.

as long as a crotchet, will lead to 'knowing how' to accurately perform a rhythmic phrase.

However it is widely recognised that these instructions are actually not sufficient for the learning of a skill, and that something more is necessary to get to the stage of 'knowing how'. The exact nature of the transition is a matter of debate. Anderson (1983) suggested that procedural knowledge is initially represented as a series of statements, and is converted to production rules with practice. Newell (1990) emphasised the importance of an ongoing process of recognising generic features of rules so that they can be 'chunked' for faster processing in more complex procedures.

The appeal of connectionism is that it represents 'knowing how' in a way that dispenses with rules. Instead of 'knowing that' being a precursor of 'knowing how', the latter is arrived at without the former, and with no application of given rules. This line of enquiry seems particularly relevant to learning rhythm notation, where it is the transition from 'knowing that' to 'knowing how' that causes the problems. It may be that the reverse order progression, from 'knowing how' to perform a rhythm to 'knowing that' a minim is twice as long as a crotchet, will be more successful for learning than the traditional order.

First of all I will attempt to clarify a point concerning the use of the term 'rules', that may cause confusion. Machine learning in connectionist networks does not depend on applying external learning rules, but it may still depend on applying internal learning rules to the network. For example, a network which is taught the past tense of the English language will not be taught rules such as 'the past tense can be formed by adding the suffix *ed* to a regular verb', but a learning rule will be applied to the inner workings of the network. As will be discussed, in networks learning occurs as a result of altering connections strengths between units, and the way the strengths are altered is determined by a rule, which can be a series of extremely complicated mathematical formulae. This leads to the confusing situation where learning is described as taking place without the use of rules (external), but with the use of learning rules (internal). Therefore where the term 'learning rule' is used it describes the manner in which the connection strengths are altered, and should not be confused with rules such as 'a minim is twice as long as a crotchet' which are used as external rules to teach humans. Such rules will be acquired, although not necessarily consciously, through internal processes based on experience with, in this case, music notation and performance.

Historical background

At this point is may be helpful to place connectionism into a historical perspective. It is not relevant here to explore in detail the background to present day connectionist theories. Instead an outline detailing key stages will be given. For further information readers are referred to the excellent volumes by Bechtel and Abrahasen (1991), and McLeod, Plunkett, and Rolls (1998), that provided the main sources of information for this section. Much of the work mentioned describes learning by machines, and the reader may well wonder what the relevance of that is to learning by children! The rationale is that by investigating the processes used by machines capable of emulating human thought processes, we may increase our understanding of those processes. It is, after all, perfectly acceptable to alter the components of a machine in order to see the effect, but not to do so with people. Evidence of the validity of this kind of work can already be seen in the field of dyslexia research. Many connectionist researchers have reported networks which produce the same errors as are typical of different forms of dyslexia (for example see Hinton & Shallice, 1991; McLeod, Shallice, and Plaut, 2000). There appears to be an applicability of this kind of research to other areas of learning, including music.

It took decades for the architecture of networks to evolve, and a good starting point for a review and discussion of that evolution is the 1940's, when researchers began to follow one of two routes: a parallel processing system based on the supposed features of the brain, or a symbol processing system based on von Neumann machines. In 1949 Donald Hebb, focusing on the supposed features of the brain, published *The Organisation of Behavior,* in which he put forward a case for an ideological shift in psychological thinking. Previously psychologists had been unconcerned by the actual structure of the brain (as some still are), believing either that it was too complicated for accurate study, or that the structure itself was not relevant. Those supporting the latter view were only interested in the stimulus and response, not the physical means that enabled the response to occur. Hebb convincingly argued that it was helpful to consider the physical structure of the brain when formulating psychological theories. He was interested in learning and proposed that a synaptic change, known as the Hebb synapse, was the physical process through which learning took place: when two cells frequently fire at the same time the strength of the connection between them is increased, and therefore so is the likelihood of one firing as a result of the other doing so. Simple applications of his theory are any form of learning that involves associations. For example, if a child is repeatedly exposed to a card painted yellow at the same time as the spoken word 'yellow', then the mechanisms involved in hearing the word and those involved in colour perception will be activated simultaneously. Eventually the activation of one set of cells will lead to the activation of the other set, even in the absence of the other stimulus.

One of the early attempts at non-symbol processing networks were 'perceptrons' (Rosenblatt, 1958, 1962), a simple example of which is shown below in Figure 5.1. Perhaps the most fascinating property of the perceptron is its ability to learn. During the teaching phase a stimulus is 'given' to the input units simply by turning them on or off. The answer produced by the output unit is then compared with the correct answer, and, if correct, nothing done. If it is wrong the strengths of the connections are altered so as to make the correct

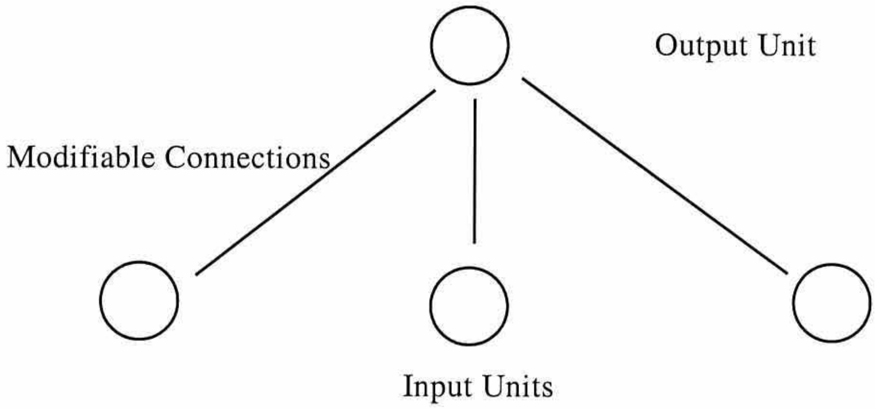


Figure 5.1: A simple perceptron

answer more likely. Eventually, after many repetitions of this process, the machine effectively 'learns' what pattern of connection strengths is necessary to give the correct response to any given input. Rosenblatt concentrated on producing networks that were capable of perception, an early example being his network that distinguished between horizontal and vertical lines (1962). Subsequently perceptrons were seen to be suitable networks to use in modelling visual perception, a task to which they were frequently put. (See Block, 1962, for example, who built a perceptron which was capable of distinguishing the 26 letters of the alphabet.) However perceptrons do have quite serious learning limitations. As Rosenblatt himself noted they are not very good at classifying objects according to a concept. For example they can learn a large number of horizontal and vertical lines but cannot then go on to classify a previously unseen example, an essential ability if the networks are to be said to mimic human perception.

One particular limitation of perceptrons, their inability to solve the Exclusive – Or (XOR) problem, became infamous. When presented with an input pair A and B each of which can either be on (1) or off (0), the perceptron cannot be taught that the correct answer is 'yes' if either A or B are on, (0 1 or 1 0) and 'no' if A and B are both on or both off (1 1 or 0 0). In their book Minsky and Papert (1969) criticised many aspects of perceptrons, but it was that limitation in particular which attracted wide attention. Subsequently it was found that by the addition of another, 'hidden', layer a network could solve that problem (see Figure 5.2). However, at the time the book appeared to raise problems of sufficient magnitude to suggest that networks were not a profitable line of enquiry. Their inability to solve particular problems was seen to be indicative of a general, more serious, problem; that they could only recognise patterns and deal with associations. By the 1960's research using networks had fallen behind that using symbol processing systems anyway, and the publication of Minsky and Papert's book was the final nail in the coffin.

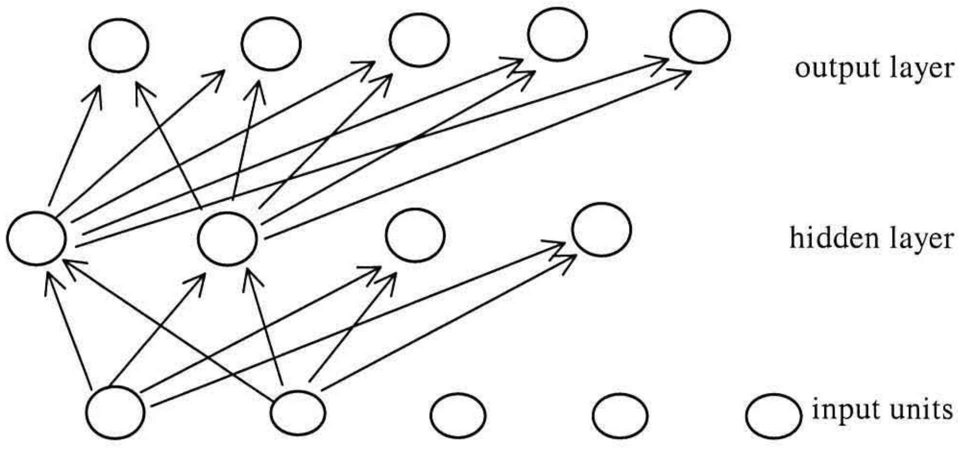


Figure 5.2: The use of a hidden layer. (For clarity not all connections have been shown)

Despite the criticisms of Minsky and Papert, research on networks did continue, but somewhat in the background. It was the 1980's before any major new advances were seen. In 1982 Hopfield developed a network (utilising a modified Hebbian learning rule) that was capable of retrieving a complete pattern even if only part of the pattern was given as input. This was a significant breakthrough as he was able to demonstrate that networks could be made to process information in the same way as do people, rather than just recognise patterns. His network displayed properties that are features of human memory retrieval: content-addressability, fault tolerance, and noise resistance; all of which are not present in symbol processing machines. 'Content-addressability' refers to the process people use of searching their memory to retrieve a desired fact. For example, when asked to remember the Christian name of a person their surname may be remembered in the hope that it will jog the memory. If that fails then the Christian names of other members of the same family may be recalled in an attempt to recall the name in question. Conventional systems cannot achieve this task, which humans do all the time. 'Fault tolerance' and 'noise resistance' refer to the ability to arrive at the correct answer even if there are mistakes or omissions in the information given to it. Humans, for example, cope with minor spelling mistakes when reading, or a few words can be missed out of a sentence completely and the meaning still understood. These are all features of human thought processes that, when present in a network, very convincingly support claims that the machine is mimicking human cognition.

Another network produced around that time is the oft-quoted 'Jets and sharks' network of McClelland (1981). He constructed a network which learned the characters of West Side Story, along with their profession, age, marital status, etc.. Once learned the network exhibited the same characteristics as if a person had learned the facts. It too was content-addressable. By inputting the various attributes of a person their name was given as the output. It was tolerant of faults: the correct name would be found even if one of the input values were wrong. It also displayed 'graceful degradation'; if the network was overloaded by giving it too much information it still kept going rather than crashing. Impressively, it also managed to produce reliable answers when 5% of its connections were destroyed (Bechtel & Abrahamsen, 1991). Although interesting and much quoted, the network does not follow conventional construction though, as, rather than information being stored as a pattern of connection strengths, each unit stored information. McClelland's network is an example of *localist* construction, where each unit represents one concept. A more flexible design, and the one most commonly used, is *distributed*, where a concept is represented by the strengths of the connections between units of different layers.

Whatever task a connectionist network is being asked to learn the procedure is dependent on altering the strengths of the connections between the units of different layers. This obviously has to occur in an ordered way, not merely haphazard, and there are three main ways of achieving this, falling into the two categories of *supervised* or *unsupervised* learning.

Supervised learning

Two examples of supervised learning are:

i) The network has the correct response imposed on the output layer, and the connection strengths are altered in order to achieve this response.

ii) The network is told what the correct output should be, the difference between that and its actual output calculated and the strength of the connections altered according to whichever learning rule is being used. (See below for a discussion of learning rules.)

Unsupervised learning

> The network is not actually told what the correct answer is, but finds its own way of arriving at it.

There a number of learning rules, together with modifications of those rules, but they fall into one of the two main categories listed above.

Learning rules

Some forms of learning are more intuitively suitable for application to human learning than are others. An example of a learning rule that is well suited to human application is the Hebbian rule, which has been briefly mentioned, and is an important example of supervised learning. The rule is appropriate for any task that involves learning associations, and that kind of learning is important for humans engaged in many activities, including learning rhythm notation. There is, however, a major difference between it and other examples of supervised learning: with Hebbian learning the output units have the correct answer imposed upon them, whereas with other rules the units produce their own answer, which is then judged to be correct or not. Networks using either the Hebbian rule, or a modified version of it, have shown impressive results (see Hopfield, 1982).

Another example of supervised learning is the backpropagation, or generalised Delta rule. Here the network is allowed to produce its own output, which is then compared to the correct output, and the error calculated. The backpropagation method was developed as a way of using error calculations in networks with a hidden layer. The addition of hidden layers makes a network much more flexible and powerful. Indeed there are many problems, such as the XOR, which cannot be solved without it. However the existence of the hidden layer creates problems for any learning rule that depends on error calculation. How can the amount of error present at the hidden unit stage be known when there is no correct answer for that stage? By linking error on the output units with the hidden units feeding them, this problem is overcome. Hence the name 'back' propagation: information is sent backwards from the output layer to the hidden units. The technique is very successful but critics claim that it is biologically implausible because it requires information to be passed in two directions, and there is no evidence that this actually happens in the brain. Furthermore the actual number of units in the hidden layer is crucial. Too many or too few and the network will not function. Despite this many researchers favour backpropagation as a learning rule and it is extensively used in research with machines. Sejnowski and Rosenberg (1988) utilised backpropogation in their NETtalk model. This three-layer network was successfully taught to read English, and, when the hidden units were subsequently examined, it was discovered that the network had learned to differentiate vowels from consonants, and had produced grapheme-phoneme clusterings. Although effective in machine learning, it is difficult to see how the rule can be utilised in human learning.

An example of *unsupervised* learning in a network is competitive learning. Intuitively it would seem that it is not possible for learning to take place in such circumstances, as the network is never told what the correct answer is; it finds regularities in the inputs which it then uses to form clusters or patterns. It is termed 'competitive' because the output units compete with each other to decide which one has produced the largest response. Connections to input units that feed this response are then strengthened, while those to units that do not are weakened. Eventually the input units become grouped, with one output unit reacting to that group. An example of this was demonstrated by Rumelhart and Zipser (1985) who developed a competitive network that learned to classify patterns of letters. In humans the application of such learning is very limited, as it is always possible that a person would group the information in a different way to that intended. 'Discovery learning' is an example of this kind of learning, but it is difficult to see how rhythm notation could be learnt in that way, as the outcome of learning has to correspond to the accepted interpretation of the symbols. In humans, 'guided discovery learning', however, channels the learner through active exploration of the skill or knowledge to be acquired, to a pre-determined solution.

In *reinforcement learning* the network is not told what the correct output should be, but is told whether or not the output is close to that required. A subsequent desirable change in output will increase corresponding connection strengths, while an undesirable one will decrease them, an approach that has links with the training and conditioning of humans and animals. As with humans and animals though, it takes many, many training trials before the output reliably matches that required, and for large networks training is therefore problematically slow. Although reinforcement learning has many applications with humans it is not suitable as the sole means by which rhythm notation is learned, as, at best, training would take so long as to not be viable. However it is a very useful supplementary learning tool in many areas, including rhythm performance. Novices, for example, may be allowed a greater degree of error than more experienced performers. Their initial ability and accuracy may be 'fine tuned' by reinforcing accurate responses, and the teacher being increasingly demanding as to what constitutes an inaccurate performance.

Machines that talk

The acquisition of language, both verbal and written, is a subject that has attracted a phenomenal amount of attention from researchers. It is a complex behaviour that is uniquely human, and so it is easy to see how the challenge of constructing a network that can read and/or talk is so irresistible to connectionist researchers - and they have far from resisted! A recurrent feature of the networks is that, like Hopfield's of 1982, they find the structure in language even though it is not a component of the training. It has traditionally been assumed that only by the use of rules can something as complicated as the English language be effectively learned. However this results in both many rules and also many exceptions to the rules, and it is these exceptions that cause problems. Even the pronunciation of single syllable words is fraught with difficulties, as manifest by the different pronunciation of visually similar words such as *'save'* and *'have'*, *'dough'* and *'tough'*, *'how'* and *'tow'*. The list is seemingly endless. Then there are the words that are spelt identically, but pronounced differently depending on their meaning. Just how is it possible to learn the pronunciation differences between 'I'm learning to *read*' and 'I've *read* that book'; a '*lead* pencil' and 'taking the *lead*'? Yet the vast majority of children accomplish this learning task. If connectionist theories can help in understanding how this is accomplished, then they should also be of assistance in understanding the apparently simpler task of reading and learning music notation.

In 1989 Seidenberg and McClelland taught a two-layer (plus one hidden layer) network, by using backpropagation, to pronounce monosyllabic words in the English language. In its original form, although the network could reproduce its training words in a manner which was similar to skilled readers, it was not as efficient at reading non-words, or deciding whether a string of letters was a word or not. However with modifications it improved on those aspects. The basic idea of the network is very simple, although the implementation in terms of learning equations etc., is not. The network was presented with words, the letters of which activated the input units. The output units then generated, in response to the input pattern, phonological features. The network was taught 3,000 words, with common words being presented more frequently than uncommon. After 250 exposures to the training regime the network could pronounce 97% of the words correctly. An impressive result, and a result achieved without the need for a single rule.

Another task, which would seemingly necessitate the application of rules, is learning the past tense of the English language. Again many verbs are regular and *'ed'* can simply be added as a suffix. But many verbs are irregular, and the learning of what is or is not regular, and the nature of the exception if the verb is irregular, is a difficult task. Rumelhart and McClelland (1986) were the first to tackle the problem of past tense learning by networks and produced a network that they claimed successfully did so. They also claimed that it was developmentally accurate as, like young children, it went through a stage of over generalising the rules and producing *'ed'* endings where it should not have done, before progressing to accurately learning the exceptions.

The problem was tackled again by Plunkett and Marchman (1993; 1996) whose network successfully learned 500 verb stems, again showing that just because verb structure *can* be explained by rules it does not mean that it *must* be.

A major development occurred when Plaut, McClelland, Seidenberg, and Patterson, (1996) built a network reported to be capable of not only reading, but also of utilising semantic information in the reading process. This was achieved by using two pathways: one for semantics and the other for phonology. This combination is essential if the problem of the different pronunciation of 'I'm learning to *read'* and 'I've *read* that book' is to be solved.

In all of the above examples the lack of use of rules is encouraging as it supports the idea that rhythm performance from conventional notation could also be learned in a similar way.

Developmental issues

Investigations into learning the past tense were the beginnings of investigations into areas of child development in general. In particular - could a network be made to 'behave' like a child?

Underlying many theories of child development is the idea that development progresses in stages, the assumption being that the completion of one stage in some way equips the child with the necessary tools to progress further. Piaget, for example, believed that a child's thought processes were fundamentally different at different stages. He believed that early infant thought is non-symbolic, which restricts a child to only being aware of what can be seen. With the emergence of symbolic thought children can be aware of an object even when it is removed from their sight; they now have a means of representing it in their mind. There are therefore different thought processes and mechanisms in operation at different stages. This would appear to conflict with connectionist theories, as a network remains 'physically' the same throughout learning. In a network the strength of the connections are modified resulting in a gradual alteration of activation pattern, but how can such a gradual change be responsible for behaviour which changes in stages? Connectionists have risen to the challenge and produced networks in order to test whether a network can produce stage-like changes of behaviour. A brief explanation of one such stage, 'object permanence' will be described here.

Object permanence refers to an infant learning that an object continues to exist even when it is moved out of their sight. By studying the behaviour of infants Piaget concluded that, at around the age of nine months, an infant will continue to reach for an object that is no longer in view. Prior to that age it is a case of 'out of sight, out of mind'. More recently researchers (see Baillargeon, 1993 for example) have demonstrated that infants have actually gained the concept of object permanence by around the age of 4 months, but do not change their reaching behaviour until about 9 months of age.

Mareschal, Plunkett, and Harris (1995) constructed a network based on the response observed by Piaget (reaching), and that observed by Baillargeon (surprise). Of course the network could not actually reach or express surprise, but representations of both were used, which could then be developed into the actual action or reaction. The aims were to see if the network would automatically progress from reaching for a visible object to reaching for a hidden object, and to see if the expectation of where an object should be occurred before the ability to reach for it. Input came from an artificial retina consisting of 100 cells, and the output was separately processed by 'what' and 'where' channels. The use of separate output channels meant that, in effect, the network was two separate networks that could work separately, or combine at the final stage.

The results reported were that the network very quickly learned to 'reach' for an object that it could see, and also that it took much longer (another 30,000 training trials) before it would reliably 'reach' for an object that was hidden. However the transition from one behaviour to the other only involved the changing of the connection strengths, not the formation of new units or other changes to the network's architecture. The representations remained the same in kind but changed in strength, which is not congruent with Piaget's proposals, as he believed that the change in behaviour was caused by a fundamental change in representations. Like an infant, the network also took longer to learn the task of reaching for an object than it did to express 'surprise' if an object did not re-appear as expected.

Readers who are interested in connectionist theories of development are referred to Elman, Bates, Johnson, Karmiloff-Smith, Parisi, and

Plunkett's book (1996), which gives a very persuasive account of development from pre-birth in terms of connectionist principles.

Children

So does connectionism really represent the solution to all our problems? Can it be of practical help in finding ways to facilitate children's learning? An important contribution has to be that connectionism encourages us to dispense with the historical learning prop of rules. Networks learn, emulating human behaviour, *without* external rules. In teaching children or adults new skills, rules have traditionally played an important part in the process. 'Learn the rules to play the game' is the order of events. Connectionism argues a very strong case for investigating 'play the game to learn the rules', which takes us back to the difference between 'knowing how' and 'knowing that' discussed at the start of this chapter.

So what conclusions have researchers arrived at when utilising connectionist learning principles with children, rather than machine networks? I will attempt to answer that question by looking at separate areas of learning.

Learning to read

The area of young children learning to read is one that has received considerable attention from researchers over the years, and is of particular relevance to music reading. There has been hostility between advocates of different teaching methods, and in particular whether to use phonics. In her extensive review of the debate over the efficacy of different methods of teaching reading Adams (1990) concluded in favour of connectionist theories. She stressed that a combination of an effective reading programme and an effective classroom environment are essential for successful reading. In fact she went further than simply commenting on the classroom environment, and stressed the importance of the home environment of early readers. She cited research in which it was reported that children who knew their letter names before beginning reading instruction were better readers after one year than were those who did not (Bond & Dykstra, 1967; Chall, 1967). However, later it was successfully argued (Venezky, 1975) that the letter name knowledge was a result of a favourable home environment, and it was that which was the predictor of success, not the letter name knowledge *per se*. In this respect children are like networks in that they will learn from whatever information is presented to them. A child will not start to learn to read on the first day of his or her school career. Early exposure to words and books at home will have started the learning process, and connectionism explains in a palpable way exactly how effective such early positive exposure can be.

Adams does not recommend a specific reading programme. Instead she draws upon the vast research conducted in the area to conclude that emphasis on any one aspect, such as phonics, will achieve only sub-optimal results. She emphasised that it is only by many hours of fruitful reading will a child learn how to read. Simply learning phonics, the rules of pronunciation, will not, by itself, be effective. This is in agreement with what has previously been stated about rules; by themselves they are not sufficient, much more is needed. Overall her message can best be summarised as 'the only way to learn how to read is to actively read'. In that way the connections can be so well in place that it becomes an effortless task. Again, there are links here with learning by networks. Learning in networks takes many thousands of training trials, and likewise learning to read, argued Adams, takes many, many, hours, and there is no short cut.

Snowling (1998) reviewed traditional accounts of reading development and acquisition, and compared them with connectionist theories and applications. She too concluded that connectionism represents a very plausible way to approach the issue. In particular she commented favourably on the way it can be used to explain the development of both normal children and those who experience reading difficulties. Reason (1998) supported Snowling's ideas and went on to explain why she believed connectionist principles important when considering issues relating to teaching reading in the classroom. She very much agreed with Adams (1990), and made the point that 'the more children read the better they get at reading' (page 62).

Berninger, Abbott, Zook, Ogier, Lemos-Britton, and Brooksher (1999) conducted an intervention study, utilising connectionist principles, to investigate whether children could improve their reading without rule-based instruction. Their participants were 48 children who had all experienced difficulty in reading during their first year at school, and were at the bottom of their classes, scoring low on standardised reading tests. The children were randomly assigned to 3 treatment groups: a whole word method, a sub-word method, and a method based on a combination of the previous two; there was no control group. The authors justified the lack of control group by explaining that they were not interested in whether treatment was better than no treatment, only in whether learning to read could take place at all without the use of rules, and if it could, which particular method was the most effective.

The whole word group was taught by the instructor first showing the child the word, and if the child did not reply quickly, or gave an incorrect answer then the following explanation was given. The instructor said the word, and then followed the letters with her finger while spelling the word out, before saying the word again. The example given was the word 'sleep', which would first be said, then spelt out '*s -l-e-e-p* says sleep', and finally said again. The authors explained that the idea behind the procedure was to help the children to associate the spelling of the word with the complete written word, and to enable them to say the word when the complete word was seen. For the sub-word method the words were presented in a colour coded manner, with a different colour being used for each single or multi-letter spelling unit. In the 'sleep' example the instructor said 'sl' while pointing to *sl,* 'i' while pointing to *ee*, and 'p' while pointing to *p*. She then said the whole word. The child copied each of these stages exactly. The idea behind this procedure was to help the child associate the individual written units with their corresponding phonemes, as well as to associate the written word with the spoken word. In the combined method the words were written on both sides of the card, black on one for the whole word method, and colour coded on the other for the subword method. The child was then exposed to both readings of the word, in the relevant manner.

The reported results were that the children in all treatment groups significantly improved their scores by post-test stage. However no treatment method was reported to be more effective than another. Although the authors stated that their aim was to investigate whether learning without rules was possible, it would have been an interesting addition to compare the results from children who received the connectionist based tuition to those who received other tuition. Perhaps it was merely the one-to-one nature of the intervention that resulted in progress, and any method would have achieved the same result?

These results suggest encouraging possibilities for rhythm learning as the children were simply exposed to the word and its sound, with no rules of pronunciation given. If language reading can be improved in this way, then perhaps so too can rhythm reading.

Second language learning

Connectionism has also received attention in the area of second language acquisition. Ney and Pearson (1990) investigated the relevance of connectionism to second language teaching. Their study was concerned with the extent to which current successful second language teaching corresponds to connectionist theories, rather than an investigation into ways of improving teaching methods. In particular they likened the rote learning stage to the training phase of a network. They, like Adams and Snowling, also stressed that an effective methodology must be made up of a variety of sub-methods.

Connectionism and music

Musicians have not ignored connectionist ideas, and connectionists have not ignored music. However the areas investigated are not of much help in the search for ways to help children learn how to accurately perform from rhythm notation. Unlike in the area of language acquisition, I could find no reference to networks being taught how to read and perform musical rhythm, or to children being taught rhythm performance through the use of connectionist techniques.

Music perception has been investigated using connectionist principles (Fiske, 1996; Gruhn, 1996; Longuet-Higgins & Lisle, 1989; and Page, 1994), and the processing of harmony by Bharucha (1987). Stevens and Latimer (1992) compared the recognition of short pieces of music by musically trained and untrained listeners, and connectionist networks. They asserted that the differences between trained and untrained listeners could be represented as differences in the networks' connection strengths.

Computer generated music is an area that has received a great deal of attention, and it is an area where the complexities of rhythm cannot be ignored. Mozer (1994) developed a network called CONCERT, which was capable of generating music. Pitch, harmony, and duration were represented separately in the network, but CONCERT was not successful rhythmically. In other areas it was, being able to learn the construction of the major scale and complete previously unseen, unfinished, scales. As a test of its ability to generate music the network was taught the melodies from ten simple pieces by J.S.Bach, and then asked to continue one of the melodies from a four-note opening. The author's own comment was that the resulting music would not be mistaken for a piece written by a human. Rhythmically, although each bar contained the correct number of beats, the network had failed to learn musical style.

Gasser, Eck, and Port (1999) developed a network that was trained to recognise one aspect of rhythmical style, meter. The network contained oscillators that were linked to each other and also to the single input/output unit. When in the training phase, this single unit received input pulses which varied in intensity according to the metrical pattern being presented, with the first beat of the bar being of greater intensity. The use of a stronger pulse for the first beat of the bar is the same input that humans receive when listening to music. The network effectively learned to prefer the metrical pattern, either duple or triple, on which it had been trained, and was also more efficient at detecting changes from that meter to another. The actual description of the workings of the network is extremely complicated and mathematical, but it was capable of emulating a feature of human rhythmical development; being able to tell different meters apart. The implication in their conclusion was that the authors are, unfortunately for music, intending to develop their ideas further by concentrating on the rhythm of speech, rather than that of music.

Others have adopted a simpler approach to rhythm, and represented duration by a number of time steps on the input layer. Todd (1989) used this approach, with a crotchet being 4 time steps, a minim 8, and a quaver 2 etc.. A drawback of this method is that even a short piece of music results in a very large number of steps.

Another area where the representation of rhythm is important is the computerised transcription of music performance. There are a number of computer software packages commercially available which aim to transcribe a played piece of music, i.e. to produce the written music from an instrumental performance of it. Typically the piece is played on an electronic midi keyboard connected to a computer. The software reads the midi input from the keyboard, the music is displayed on the screen, and the resulting file can be saved and edited. The conventional way for rhythm to be dealt with is for time to be split into segments, with each segment representing a note value, perhaps a semiquaver. The problem is that because of the normal slight inaccuracies of performance, together with the complexity and variety of rhythm, the programs tend to produce a transcription which, for anything but the simplest rhythm, is at best spoilt by many mistakes, and at worse musical gibberish. Desain and Honing (1991) developed a network that overcame these problems by the addition of an interactive unit that effectively mediated between the input units in order to ensure that the result made musical sense.

Away from music, connectionist researchers are close to developing a network that can explain how the brain processes time. Shapiro (1999, in Wearden, 2000) constructed a network where the spreading of activation measures time, rather like dropping a stone in water causes the ripples to grow over time. By using this method he has developed networks that display properties characteristic of human timing, such as scalar. Could such networks soon represent human rhythm processing?

Methodological issues

Interesting though that question is, the task here was to investigate whether children can learn to perform from conventional rhythm notation without being given any rules from which to work. The children were not instructed to count, or given words with which to associate each note value. They were simply shown written rhythmic phrases along with a demonstration of their correct performance. Feedback, in terms of whether their performance was accurate or not, was provided when the children performed the phrases themselves.

Berninger et al. (1999) improved children's reading by linking the correct response to stimulus presentation. In this study, it was decided to use a similar method, adapted for rhythm reading. The method has its roots in Hebbian learning, which in its most fundamental form, is simply learning associations between stimuli. However, for successful rhythm performance the children need to progress beyond the stage of producing the correct response to learned stimuli; they also need to be able to produce the correct response to novel stimuli. In order to achieve that an element of reinforcement learning was also used. The combination of the two kinds of learning resulted in a logical learning sequence:

i) The starting point was to associate specific written rhythms (training rhythms) with their correct performance. Exposure to the correct answer is a natural way for young children to learn, and a way in which they learn many skills.
ii) The child was then asked to produce the correct response to the training stimuli. Any errors at this stage were corrected by telling the child that their performance was not correct, followed by a demonstration of the correct response.
iii) The final stage was producing the correct response to novel stimuli.

In one of the methods used in Berninger et al.'s study the attention of the children was brought to phonemes by the use of colour. In a similar way, in this study, children who were not able to progress on to the final stage, that of being able to produce the correct response to novel stimuli, were given extra help. This extra help was only to draw the children's attention to the fact that some notes were longer than others, and that each button press was represented by one written note.

The first problem was to decide which rhythms to use as the training rhythms. In the research studies that taught networks how to read, the most common words were presented first, and also more frequently, reflecting their natural occurrence. Children of this age are exposed to a variety of music, ranging from that which is not specifically aimed at them such as that listened to by their parents, to that which is part of their own environment, such as nursery rhymes. Nursery rhymes are readily learned by children, and appear to have a universal appeal. It was therefore decided to use a small number of these rhymes as the vehicle for teaching rhythm. Furthermore, the use of nursery rhymes helped to counter any differences in the home musical exposure of the children. In the nursery the children all had a similar repertoire of songs, and a similar exposure to them.

However there is a problem with nursery rhymes: they only contain semibreves at the end of phrases. The true length of the note is therefore not apparent, as the increased duration could be the result of a gap between one phrase and the next. To overcome this, new songs were written which used semibreves as a central part of the phrase. It was decided to use two songs per note value, on the basis that one would not give sufficient exposure to the note values, and more than two might be too difficult for the children to remember.

The main purpose of this study was therefore to ascertain whether it is possible for young children to learn to perform rhythms from conventional notation without the use of rules. A secondary purpose was to investigate further the role of constant pulse ability. The previous study (Chapter Four) was specifically designed to improve the children's ability on constant pulse tasks. By giving the same Constant Pulse tests to the children in this study, comparisons could be made. It is expected that the children in the previous study would, as a result of the relevant training which they received, score higher on the tests than the children in this study, who were to receive no constant pulse training.

Methodology

Participants

Ten children (6 girls and 4 boys, from the same nursery as previously) took part in the study. Their ages at the start of the study ranged from 3 years 5½ months to 4 years 4½ months (mean age 47.35 months). Written consent was obtained from the parents, and it was verbally established that none of the children was receiving private music tuition.

Resources

Computing equipment

The same computing equipment was used as in the previous study. (See Chapter Four, page 102, for a description.) As before the computer and beeper button were used in the teaching sessions as well as the testing sessions, but the timing program itself was only used during the testing sessions.

Teaching Materials

i) During the initial training phase two songs were linked with each note value. The songs used are shown in Table 5.1. (See Appendix F for a full copy of the songs.)
ii) The training rhythms were written in large print on sheets of A4 paper.
iii) Some of the above rhythms were written, in colour, to a

computer file, as in the previous study.

iv) Other, novel rhythms were also written in large print on A4 paper.

v) The child sometimes used a small teddy bear and/or a clown to play the rhythms.

Title of song	Associated written rhythmic phrase
Ding dong bell	♩ ♩
Twinkle, twinkle little star	♩ ♩ ♩ ♩
The wheels on the bus	♩ ♩ 𝅗𝅥
Clap hands	♩ 𝅗𝅥
I've got	𝅝 ♩
I can march	♩ ♩ 𝅝
Mi welais jac y do	♩ ♫ ♫
Jingle bells	♫ ♩ ♫ ♩

Table 5.1: Training songs and associated rhythms

Testing Materials

Constant Pulse

With the exception of the Itchy program, which was not used, the same Constant Pulse tests were administered as in the previous study. These were:

i) Tapping in Time with Vivaldi. The children tapped, both at a quick (crotchet) and slow (minim) pulse, in time to an extract from the First Movement of the Vivaldi Lute Concerto. Again the number of taps, at each pulse separately, in time with the music was recorded, up to a maximum of 10.

ii) Pulse Continuation at mm 40, mm 60, mm 80. At each of the speeds I began pressing the button and invited the child to join in. They were told that I was going to stop, but that they were to continue at **exactly** the same speed. The number of correct consecutive taps (+/- 12%) was recorded by the timing program, up to a maximum of 10.

Rhythmic Discrimination.

As the children would not be given any rules from which to work they would themselves have to be aware of the differences between the training rhythms, and then discover the relevance of those differences to the written rhythm. It follows that if they could not discriminate between two performed rhythms, they would be unable to learn which written rhythm corresponded to which performed rhythm. It seems logical that children who were better able to detect rhythmic differences and similarities would learn quicker, and perhaps more efficiently. A Rhythmic Discrimination test was therefore included in order to test for this hypothesised link. For this test the children listened to two rhythms, played by me using the beeper button. They simply had to state whether the two were the same or different. (See Appendix G for a copy of the test.)

Complete Rhythms

The same Rhythm Performance test was used as previously. As in the study reported in Chapter Four the children performed the rhythms by pressing the button attached to the computer. The timing program recorded the length of each button press, together with the length of the interval between presses. (See Appendix B for a copy of the test).

Procedure

All the teaching and testing sessions took place in one of the purpose built research rooms in the nursery, and were video recorded. The computer was also used to record all testing sessions.

Teaching Sessions

Before the teaching sessions began (and also prior to the administration of the pre-test), the children were taken in groups of 3 or 4 to practise the nursery rhymes. This was to ensure that all the children were indeed familiar with them. The sessions lasted 20 minutes and each child took part in a total of 3 sessions. The children were familiar with most of the songs, having learned them as part of their everyday nursery activities, and so only had to learn the two semibreve songs.

The teaching sessions began within a few days of the pre-test. Each child had two individual ten-minute sessions per week. This routine was occasionally interrupted by a child's absence from the nursery, but the total number of session was 20 in each case, with no child exceeding an overall time limit of 14 weeks.

The sessions were grouped into three stages, and a child was not allowed to move on from a stage until it had been successfully completed. Rather than introducing the four note values at the same time the notes were introduced in the order crotchets and minims together, followed by semibreves, and finally quavers. The progression through the three stages was repeated for each new note value. An explanation of each stage is given below:

Stage One

The aim of the early sessions was to introduce the children to the written representation of the rhythmic phrases they had learned in the nursery rhymes. As an example the introduction of the rhythm ♩ ♩ 𝅗𝅥 is given; all the rhythms were introduced in a similar manner. My words and actions are written in *italics* and the words and actions of the child in standard typeface. Obviously the children responded differently, so the following are examples of typical responses.

After some introductory conversation I said:
'Let's sing the song "The Wheels on the Bus".' The written rhythm was then placed on the table and the child's attention drawn to it.
'This is the part that goes 'round and round' (singing). Just that part and no more. Let's sing it together...........' Usually the child tried to carry on and sing more of the song. This was corrected by:
'Oh no! We can't keep going because this – (pointing to the written phrase) is only this much.... (singing 'round and round' again).'
'Let's try again.'
Child this time stops.
'Good! Well done! Now see if you can sing it by yourself.'
The child sang the phrase correctly.
'OK. Now let's try the beeper! It goes .... (I play the rhythm). Now you try.'
If the child made a mistake, it was corrected with the words:
'Listen really carefully, it goes (I repeat the phrase).'
Child tries again.
The phrase was then repeated until the child played the correct rhythm three times, after which the song was sung again.

Once a child had learned the first four rhythms, those using crotchets and minims, and was confident and accurate in playing them, the progression to the next stage was made.

Stage Two

The aim of this stage was to match the written rhythmic phrases to performances of the phrases, and *vice versa.* This stage took the form of various games:

i) I sang a phrase (without words) and the child had to state which song it was from.
ii) The rhythms were placed on the table and I played one of them. The child had to point to the one I had played.
iii) From the rhythms on the table the child had to choose one, without telling me which one, play it, and I had to guess which one it was.
iv) I showed a phrase to the child and asked him or her to sing the appropriate song.
v) The rhythms were placed face down on the table and the child chose which one to turn over and play.
vi) The computer rhythms relevant to the learned note values were minimised and the child chose which ones to maximise and play.

In all of the games teddy or clown were occasionally used to 'play' the rhythms. Mistakes during the games were corrected by my saying *'listen carefully – (playing the rhythm), now try again'*. Even if the child played the rhythm correctly, I/teddy/clown still repeated it to provide exposure to the correct version.

When a child consistently gave the correct answer in these games then Stage Three, the performance of previously unseen rhythms, was begun.

Stage Three

A previously unseen rhythm, but only made up of the note values learned was placed on the table and the child asked *'How do you think this goes?'*
Only a brief amount of time was spent on this stage, sufficient for the child to demonstrate that they had understood, but no more.

When the crotchet and minim values had been successfully learned the semibreve songs were introduced by my saying *'Let's sing a new song to-day'*. The same procedure was followed as before, and as soon as the child could recognise and distinguish between the two training rhythms all learned values were used.

The following tactics were used if a child had difficulty with a particular rhythm:

i) As clown or teddy played the rhythm I held one arm and the child the other. In this way the child could feel the correct rhythm as well as hear it.
ii) Whilst using the beeper they put their finger on top of mine, again enabling them to feel the rhythm.
iii) Whilst playing the rhythms they placed their finger on one half of the beeper while mine was on the other.
iv) Copying games. I played one of the training rhythms and the child simply had to copy it.

Each session followed the same pattern. It began with work using the written rhythms, followed by the singing of one or more of the songs, and concluded with playing each of the rhythms once more.

Testing Sessions

The children were given the pre-test, 20 ten-minute individual teaching sessions, and then post-test. An intermediate test (to test for change in performance level) was given after Session 11. A re-test was administered 7 weeks after the final teaching session in order to check that learning had taken place. The Constant Pulse tests were administered at pre and post-test only. The Rhythmic Discrimination test was also given at pre and post-test stages only.

Pre-test – Rhythm Performance

Once again the Nidaq timing board connected to a PC computer and beeper was used. In the previous study this had proved to be an accurate and reliable means of recording the lengths of the notes, and the children were happy to press the beeper.

The wording of the pre-test had to be slightly different with this group as it was important not to instruct the children as to the precise nature of the association between the written note and performed duration. The first part of the test was introduced and conducted in the same manner as previously, but at the point where the written music was introduced the wording was changed and is described below:
'Now – something that you probably won't have seen before.' Removing the word and replacing it with a sheet of A4 with 2 crotchets written on it. 'What's that I wonder?'
'Don't know.'
'It's music, and you're going to learn how music is written down. I've already learnt and I know that if I see that it goes....... (I play the rhythm on the beeper button attached to the computer).'
'Can you do it?'
Child presses the beeper.
'Yes!' The piece of paper is removed and changed to one with 2 minims. 'And I've already learnt that if I see this it goes.........(I play 2 longer beeps.'
'Your turn.'
Child presses the beeper
'Good! Well Done! Now – (the rhythm 𝅗𝅥 ♩ ♩ *is placed on the table.) I've already learnt that if I see that it goes .... (I play the rhythm). Your turn.'*
The child presses the beeper.
'Yes! Now - I've got some more for you to do!'
At this point the pre-test rhythms were presented to the child one at a time. (See Appendix B for a copy of the test). Each rhythm was introduced with the words *'How do you think that goes?'* or *'And that*

one?' or *'What about this one?'*. The child was praised frequently during the test and when finished the computer file saved.

Pre-test - Rhythmic Discrimination

The Rhythmic Discrimination test followed on immediately. The beeper was placed in the middle of the table and I said:

'Now - I'd like you to do some listening – can you listen ever so carefully? If I go ♩ ♩ and then ♩ ♩ they're the same aren't they.'

Child nods head or says 'Yes'.

'They were the same, they sounded the same. Listen again – ♩ ♩ is the same as ♩ ♩ .'

'OK. But if I go ♩ ♩ and then ♫ ♫ ♫ ♫ it's not the same is it?'

Child shakes head or says 'No'.

'You try –play something which is the same as this ♩ ♩ Do the same again.'

Child plays 2 crotchets. (The explanation was repeated if the child did not manage to produce a matching pair).

'Well done! That was really good. Now let's try another.'

'Is this ♩ ♩ the same as 𝅝 𝅝 ?'

'No'

'Well done – it isn't is it.'

'Tell me if this ♩ ♩ ♩ is the same as this ♩ ♩ ♩ ?'

'Yes.'

'Well done it is. And now is this ♩ ♩ the same as this ♩ ♩ ♩ ♩ ?'

'No.'

'Well done – that was a difficult one.' Any errors at this stage were corrected, and the pair of rhythms repeated.

After that the Rhythmic Discrimination test was carried out, with errors not being corrected. The test was introduced with *'Now let's try these. Are you going to listen ever so carefully?'* Each question was asked in the same manner as the practice examples by my saying *'Is this .... the same as ....?'*
At the end of the test the child was praised and taken back to the main nursery.

Pre-tests - Constant Pulse

The constant pulse tests (tapping in time with Vivaldi and Pulse Continuation) were administered 2 or 3 days later. As before a short extract from the first movement of the Vivaldi Lute Concerto was played and the number of consecutive taps in time with the music noted. The extract was played through twice, once for the child to tap the quick, crotchet, pulse; and again to tap the slow, minim, pulse.

The Pulse Continuation test was administered at the same metronome speeds as in the previous study: mm 40, mm 60, and mm 80. I began by pressing the button with the child at the appropriate speed. They were then told that I was about to stop, but they were to keep going at **exactly** the same speed.

Post11 test

An intermediate test was given after session 11 in order to test for change in performance level. It was decided not to give the intermediate test as early on as in the previous study (post7) so as to give the children enough time to have extracted their own information. The test itself was administered in the same way as before, with the following explanation given by way of introduction: *'Here are some rhythms which you haven't seen before, but just have* *a look and see how you think they go.'* Each rhythm was introduced by *'How do you think this one goes?'* or *'What about this one?'* or *'Oh! Look, here's another!'*, and the child was frequently praised.

It had been decided that if, by the post11 test stage, some or all of the children had not been able to extract the necessary information themselves, they would be given hints. The children were not told the precise nature of the relationship between the notes, rather a general explanation was given. They were told that for each written note they should press the beeper once, and their attention was drawn to the fact that some of the notes were coloured in black, while some were left white. It was simply explained that the ones that were left white were longer.

Post-tests

The Rhythm Performance post-test was administered within 5 days of the final teaching session, in the same manner as the post11 test. The constant pulse tests were given 2 or 3 days later.

Re-test

The re-test was given 7 weeks after the final teaching session. The children received no tuition, and were not allowed to practise, in the intervening period.

The tests were marked as previously. Tapping in Time with Vivaldi was marked from the video recording, with a mark being award for each consecutive tap in time with the music, up to a maximum of 10. The Pulse Continuation test was marked from the computer file (margin of error +/- 12%), again with a mark awarded for each correct consecutive tap, up to a maximum of ten. For the Rhythm Performance test the duration of each note was calculated, and a mark awarded for each correct note (+/- 12%). The exceptions were again Question 3, where only ½ mark was awarded for each correct note, and the quaver questions, where ½ mark was awarded for each correct quaver.

Results

Table 5.2 shows the test scores and ages for each of the children. As can be seen one child, participant 7, did not improve at all from pre to post-test. This was because she was completely uncooperative during the sessions, refusing to sing or tap as required. She did however enjoy the sessions very much, but on her terms! She completely refused to sing the requested songs, preferring to sing those of her

child	pre-test (max 37.5)	post11 (max 37.5)	post-test (max 37.5)	re-test (max 37.5)	age
1*	11	11	23.5	27	51.5
2	7	17.5	24	27.5	52.5
3	5.5	13.5	20.5	23.5	52
4*	6.5	6.5	23.5	23	52
5	5.5	20.5	25	22	49.5
6	14.5	18.5	22.5	26	46.5
7	11	7.5	11		44
8	5.5	9	25.5	20.5	42
9*	5.5	12	15.5	15.5	42
10*	13	15.5	23	22	41.5
Mean	8.5	13.15	21.45	23	47.35
S.D.	3.51	4.79	4.65	3.71	4.66

* Indicates those children who needed more help. (See also Table 5.3)

Table 5.2: Age and Rhythm Performance test scores.

own choosing. Because she enjoyed the sessions it was felt that she should continue with them, and the possibility remained that she would become more co-operative. This however did not happen and so her scores were not included in the analyses.

A one-way repeated measures ANOVA was employed to investigate whether the children improved their scores on the Rhythm Performance test over the course of the sessions. A significant main effect for test was found [F (3,24) = 46.266; $p<0.001$]. Tukey's HSD follow up tests indicated that there were significant differences between pre and post11 test ($p<0.01$), and between post11 and post-test ($p<0.01$). No significant difference was found between post-test and re-test ($p>0.05$).

Four children (indicated by asterisks in Table 5.2) were judged to need extra help by post11 stage. The scores and ages of the children who needed more help, and the scores and ages of those who did not, are shown in Table 5.3. A 2 x 4

		Did not need explanation n=5	Needed explanation n=4
pre-test	Mean	7.6	9.0
	SD	3.91	3.58
post11	Mean	15.8	11.25
	SD	4.58	3.71
post-test	Mean	23.6	21.38
	SD	1.98	3.92
re-test	Mean	23.9	21.88
	SD	2.86	4.77
age	Mean	48.5	46.75
	SD	4.34	5.78

Table 5.3: Rhythm Performance test scores and ages of the children who needed more explanation, compared with and those who did not

(group by test) repeated measures ANOVA revealed a significant main effect for test [F (3,21) = 47.177; $p<0.001$], as indicated in the previous analysis. No significant main effect for group was found [F (1,7) = 1.142; $p>0.3$], or significant group by test interaction [F (3,21)

= 1.395; $p>0.2$]

In order to test how well the children coped with complicated rhythms, compared to straightforward ones, the scores on the questions were again grouped according to the number of different note values. For example, the 'one note value per rhythm' group contained all the rhythms that only contained crotchets, or only minims, or only semibreves etc.. The 'two note values per rhythm' group consisted of the rhythms which contained crotchets and minims, or crotchets and semibreves, or quavers and crotchets, etc.. Finally in the 'three note values per rhythm' group were the rhythms that contained crotchets, minims, and semibreves; or quavers, crotchets, and semibreves, etc.. No rhythm contained more than three different note values. The mean percentage score for each group was calculated and is shown below in Table 5.4. As each group had a different maximum score the percentage score was used in order to facilitate comparisons.

number of note values	mean % score	SD
one note value per rhythm	80.22	9.96
two values per rhythm	60.00	7.75
three values per rhythm	35.22	14.20

Table 5.4: Mean percentage score according to the number of different note values

A paired samples *t* test was employed to investigate scores on the Rhythmic Discrimination test (shown in Table 5.5). When the children were taken as a whole group (n=9) post-test stage scores were significantly higher than pre-test stage scores ($p<0.05$). However, when only the scores of the 6 children who managed the pre-test stage were subjected to analysis pre to post-test gains were not significant (p>0.09).

child	pre-test (max 10)	post-test (max 10)
1	7	9
2	5	5
3	7	7
4	4	6
5	6	7
6	Did not understand	7
8	Did not understand	6
9	8	8
10	Did not understand	5
All 9 children		
Mean	4.11	6.67
SD	3.30	1.32
The 6 who scored on pre-test		
Mean	6.17	7.00
SD	1.47	1.41

Table 5.5: Rhythmic Discrimination test: pre and post-test stage scores.

Pre to post-test stage changes in the number of consecutive taps in time with Vivaldi were recorded and are shown in Table 5.6.

		pre-test stage	post-test stage
Vivaldi slow			
	Mean	2.75	1.75
	SD	3.20	2.06
Vivaldi quick			
	Mean	4.50	5.50
	SD	1.85	3.12

Table 5.6: Pre and post-test stage scores for Tapping in Time with Vivaldi. (Maximum possible score = 10)

The scores were subjected to a 2 x 2 (speed by test stage) repeated measures ANOVA and a significant main effect for speed was found [F (1,7) = 9.625; p<0.05]. No significant main effect was found for test stage (p>0.05), and there was no test stage by speed interaction [F (1,7) = 1.231; p>0.3]. Scores at the quick pulse (post-test stage) were significantly higher than those at the slow (p<0.05).

Pulse Continuation scores at the pre and post-test stages are shown in Table 5.7. A 3 x 2 (mm speed by test stage) repeated measures ANOVA indicated that there was a significant test by mm speed

		pre-test	post-test
Continuation @40	Mean	2.33	2.11
	SD	1.66	1.90
Continuation @60	Mean	2.22	4.67
	SD	1.79	4.15
Continuation @80	Mean	3.44	1.67
	SD	3.05	1.80

Table 5.7: Pulse Continuation scores at pre and post-test stage.

interaction [F (2,16) = 3.989; p<0.05]. No significant main effect was found for test stage [$F = (1,8) = 0.025$; $p>0.8$], or for mm speed [F $(2,16) = 2.227$; $p>0.1$).

The interactive effect can be seen in Figure 5.3. Follow up tests

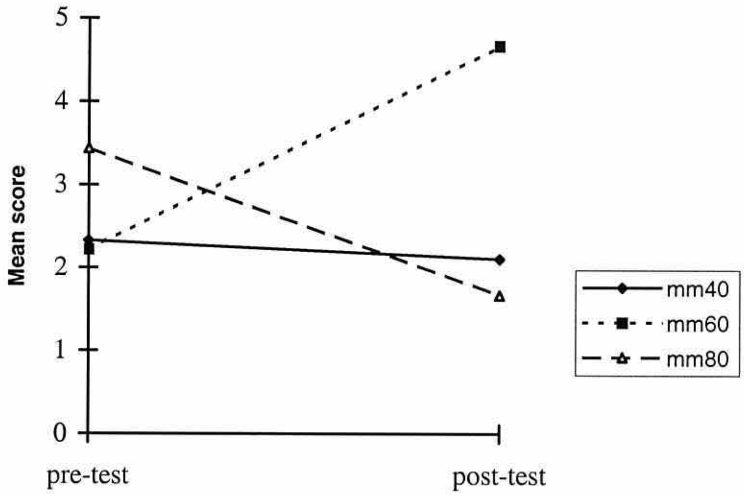


Figure 5.3: Graph showing Pulse Continuation scores at pre and post-test stage

revealed that there were no significant differences between the scores at pre-test stage. At post-test stage scores at mm 60 were significantly higher than scores at mm 40 and mm 80 ($p<0.01$).

Pearson's correlation coefficients were calculated to examine links between the Rhythmic Discrimination scores, Constant Pulse scores, age, and Rhythm Performance test scores. The results are shown in Table 5.8.

The Rhythm Performance re-test scores were significantly correlated with pre-test stage Pulse Continuation scores at mm40 ($r=0.752$, $p<0.05$), and age ($r=0.683$, $p<0.05$). Other significant correlations are identified in the correlation matrix, Table 5.8.

	pre-test	post11	post	re-test	pre40	pre60	pre80	post40	post60	post80	previvq	previvs	posviq	posvivs	RDpre	RDpos
pre-test	1.000															
post11	.288	1.000														
post	.164	.127	1.000													
re-test	.451	.266	.595	1.000												
pre40	.300	.369	.454	.752*	1.000											
pre60	-.106	-.008	.412	-.057	.267	1.000										
pre80	-.408	-.085	.640	.122	.412	.668*	1.000									
post40	-.497	.451	.085	.124	.145	.213	.250	1.000								
post60	-.287	.689*	-.271	.110	.290	-.107	-.036	.718*	1.000							
post80	-.449	-.040	-.831**	-.860**	-.669*	-.323	-.402	.012	.267	1.000						
previvq	.271	.386	-.490	-.009	.248	-.162	-.254	-.144	.512	.277	1.000					
previvs	-.337	.596	.504	.140	.209	.137	.449	.517	.465	-.081	-.164	1.000				
posviq	-.100	.083	.350	-.162	-.015	.600	.395	-.124	-.102	-.072	.025	.430	1.000			
posvivs	-.443	.434	-.011	-.026	-.127	-.164	1.000	.351	.631	.273	.188	.708*	.469	1.000		
RDpre	-.533	-.470	-.510	-.123	-.122	-.302	-.317	.357	.524	.449	.094	.092	-.059	.598	1.000	
RDpost	.004	-.126	-.397	-.102	.114	.247	-.269	-.083	.114	.157	.229	-.292	.297	.125	.583	1.000
age	-.185	.045	.262	.683*	.352	-.109	.044	.541	.366	-.455	-.190	.193	-.183	.374	.494	.122

* is significant at the 0.05 level (2 tailed). ** is significant at the 0.01 level (2 tailed).
The pre, post11, post, and re-tests columns refer to the scores obtained on those Rhythm Performance tests; pre40, pre60 etc. refers to Pulse Continuation scores at those metronome speeds at each test stage; previvq to Tapping in Time with Vivaldi at the quick pulse, and previvs to Tapping in Time with Vivaldi at the slow pulse; and the 'RD' column refers to scores obtained on the Rhythmic Discrimination tests.

Table 5.8: Correlation matrix showing Rhythmic Discrimination scores, Constant Pulse scores, Rhythm Performance test scores, and age.

Discussion

These results demonstrate that it is possible for 3 - 4-year-old children to learn how to accurately perform previously unseen rhythmic phrases from conventional notation, without the use of externally given rules. From a musician's perspective the success of the children is counter-intuitive as rhythm learning has traditionally been based on explicit rule learning. However as stated at the start of the chapter, although in music and other domains the approach may traditionally have been to progress from 'knowing that' to 'knowing how' (Ryle, 1949), the problems associated with that approach can be considerable. The success of the children in this study suggests that our habitual dependence on rules may be misguided, especially in the early stages. However, there is no suggestion that it is possible to learn how to perform complicated rhythmic phrases without knowing the rules, but that alternative methods for the acquisition of rules may be possible. From this study it is not possible to conclude that the children learned more efficiently without being given rules, simply that they did learn. In the next chapter, Chapter Six, a comparison between the three rhythm groups will be made. Here I will only be concerned with the performance of this group.

Adams (1990), Reason (1998), and Snowling (1998), and all expressed support for connectionist based methods of reading instruction. Reliance on any particular rule-based method, such as phonics, was criticised and instead emphasis placed on the importance of spending time on the actual task itself. Here that support is extended to include rhythm instruction, and again the importance of spending time on the actual task is emphasised, as that is the means by which the children learned.

The teaching method used, one based on Hebbian learning, worked well. The children accepted the natural progression through the stages, and also occasionally displayed their thought processes. Some children were seen to follow the rhythms with their finger, indicating that they had grasped the principle of 'one symbol, one sound'; others said 'that's the long one' while pointing to a minim. They were also not disconcerted when asked to play a rhythm they had not seen before, something which perhaps would intuitively have been thought likely. They realised that it was a new rhythm, and sometimes would ask me what song it was from. Occasionally a child hesitated, and if so the only encouragement needed was for me to say 'How do you think it goes? Just try - it doesn't matter if you don't get it right.' From the perspective of a piano teacher that was surprising. In my dual role as teacher/researcher I experienced a degree of inner conflict prior to undertaking the teaching sessions for this study. The 'researcher' side of me was of the opinion that the children would be able to learn rhythm performance skills following the connectionist based instruction; the 'teacher' side was of the opinion that it would surely not be possible. After spending so many years teaching rhythm by mainly mathematical methods, with some use of syllables, that side was very skeptical that it could be achieved simply by exposing children to rhythmic phrases and their correct performance. The 'teacher' side was therefore surprised by the confidence with which all the children (once extra help had been given to those children who needed it) approached both the learning activities, and the performance of previously unseen rhythms.

It had been anticipated that some of the children would not be able to extract sufficient information by themselves, and would need to be given more information. This was indeed the case with four of the children needing further help. The extra help given was along the lines of that given by Berninger et al. (1999) who improved children's reading without the use of rules. In Berninger's study in one group the instructor spelt out the letters of the word while pointing to each letter, and in another the phonemes were printed in different colours so as to draw the child's attention to them. The instructions given to the children here, that some notes were long and some were short, and that each written note represented one press of the beeper, were of a similar nature. In neither case can they be viewed as providing rules for the child to work from. Berninger et al. reported no significant difference between the groups in his study, and the same lack of difference was found here. The children who received extra help scored similarly to those who did not. The analysis of the results revealed that although the children who did not need more explanation scored slightly higher on the tests, the differences were not significant. This is somewhat surprising as the decision as to which child should be given extra help was made according to how confused they appeared to be. The lack of significant difference indicates that the children may have actually understood more than was apparent; although they appeared to be confused, and probably felt confused, they were in fact understanding the principles involved. As the children were not initially told whether the information they had deduced for themselves was correct or not, they had to have faith in their own ability. Perhaps the confused children displayed less confidence, or maybe they had deduced the information but were relying on an adult to confirm that they were correct. It is possible that the extra help given to those children did not, in fact, tell them anything new, but simply provided reassurance that their thoughts had been correct. Obviously there is no way of knowing whether that was indeed the case, but the lack of significant difference in the test scores indicates that it is a possibility.

As previously there was no significant difference between post and re-test Rhythm Performance scores, indicating that learning had taken place. Furthermore four of the children *improved* their scores, with three more equalling their post-test score or being less than one mark below it. It is unclear why that is the case. Perhaps the intervening time was necessary for the information to somehow settle and become readily available? Perhaps the children concentrated more because the work was once again a novelty? Whatever the reason it is apparent that the children did not forget, and very convincingly retained their abilities.

It had been thought that scores on the Rhythmic Discrimination test would be linked to scores on the Rhythm Performance test. However, no evidence could be found supporting that idea, with no correlation between Rhythmic Discrimination scores and Rhythm Performance test scores. When taken as a group the rhythmic discrimination abilities of the children improved over the course of the intervention. However, that was because more children were able to understand and carry out the task at post-test stage, not because the children actually improved in their ability to do so. At pre-test stage three of the children could not understand the nature of the task sufficiently well to be able to perform it, but by the post-test stage all the children could manage it. This increase in the number of children coping with the task is interesting because the task itself was never practised during the sessions. However, although the task as such was not practised the children were constantly being asked to decide which written rhythm matched which performed rhythm, and this would be expected to increase their general discriminatory ability.

There was no significant improvement in the children's ability to tap in time with Vivaldi. However, as with the previous group, the children displayed a preference for tapping at the quicker pulse, with scores at that speed being significantly higher than those at the slower speed. There was also no improvement in the children's ability to continue tapping at a predetermined metronome speed, although the results of the ANOVA are somewhat curious. An interactive effect between test stage and speed was found. Further investigation revealed that, although at one of the speeds, mm 60, scores increased, at the other two they actually decreased. This result is rather difficult to interpret as if it were the case that quicker speeds became easier then mm 80 should also have increased. Perhaps the children tended to use a pulse of mm 60 in their rhythms and were therefore more comfortable with that speed? This was checked and four of the nine children did have a tendency to use mm 60 as the crotchet pulse at post-test stage. However those were not the children who also scored highest on the Pulse Continuation test.

There was only one significant correlation between test scores and Constant Pulse scores; namely the post-test stage Pulse Continuation score at mm 80 which correlated with post and re-test Rhythm Performance test scores. However, the correlation was negative, implying that the better the children were at continuing a given pulse at mm 80 the worse they performed on the Rhythm Performance test. That result is surprising, and lends support to the argument that, at this stage, the ability to maintain a constant pulse is not necessary for rhythm performance. However caution must be exercised as there was no correlation at the other speeds, or between the tapping in time with Vivaldi scores and Rhythm Performance post-test test scores. To further cloud the issue there was indeed a significant positive correlation between post-test stage Pulse Continuation scores at mm 60 and post11 Rhythm Performance test scores. From the data reported in this study it is not possible to arrive at any conclusions on the matter; further research is needed. Nevertheless it is suggested here that constant pulse ability may not be as important as it is intuitively thought to be. It is an ability that is valued by expert musicians, and therefore one traditionally used in teaching, but maybe it is inappropriate to emphasise its use at this stage. Further investigation is obviously needed in order to ascertain whether that is indeed the case. The issue of comparing this group, who received no constant pulse training or practice, with the dual task group, who did, will be addressed in the next chapter, as will other differences, such as the percentage error according to the number of differing note values in the test rhythms.

There was no correlation with age at post-test stage, but there was at re-test, implying that the older children had learned more effectively and retained their ability more than did the younger. There is a suggestion that although age is not a factor in the ability of the children to improve their performance, it appears that it affects learning in terms of retaining that ability. However caution must be exercised as no other age correlations were found at all.

The structure of the sessions worked well, and the children retained their interest throughout the twenty sessions. They enjoyed singing the nursery rhymes, and, as more notes were learned, the greater repertoire helped to retain their interest. They also enjoyed using the clown and teddy bear. The use of the computer in addition to the written rhythms proved popular, providing a colourful element of surprise when the rhythm appeared on the screen.

Most of the games used in the sessions did not present any problems to the children. The exception was the game in which all the rhythms relevant to the note values learned were placed on the table. Once all four note values had been learned some children did find the task of identifying the correct one quite difficult, perhaps needing a few attempts to find the correct one. However the difficulty was never sufficient to discourage them from participating in the task

So how relevant are investigations into computer connectionist networks when the aim is to teach children how to read music? It is argued here that background knowledge in the area is essential in order to understand the concepts involved, and much of this background is in the area of computers. As mentioned earlier networks have provided information that is helpful in understanding dyslexia, (see Hinton & Shallice, 1991; McLeod, Shallice, and Plaut, 2000) and networks have also been shown to exhibit one facet of child development, object permanence (see Mareschal et al., 1995). It is therefore possible that they could also provide information helpful to understanding how people process rhythm.

For example computer networks could help to solve the problem of whether constant pulse ability is important, and when it should be introduced. If a network were constructed which learned rhythm performance it would be quite straightforward to investigate the effects of different training schedules, helping in the understanding of when to introduce rules, and what rules to introduce. Unfortunately, at present, a network capable of learning rhythm performance has not been developed. Furthermore, knowledge concerning time and rhythm processing is not as advanced as in other areas. However those issues will no doubt be solved in time, particularly the time processing one. Rhythm performance though may remain one that is not pursued, with the rhythm of speech being the main area of interest, as demonstrated by Gasser et al. (1999).

As Rhythm Performance tests for this age group do not exist it was necessary to write one, and the resulting test may well, for this group, have included an extra difficulty; that of not considering meter. No attempt was made to use meter in the test rhythms, or to match the meter of the test rhythms to that of the training rhythms. According to Gasser et al. (1999) the use of meter is important, so a logical progression would have been for the meter of the training and test rhythms to initially match, with non-metrical rhythms only being introduced when a competent level of performance had been reached on the metrical. In fact some of the test rhythms were difficult, as in the implied syncopation of ♩ 𝅗𝅥 and the non-metrical

𝅗𝅥 ♩ ♩ ♩ 𝅗𝅥 . Further investigation is obviously needed to test this theory, but it seems plausible.

Conclusion

This study has demonstrated that it is possible to teach children how to perform from conventional rhythm notation without the use of rule-based instruction. Even the children who required an explanation only needed their attention to be drawn to the correct area, perhaps only to have their own ideas confirmed as accurate; they were then able to sort the rest out for themselves. This has far reaching implications for the teaching of rhythm, particularly in the early stages.

One study obviously does not provide sufficient evidence to warrant throwing away the rulebooks! Further investigations, to replicate and extend this study are needed. Apart from the issues already raised are others such as those concerning the appropriate age range. At 3 - 4 years of age children have little, if any, experience of formal rule-based instruction. This is not the case with older children who may, as a result of their prior learning experiences, be unwilling to learn by the method described in this study. It is recognised that further research is needed; however what this study has clearly demonstrated is that further investigation is justified.

The next chapter will discuss whether the children performed any differently as a result of not having to contend with rules. The children certainly enjoyed the sessions, and found the work easy to manage, but did it result in more effective learning than resulted from the other methods?

Chapter Six

A brief comparison of rhythm teaching methods[1]

This chapter investigates differences in the performance level attained by the children in the three rhythm groups. A direct comparison between the level achieved by the children taught using the dual task method (DualTask) and those taught using the method based on connectionist principles (Connect) can be made. Both groups were given the same Rhythm Performance test material, and the children's performances recorded and marked in the same way (using the 'beeper' button, timing board, and computer). There is a problem comparing either of those two groups with the first group (Initial), who participated in the study reported in Chapter Three. The work with the Initial group was very much exploratory in nature as, due to the lack of previous research, it was not clear at that stage whether such young children would be able to manage rhythm performance tasks at all. Much was learned from that group, including the unsatisfactory nature of marking the tests with a stopwatch. Although the actual Rhythm Performance test used was the same for all three groups, the difference in the means by which it was marked inevitably means that a direct comparison across all three groups cannot reliably be made.

Because of this, omitting the Initial group from the analyses completely was considered. However it was decided that if the scores of the Initial group were not significantly different to the other groups at pre-test stage then comparisons would be made, albeit with a great deal of caution being exercised in drawing any reliable conclusions from the results. Even in the comparison between the other two groups the small number of children involved inevitably means that slight differences might not be identified. The comparison therefore

[1] *As before, the term 'rhythm performance' is used to describe performance from conventional rhythm notation.*

only provides the broadest of indications, rather than fine detail. Because of the lack of previous research in the area it is considered that any differences and similarities are of interest, worthy of investigation, and provide information useful for future research.

The children in all groups received twenty individual ten-minute teaching sessions, over the course of 10 weeks. The Rhythm Performance test was administered as a pre-test, post-test, and re-test to all groups. The Initial and DualTask groups received intermediate tests after the 7th and 14th teaching session, and the Connect group after the 11th teaching session. The accuracy of the children's performances was recorded using a computer and timing program for the DualTask and Connect groups. The performances of the children in the Initial group were marked from the video recordings using a stopwatch. A mark was awarded for each correct tap (+/- 12% margin of error), with the exception of the Question 3, where ½ a mark was awarded for each correct tap; and the quaver questions, where ½ mark was awarded for each correct quaver.

Findings

Rhythm Performance tests

		age (mnths)	pre	post7	post11	post14	post	re
Initial	mean	45.65	9.3	15.65		21.85	26.2	21.75
group	SD	4.47	2.18	6.85		8.43	6.94	7.37
DualTask	mean	46.65	8.55	15.5		20.45	21.50	20.94
group	SD	4.74	2.86	3.04		4.7	4.70	3.47
Connect	mean	47.72	8.22		13.78		22.61	23.00
group	SD	4.78	3.61		4.62		3.02	3.71

Table 6.1: Age and mean Rhythm Performance test scores for the three groups

Table 6.1 shows the mean Rhythm Performance scores for the three groups. Analyses of variance were employed to investigate differences in the scores between the groups. As only six children in the first group were given the re-test, the comparison was restricted to pre- and post-test.

A 3 X 2 (group by test) repeated measures ANOVA revealed a significant main effect for test [F (1,26) = 250.847; p <0.001], with post-test scores being significantly higher than pre-test. There was no significant main effect for group [F (2,26) = 1.864; p > 0.1], and no significant test by group interaction [F (2,26) = 1.591; p > 0.2]. Scores on the re-test were subjected to a one-way ANOVA and no significant difference found between the three groups (p>0.6).

As mentioned previously these findings must be viewed with extreme caution, especially in comparisons between the Initial group and the other two. However, for each group significant differences were found, and reported in the relevant chapters, between the test scores obtained at different stages of learning, for example post7 and post14 tests. Therefore if differences of the same magnitude existed between the groups the analyses would have revealed them also. It can therefore be stated with some confidence that differences of that magnitude were not present. It may be though that smaller differences exist, but were not identified. Further research, the nature of which will be discussed later, is needed.

In order to investigate whether any of the teaching methods helped the children to cope with more complex rhythms, mean percentage scores grouped according to the number of different note values per rhythm were compared. For this the Rhythm Performance test rhythms were divided into 3 groups: those containing only one note value, e.g. all crotchets or all minims; those containing 2 note values, e.g. crotchets and minims, or crotchets and semibreves; and those containing 3 note values, e.g. crotchets, minims, and semibreves, or crotchets, quavers, and minims. For ease of comparison the scores have been converted to a mean percentage score, and are shown in Table 6.2.

		one value %	two values %	three values %
Initial	mean	86.60	67.60	48.70
group	SD	14.80	21.45	28.27
DualTask	mean	75.60	54.40	37.70
group	SD	10.00	14.99	21.95
Connect	mean	80.22	60.00	35.22
group	SD	9.96	7.75	14.20

Table 6.2: Mean percentage post-test scores according to number of different note values per question.

This comparison was repeated using only the scores from the children

		one value %	two values %	three values %
Initial	mean	94.14	78.29	64.43
group	SD	8.13	14.02	15.09
DualTask	mean	75.50	62.67	52.33
group	SD	9.44	13.78	14.58
Connect	mean	82.63	61.50	38.50
group	SD	7.35	6.74	10.94

Table 6.3: Mean percentage post-test scores according to number of different note values per question – scores from only the children who learned all 4 note values.

who performed all rhythms at post-test stage, i.e. those who progressed to learning quavers. The results are shown above in Table 6.3, and in graph form in Figure 6.1.

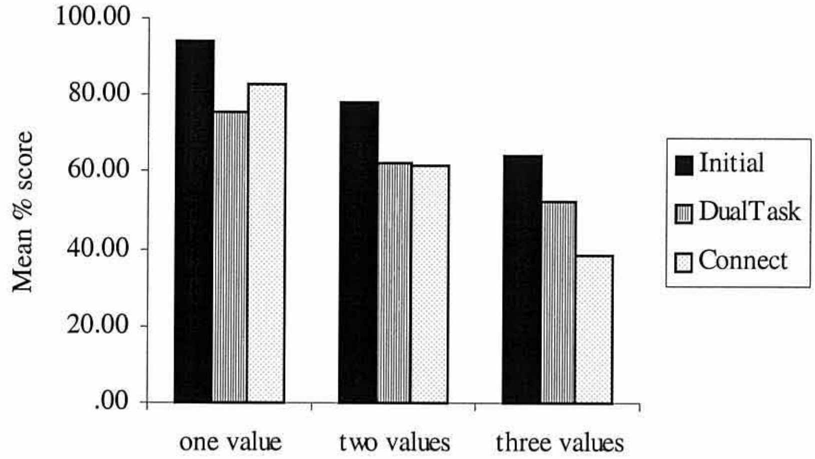


Figure 6.1: Mean percentage post-test scores according to the number of different note values per question – scores from only the children who learned all note values

The results from all groups indicated that the children found the rhythms increasingly difficult as more note values were added. This is as would be expected; scores deteriorated as increasing complexity results in an increase in error. It appears that the children in the Initial group were more accurate than the rest in their performances, especially with regard to the questions containing three different note values. For those questions the Initial group were 64% accurate, as opposed to 52% for the DualTask group, and 39% for the Connect group. However a likely explanation for this difference is the manner in which the tests were marked. As explained in the relevant chapter (Chapter Three), it was very difficult to accurately mark the questions with a stopwatch, particularly the quaver questions, and all but one of the questions in the three values group was a quaver question. Therefore lack of reliability in marking the tests is the most likely explanation for differences rather than the performances of the children. It had been anticipated that, because of their dual task training, the DualTask group would not suffer this decrement to the same extent as the others, but they did. This issue has already been discussed in the relevant chapter (Chapter Four), and will be discussed later, and so will not be repeated here.

The percentage scores for the questions grouped according to the note value they introduced were calculated, and the results shown in Table 6.4. The crotchet column refers to scores obtained on the questions that contained only crotchets (Questions 1 – 3); the minim column refers to those questions that only contained crotchets and minims (Questions 4 – 6); the semibreve column refers to those questions which only contained crotchets, minims, and semibreves (Questions 7 – 9); and the quavers column refers to those questions that contained all the note values (Questions 10 – 13). Only the scores of the children who learned and performed all 4 note values were included. These results are also shown in graph form in Figure 6.2.

		crotchets %	minims %	semibreves %	quavers %
Inital	mean	96.64	85.72	87.5	59.52
Group	SD	6.67	12.36	7.22	22.53
DualTask	mean	83.33	64.82	60.42	53.47
Group	SD	12.01	10.93	18.40	9.65
Connect	mean	83.09	68.06	64.06	43.23
Grp	SD	7.98	11.01	8.01	9.69

Table 6.4: Mean percentage post-test scores according to whether the group of questions introduced crotchets, minims, semibreves, or quavers - scores from only the children who learned all 4 note values

Seven out of the ten children in the Initial group completed the quaver questions at post-test stage, compared to six out of ten in the DualTask group, and eight out of nine in the Connect group. Therefore, only one child in the Connect group failed to learn quavers, compared to three in the Initial group, and four in the DualTask group. The possible implication to be drawn from this is that the children in the Connect group found the tasks easier, thereby enabling them to progress more quickly and learn all note values. There is no suggestion that the learning was more efficient, simply quicker.

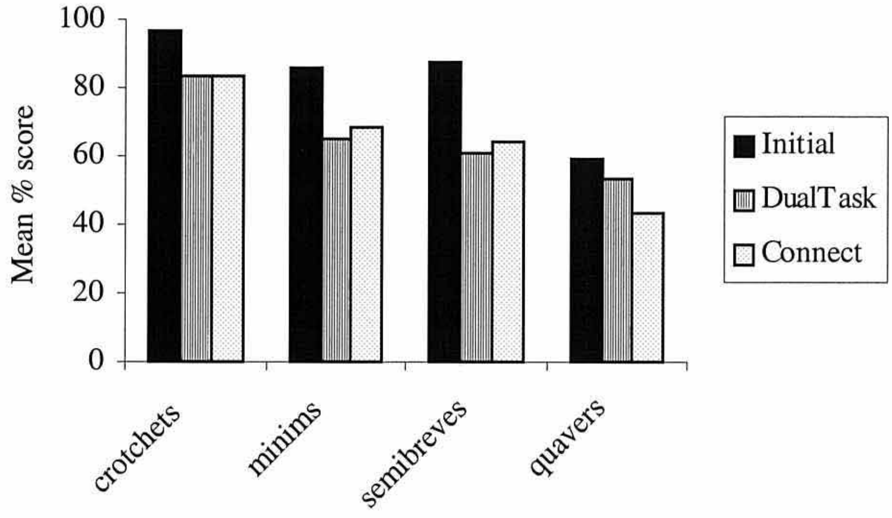


Figure 6.2: Mean percentage post-test scores according to whether the group of questions introduced crotchets, minims, semibreves, or quavers - scores from only the children who learned all 4 note values

This reflects what had been observed during the actual teaching sessions: that the children in the DualTask group found some of the constant pulse tasks difficult, whereas the children in the other two groups found almost all the tasks well within their capabilities. As discussed in Chapter Four, the difficulty level of many of the constant pulse activities was too high. Furthermore, the order of introducing the activities was erroneous. Chapter Four concluded that, in future, easy constant pulse activities should be introduced first, and more complicated tasks only after a certain level of performance is reached, rather than introducing them concurrently as here. Because the children spent half of each session on constant pulse activities it is possible that they were effectively wasting half, or almost half, of each session. If the sessions had continued in order to allot the DualTask group the same actual learning time as the other groups, then more children might have progressed to learning quavers. Moreover, even if learning by the method is slower, it may still be more secure, ultimately resulting in a higher level of performance. This potential long-term effect was not measured in this study. Many ways of facilitating dual task learning, and of improving the methodology used here, were discussed in the relevant chapter, and this comparison emphasises their need.

All groups scored very highly on the crotchet only questions, and poorly on the quaver questions. Although scores on the minim and semibreve questions were lower than the crotchet questions, the scores on those questions were similar to each other. This indicates that, although introducing minims increases the level of difficulty, subsequently introducing semibreves does not alter the situation very much. However, the introduction of quavers results in a noticeable reduction in accuracy. As before, the Initial group achieved the highest scores, however, as before, the difference in the marking procedure inevitably means that it is the likely cause of the difference, rather than the children's performances. In this comparison the scores of the DualTask group only fell from 61% to 53% between the semibreve questions and quaver questions, whereas the scores of the Connect group fell from 64% to 43%. As mentioned earlier, 8 out of the 9 children in the Connect group progressed to learning and performing quavers, whereas only 6 out of the 10 children in the DualTask group did so. There is a suggestion here that, although fewer children in the DualTask group were successful in reaching that stage, their performances were more secure when they did so. This obviously needs further investigation.

For all groups, one contributing factor to the low quaver scores may be that, in the early stages, the children slowed the crotchet pulse in order to perform rhythms containing quavers. As noted previously, in Chapters Four and Five, the children performed the Constant Pulse tests better at a quicker pulse. Simply slowing the crotchet pulse in order to accommodate quavers may in itself have resulted in performance decrement. In addition quavers were the last value to be learned, and therefore had the least amount of practice. As a result it is not possible to judge whether quavers were performed less well because they are too difficult for most children of this age, or because there was not sufficient time available to enable effective learning to take place. The children in all three studies received a fixed number of sessions. A useful alternative approach would be to continue the teaching sessions until each child had reached his or her own optimum level of performance. In that way the issue of whether quavers simply need more practice, or are fundamentally too difficult, could be investigated.

Constant Pulse tests

Differences between the Dual Task and Connect groups on the Constant Pulse tests at post-test stage were investigated. As the previous analyses had revealed that the children found the Tapping in Time with Vivaldi tests easier than the Pulse Continuation tests, two separate analyses were conducted.

		Vivaldi slow	Vivaldi quick
Dual Task group	mean	3.37	7.62
	SD	2.13	2.77
Connect group	mean	1.75	5.5
	SD	2.05	3.11

Table 6.5: Post-test stage scores on the Tapping in Time with Vivaldi test

Table 6.5 above shows scores for the two groups on the Tapping in Time with Vivaldi test. A 2 x 2 (group by speed) ANOVA was employed to examine these scores. Scores at the quick pulse were found to be significantly higher than those at the slow pulse [F (1,14) = 26.548; $p<0.001$]. There was no significant main effect found for group [F (1,14) = 3.402; $p>0.08$], and no significant speed by group interaction [F (1,14) = 0.104; $p>0.7$].

Table 6.6 below shows the scores for the Pulse Continuation test, at post-test stage.

		cont@40	cont@60	cont@80
DualTask group	mean	0.88	1.50	2.63
	SD	0.99	1.69	1.85
Connect group	mean	2.11	4.67	1.67
	SD	1.90	4.15	1.80

Table 6.6: Post-test stage Pulse Continuation scores.

The scores were subjected to analysis using a 2 x 3 (group by speed) repeated measures ANOVA. No significant main effect was found for speed [F (2,30) = 2.657; p>0.08], or for group [F (1,15) = 2.069; p>0.1]. A significant group by speed interaction was found [F (2,30) = 4.428; p<0.05]. Follow up tests revealed that the Connect group's scores at cont@60 were significantly higher than scores at cont@40. A graph of these scores is shown below in Figure 6.3.

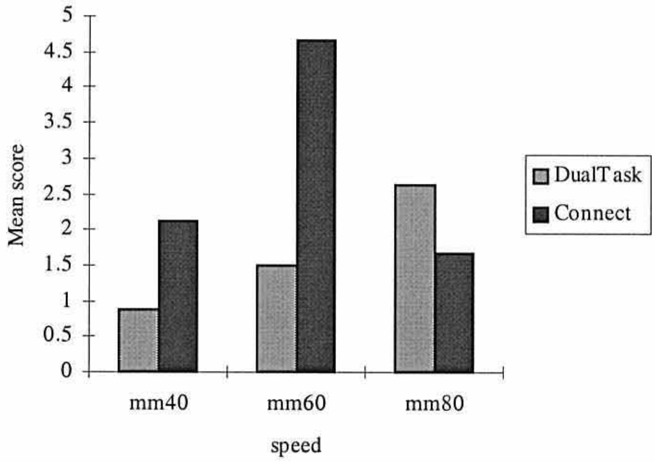


Figure 6.3: Graph of post-test stage Pulse Continuation scores for the DualTask and Connect groups

It is not clear from these results whether specific training improves constant pulse ability more than does rhythm performance and associated activities. The DualTask group received training specifically designed to improve constant pulse ability; the Connect group did not. Despite this training no significant differences between the groups were found on any of the relevant tasks. The DualTask group scored higher than the Connect group on both Vivaldi tasks, but the Connect group scored higher on two of the three Pulse Continuation tests (although the differences were not significant). This is puzzling, because only the DualTask group practised the pulse continuation tasks, it would be logical to assume that the DualTask group would, at the very least, score higher on the Pulse Continuation tests than the Connect group, even if not significantly so. Problems with the constant pulse training undertaken by the DualTask group have already been extensively discussed, and so will not be repeated here. There are two further reasons why practice on the constant pulse tasks may not have resulted in improved ability:

i) It is time spent actually playing rhythms that reinforces the idea of a constant, unchangeable pulse. Because of the time spent on constant pulse activities the DualTask group actually spent less time playing rhythms.
ii) Although the pulse was not overtly presented to the Connect group, it was nonetheless present in the songs and rhythms and could have been a feature the children used to decide which symbol corresponded to which length of note.

The above ideas are very speculative. An improved dual task methodology, and more extensive comparisons between it and other teaching methods are necessary to formulate more secure opinions.

As well as no significant differences being found between the two groups, certain similarities were observed. In the Constant Pulse tests both groups performed best on Tapping in Time with Vivaldi at the quick pulse. Tapping in time with a piece of music is, for most children, an easier task than continuing a given series of taps. For both groups, scores on the Pulse Continuation task at mm 60 were higher than scores at mm 40, and although the Connect group inexplicably dropped their score again at mm 80, the Dual Task group maintained their high score. This reflects the results of the Vivaldi tapping test; the children achieved higher scores at the quick pulse.

Conclusion

The main conclusion arising from the three rhythms studies is that 3 – 4-year-old children are capable of learning to perform from conventional rhythm notation. In addition, four points arising from the studies are of particular interest, and, although they have been discussed previously, it is worth summarising them here:

i) The traditional emphasis on constant pulse skills may be inappropriate at this stage. No link was found between Constant Pulse test scores and Rhythm Performance test scores. Furthermore, training the children on the activities did not result in significantly higher Constant Pulse test scores than no training.

ii) Counter-intuitively the children in the Connect group learned without being given any rules from which to work. Perhaps children extract more information from singing songs and other music activities than we realise. If so, this has far reaching implications for the entire range of children's musical activities. As mentioned in the introduction, we need to be aware of how much music children are exposed to in their everyday life, and the effect of that exposure, which at present is largely unknown.

iii) When marking test of rhythm performance ability it is extremely important to use a means that does not rely on human ability, either subjectively or in the operation of a stopwatch. Given current technology, a suitably equipped computer is surely an essential part of investigations into rhythm performance.

iv) Although it is apparent that children prefer a quicker pulse to a slower, there is still so much variation of preferred speed that in the early stages children should be allowed to choose their own pulse.

In the introduction it was judged that learning to read and perform rhythms would be more difficult for the children than learning to read and perform pitch. Various reasons were put forward in support of that view, the fundamental one being the very nature of rhythm. For instance, it is not possible to press the 'crotchet' key; its correct duration lies somewhere in the mind of the performer. However, the children here successfully learned crotchets, minims, and semibreves, and made a respectable attempt at learning quavers. Does that mean that they will have even fewer problems with pitch? Alternatively, was that initial premise flawed and the children will actually find pitch more difficult? The answer to that question will be sought in the next two chapters as rhythm is put to one side and pitch allowed to take its place as the focus of investigation.

With the change in focus from rhythm to pitch the reader will also notice a marked stylistic change. The chapters reporting the rhythm studies contain a great deal of background information, and are therefore some 40 pages, or more, in length. The chapters reporting the pitch studies do not contain such information, and are also written in a much more concise style. There are two main reasons for this stylistic change: firstly, the rhythm studies referred to the timing literature, which is vast, and the same link does not occur for pitch; and secondly, both pitch chapters were written for publication, and were therefore required to conform to the requirements for publication.

Chapter Seven

An initial investigation into pre-school children's ability to read pitch notation.*

The objective of this study was to establish whether young children aged 3 – 4-years are capable of understanding, learning, and utilising the pitch component of the written musical language. The previous chapters established that the rhythm component was well within their capabilities, however the nature of pitch reading is completely different to that of rhythm reading. In rhythm the symbols represent a time interval, in pitch they represent a physical location on an instrument. Furthermore the visual differences between written notes of different lengths are readily apparent, while the differences between notes of different pitches are less so. It could therefore be argued that the task of reading pitch notation is inherently more difficult than reading rhythm notation as it involves a higher level of discriminatory ability, together with a spatial ability. Of course the counter argument is that, for reasons stated earlier (Chapter Two), the perceptual processes involved in the performance of rhythm are more difficult than those involved in pitch performance. Whichever argument is favoured, what cannot be disputed is that the nature of the two tasks are very different, so success on one does not automatically mean success on the other.

In areas other than music very young children have been shown to be capable of understanding different forms of symbolic representation. Hughes (1986) showed that children from the age of 3 are capable of inventing their own written representations to show how many bricks are in a tin. Young children are also capable of discriminating between various graphic displays, with children as young as 3 able to

* This chapter is a revised version of a paper initially published in the conference proceedings of the Early Childhood Commission of the International Society for Music Education, 1996, under the title *The acquisition of the pitch component of music literacy skills by 3-4 year old pre-school children.*

distinguish real writing from scribbles to some extent (Lavine, 1977). It therefore seems reasonable to expect them to be able to understand the written musical language, providing it is presented to them in an appropriate way.

Even if pre-school children possess the ability to understand the written representation they will still be unable to apply that skill in a practical way unless they also possess the spatial ability required to understand the layout of an instrument. Researchers have reported that children as young as 3 can understand spatial representations (Blades & Spencer, 1986; Presson, 1982; Bluestein & Acreddolo, 1979); and use landmarks to understand maps (Blades & Spencer, 1990). All musical instruments have physical features that are utilised in the early stages of learning. These landmarks are more apparent on some instruments than on others, and when they are not greatly in evidence then it is common practice for the teacher to use artificial ones. For example, a string teacher will frequently place pieces of tape for the left hand thumb and figures to align to. An instrument where landmarks are very much in evidence is the piano, where the distinctive pattern made by the black notes is an easy one to follow. It therefore seems likely that young children will be able to understand the layout of the piano, aided by the use of landmarks.

The advantages of introducing young children to the piano have previously been identified (Collins, 1985a). She suggested that it is better to start at age 4 or 5 because of the interest young children have in learning new things, and their lack of anxiety about making mistakes while learning. Elsewhere (Collins, 1985b) she explained her method in more detail. In fact she did not use a teaching method that was radically different from that used for 7-year-olds. The notes were still referred to by letter names with pitch and rhythm introduced together. She also did not present any research findings to indicate the level of proficiency achieved by the children.

There appears to be a consensus among music educators (see Hicks, 1980 for instance) that children must experience the sound of music before they can be expected to understand written notation, and it has been accepted implicitly that it is the role of the teacher to introduce that sound. That children hear music from birth, if not before, has apparently been overlooked. There is seemingly no empirical evidence which establishes how much implicit learning occurs before formal teaching of music begins and this effect of environment should, claims Michel (1973) be taken into consideration in that: "Music education in nursery schools, at home and at school, must not aim to achieve those things which children have already mastered in their day-to-day contacts with music." (page 19). The need and suitability of introducing music notation in the early years has also previously been identified (Andress, 1986), but with no way of achieving it suggested.

There is a lack of relevant empirical research dealing with children under the age of 5. Capodilupo (1991) investigated the development of sight reading abilities in children aged 4 - 10. She used pictures, drawn on the actual written notes and on the keyboard, of a flying saucer for Middle C, and a moon for F. The intervening notes were explained as being 'one step away from the moon' etc.. The results reported were that the 4-year-olds could play the flying saucer and moon notes, but no others. The 6-year-olds could also play the intervening notes, implying that they had understood the stepwise structure of the scale. However the initial task of learning C and F was simply one of matching pairs, which required no understanding of music writing principles. If the first task had introduced the 4-year-olds to the concepts in a more suitable way, then they may have been capable of progressing to the second.

Because 3 – 4-year-olds are developing so rapidly it is expected that differences in ability will be found, with older children performing better than younger.

In this study the specific hypotheses investigated were:

i) That pre-school children (aged 3 - 4 years) are capable of understanding the symbolic representation of pitch and of using that skill in a practical way to play a keyboard instrument.

ii) There will be differences in ability that are linked to sex and/or age.

iii) The level of ability of the children will decline over a period if practice is not continued.

Methodology

Participants

The children were chosen from children attending a day nursery serving Bangor, Gwynedd, and the surrounding area. The children were chosen for their age, sex, and availability. Their ages at the start of the study ranged from 39.5 months to 49 months with a mean age of 44.7 months. The sexes were evenly distributed with 5 boys and 5 girls. All children at the nursery followed a music curriculum that consisted of singing songs, listening, and music and movement. Developing music literacy skills was not part of that curriculum. It was verbally established with their parents that none of the children taking part was receiving private music tuition.

Resources

The nursery contained rooms equipped and put aside specifically for research purposes and one of these rooms was used throughout. The *in situ* video equipment was used to record all the sessions.

A piano was not available for use in this room so a 5 octave Yamaha PSR36 keyboard was used instead. In order to help the children identify the middle of the instrument a piece of paper with SAMUELS written on it was placed on the keyboard, as would be found on a piano lid.

Visual Material

The visual material used in the teaching sessions is listed below. Although at no time were the notes named as C D E F G to the children, for ease of communication they will be described as such here and refer to Middle C and the 4 notes above it. Because the children were being introduced to letters and simple words as part of their nursery activities it was decided that it would be too confusing to use letter names for the notes.

1) *Distorted Keyboard.* (See Figure 1.) An altered version of a life size drawing, on A4 paper, of a portion of a piano keyboard.

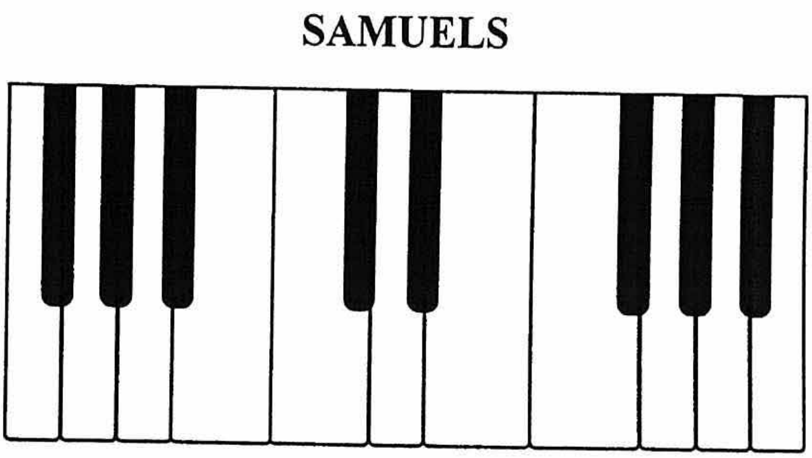


Figure 7.1: The distorted keyboard

2) Note Cards. (See figure 2.) Fifteen of these were used, 3 for each of the notes C, D, E, F, G. The actual cards were 10 cm by 15 cm.

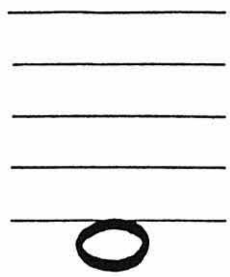


Figure 7.2: An example of a Note Card.

3. *Normal Paper Keyboard.* This was a life size drawing, on A4 paper, of a portion of a piano keyboard, with middle C in the middle.
4. *Blank Stave.* A stave with lines 2.6 cm apart drawn on A4 paper.
5. *Flappers keyboard.* (See figure 3.) A flap that hid the cartoon character covered each one of the white notes. The child was asked to find the note that corresponded to the 'yes' character.
6. *Animal Keyboard.* This was a Normal Paper Keyboard with an animal drawn on one note. There were 10 such keyboards, two for each of the notes C D E F G.

The tests

In the absence of established music reading tests for this age group a measurement instrument was devised to assess the level of proficiency of the children, and used for the pre, post, and re-tests. The children were shown the appropriate Note Cards followed by melodies, and asked to play the corresponding notes on the keyboard.

A mark was awarded for each correct note. (See Appendix H for a copy of the test.)

SAMUELS

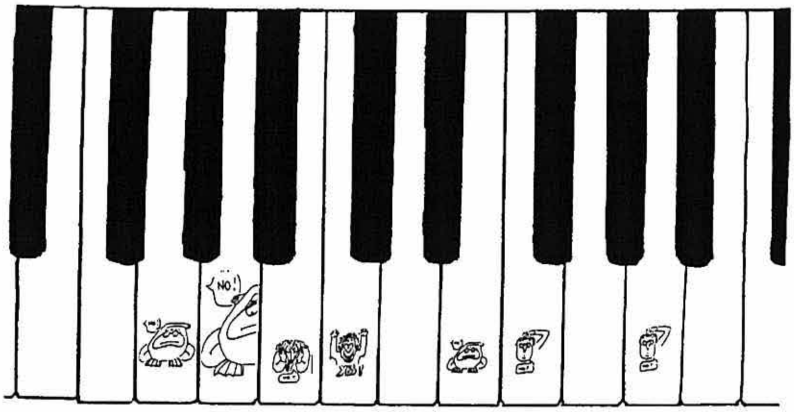


Figure 7.3. The flappers keyboard, with the 'Yes!' character on Middle C.

Procedure

A pre-test was used to establish the children's initial level of understanding of conventional notation.

Before administering the pre-test the children were given an explanation of how music is written down. They were shown the C Note Card and its location on the keyboard. It was then explained how, as the notes on the keyboard progressed to the right, the written note went higher, by steps, up the lines. The pre-test was administered immediately afterwards.

Teaching Sessions

The teaching sessions began within 7 days of the pre-test. The children were divided into groups of two or three. Each child received 2 twenty-minute sessions per week, and a total of 21 sessions. The first 10 minutes of each session were taken up with work at the table away from the keyboard.

A typical early session would begin by looking at the Distorted Keyboard. The notes in the black group were counted and the children asked to place their fingers on the two black note group. The Note Card of C was then shown and how to fall off the two black notes onto C demonstrated. All the notes were described in such a way as to help the children remember their visual appearance: C was "the one with the little line", D "the one that's touching", etc.. These labels were then linked to others that would help them remember the position on the keyboard: C was "the one at the side", and D "the one in the middle", etc.. In order to facilitate the recognition of the written notes and the learning of the corresponding note on the keyboard many different games were utilised:-

1. Choosing the correct Note Card from many different ones, or grouping identical cards together.
2. On the Blank Stave tracing over the top of an existing written note and then drawing one.
3. Colouring in the correct note on a copy of the Distorted, or Normal Paper, Keyboard.
4. Lifting the correct flap of the Flappers Keyboard.

After 10 minutes work at the table the children were then taken one at a time to the keyboard itself. Those left at the table were given a copy of the Distorted Keyboard to colour in, or a picture.

The initial work at the keyboard was designed to help the children understand how the real keyboard, although larger and more confusing, contained the same patterns as the paper Distorted Keyboard.

Post and re tests.

The post-test was administered after 21 sessions, and the re-test 7 weeks after the final teaching session. No practice was allowed in the period between the post and re-tests.

Results

Table 7.1 shows the test scores for each of the 10 children. The age is the child's age at the start of the study.

child	age (mnths)	sex	pre (max 36)	post (max 36)	re (max 36)
1	39.5	F	3	13.5	15.5
2	45	F	3	22.0	23.0
3	49	F	0	23.5	21.5
4	49	M	4	12.0	20.0
5	40	M	0	16.5	17.0
6	47.5	F	1	2.5	9.0
7	44	M	0	5.0	5.5
8	40	M	4	13.5	9.5
9	44.5	M	0	18.0	3.0
10	48.5	F	0	31.5	22.5
mean	44.7		1.5	15.8	14.6
SD	3.82		1.78	8.62	7.39

Table 7.1: Age, sex and test scores of all 10 children.

To investigate changes in performance over time a one-way repeated measures ANOVA was employed and significant main effect found for test [F (2,18) = 20.694; $p<0.001$]. Follow up tests revealed that scores on the post-test and re-test were significantly higher than those on the pre test ($p<0.001$). (Hypothesis 1 is therefore upheld.) Scores on the post-test were not significantly different from those on the re-test, ($p>0.05$). (Hypothesis 3 is therefore not upheld).

To test hypothesis 2, that differences in ability would be linked to sex, a 2 x 3 (sex by test) repeated measures ANOVA was employed. No significant main effect was found for sex [F (1,8) = 2.133; $p>0.1$], and there was no significant sex by test interaction [F (2,16) = 1.311; p>0.2]. Again a significant main effect was found for test [F (2,16) = 21.410; p<0.001]. In future analyses boys and girls were therefore treated as one group.

Pearson's Correlation Coefficient was calculated to test for a possible correlation between test scores and age, as shown in Table 7.2.

	age	pre	Post
pre-test	-0.22		
post-test	0.23	-0.19	
re-test	0.34	0.19	0.64

Table 7.2: Pearson's Correlation matrix for age and test scores.

No significant correlation was found between age and any of the test scores. (Hypothesis 2 is therefore not upheld.)

Discussion

This study shows that very young children are capable of learning and responding in a practical way to the symbolic representation of pitch, and that the skill once learned is retained without the reinforcement of specific practice. If the children were older then this result would not be surprising. What is of interest is that they acquired the skill at an age when it is not normally taught to them.

The success of the children in dealing with a new symbolic language is in keeping with the work of researchers such as Hughes (1986), who reported that three year olds were capable of inventing their own written language to represent the number of objects in a tin. All the children were confident in dealing with the written musical language, and were easily able to distinguish the written notes from each other. The sorting and matching games with the note cards, which were designed to increase that ability, were also very much enjoyed and easily carried out by even the youngest children. This ability to discriminate notes in spaces from notes cut by lines, and to take into consideration actually in which space or on which line the note was written is obviously of fundamental importance, but presented no problems.

The task of then finding the correct written note on the keyboard was well within the spatial ability of the children, supporting the work of researchers such as Blades & Spencer, (1986); Presson, (1982); and Bluestein and Acreddolo, (1979) who reported that 3-year-olds to be capable of understanding spatial representations. In particular the work of Blades and Spencer (1990), who reported that very young children were capable of using landmarks to understand maps, is supported. All the children quickly learned how to find the correct 'two black note group' and then progress to the appropriate white note on the keyboard. In the early stages they were observed to place their fingers lightly on top of the black notes and then slide to the correct white one, frequently while saying 'The one with the little line is the one at the side', or whatever the appropriate phrase was. As learning progressed this first step was then usually omitted and the correct note found straight away. With the introduction of the notes F and G this use of the 'two black note group' was less effective as the notes were further away from the black note group. At this point the children themselves adopted one of two tactics: they either continued to find the notes individually by reference to the black note group, or they worked out how far the note was from the previous one played. For example if they were asked to play the melody C E F C then some children would find C as 'the one at the side', E as 'the one at the other side', and F as 'the one at the start of the next black note group', and C as 'the one at the side'. Other children would only find the first C in that way, and would then find the E by it being 'next door but one', and the F as being 'next door'.

The advantages of introducing 4- and 5-year-olds to the piano postulated by Collins (1985a) are certainly supported here. They were very keen to learn how to play the keyboard, were happy to play the same games again and again, and when they did make a mistake were not at all concerned by the fact. Repetition and the making of mistakes are very much a part of learning any musical instrument, and the acceptance of both of these by the children no doubt contributed to their success. Whereas older children (and adults) may well have the desire to learn to play an instrument, they are not necessarily capable of the other two, which therefore hinders, or even prevents, progress.

The concept of children needing to be formally presented with the sound of music (see Hicks, 1980, for example) before they can understand written notation has been challenged by this research. The children had no problems at all in understanding the concepts involved, indeed, why should they? All the children had heard a great deal of music, both at home and in the nursery. In fact background music has become so pervasive in our society that it is difficult to see how anyone can actually avoid it. From this passive exposure the children had learned enough to enable them to tackle the challenges presented to them; they knew that music altered in pitch, and that it did so in a structured way. So here support is given to the idea suggested by Michel (1973); that music education must do more than merely repeat what children have already learned in their daily exposure to music. The learning of written notation is obviously an important part of that education. It is not suggested that it is the only part, or even the most important, others which quickly come to mind are listening to a greater variety of music, listening to and trying out a variety of instruments, and learning the descriptive words appropriate to music. While it is not appropriate here to discuss a suitable nursery music curriculum, it is important to reaffirm that the time children spend being ‘exposed’ to music in their everyday life should not be ignored.

Capodilupo (1991) reported that 4-year-olds could play C and F on the piano by the use of pictures of flying saucers and moons. She also reported that they were not able to play the intermediate notes, whereas older children were. Earlier it was argued that if the young children had been presented with the notes in a more meaningful way, rather than just matching pictures, then they may also have been able to play the intermediate notes. Support for that argument is presented by this research as, rather than the children being able to initially find the notes simply by matching pictures, from the earliest stages they had to have a basic understanding of the layout of the keyboard and its relation to the printed note, an understanding that enabled them to learn at least 4 notes.

The scores on all tests displayed a large standard deviation, suggesting that there were marked differences in the ability of the children. Whether these differences were linked to age or sex was investigated but neither of these factors were found to offer a satisfactory explanation. Because children of this age are developing so rapidly it had been thought that the older children would be more efficient learners than the younger. However this was not the case.

The retention of the skill is perhaps surprising. After the post-test the children received no further teaching sessions or even practice by themselves, yet, despite this, the scores 7 weeks later were not significantly lower than the post-test. This reinforces the idea that the skill is one that should be introduced to young children as it is apparently both easily acquired and retained.

Due to the problems of recruiting and working with very young children, a small number of participants is often unavoidable, as was the case here with only 10 children taking part. This inevitably makes generalising from the results not possible, and also, no doubt, partly contributes to the lack of logical explanations for the widely differing results. However, although there were wide differences in the abilities of the children, they all demonstrated that they could acquire the skill. It is therefore argued that the small number of subjects does not detract from the fundamental finding; that children of this age can acquire music literacy skills.

In conclusion this study is perhaps best viewed as a starting point for the investigation of the acquisition of pitch reading skills. It shows that 3- and 4-year-old children are capable of understanding the pitch component of the written musical language and of using that understanding to play a keyboard instrument. Further investigation is both warranted and necessary, as although the original question has been answered, many others have been raised. The way in which the children opted for one of two strategies is worthy of further investigation. Is one method more efficient than the other? The next chapter will investigate that by comparing the results obtained from the use of two teaching methods, each based on the tactics observed to be used by the children in this study.

Although many nursery activities are undertaken in small groups, having a group of children in the room whilst one worked at the keyboard was not really satisfactory. The games at the table worked well in groups, but there were problems when it was time for the children to work at the keyboard, as only one child could play the keyboard at any given time. In the remaining studies only one child will be in the room during the teaching, as well as the testing, sessions.

Chapter Eight

The acquisition of the pitch component of music literacy skills by 3 - 4-year-old pre-school children: a comparison of two methods.[1]

The objective of this study was to compare two different methods of teaching the pitch component of music notation to 3- and 4-year-old pre-school children. An earlier study, undertaken by the authors and completed 3 months earlier, had indicated that children of this age are indeed capable of learning this aspect of music and of utilising it to play simple melodies on a keyboard instrument. In the earlier study it had been correctly hypothesised that as pre-school children are capable of understanding written symbolic representation in other areas (Goodman, 1986; Hughes, 1986), they would also be able to understand the written musical language, providing it was presented to them in an appropriate way.

The fundamental rationale behind investigating whether or not such young children are capable of learning to read, and play, the pitch component of music notation was put very well by Sloboda (1978a):

> "The ability to read in one's native tongue is, in most cultures, an almost essential qualification for full membership of society. Accordingly, the attention devoted to the reading process by educationalists and psychologists has been immense. The ability to read music is, if not essential, an irreplaceable asset to anyone who indulges in musical activity. Yet the amount of attention devoted to music reading by teachers, educationalists and psychologists has, on the whole, been very small"
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> *Psychology of Music (1978a),* 6, page 3

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[1] This chapter was originally published, under the same title, in the *Psychology of Music, vol. 27 no. 2, 1999.*

Having demonstrated in an earlier study that young children have the capacity to learn to read music, the aim of this study was to investigate the effectiveness of two teaching methodologies based on two different theoretical perspectives of learning. The issue of whether such young children *should* be taught how to read music is not one that will be addressed here, although Sloboda (1978a) clearly emphasises the essential nature of reading skill.

The advantages of introducing young children to the piano have previously been identified (Collins, 1985a). She suggested it is better to start at age 4 or 5 because of the interest young children have in learning new things, and their lack of anxiety about making mistakes while learning. Elsewhere (Collins, 1985b) she explained her method in more detail. In fact she did not use a teaching method radically different from that used for 7-year-olds. The notes were still referred to by letter names, with pitch and rhythm introduced together. Collins (1985b) did not present any research findings to indicate the level of proficiency achieved by the child.

There appears to be a consensus among music educators (see Hicks, 1980, for instance) that children must experience the sound of music before they can be expected to understand written notation. Children hear music from birth, if not before, but there is seemingly no empirical evidence that establishes how much implicit learning occurs before formal teaching of music begins. This effect of environment should, claims Michel (1973) be taken into consideration in that:

> "Music education in nursery schools, at home and at school, must not aim to achieve those things which children have already mastered in their day-to-day contacts with music."
>
> (*Psychology of Music, 1973*, page 19)

Andress (1986) stated that notation should be introduced to children at an early age but did not offer any practical suggestions. The lack of empirical research into the notational music capabilities of pre-school children is evident from the literature searches undertaken by the first author.

One study into the development of the sight reading abilities of children aged 4 - 10 looked at the abilities of 4-year-olds. The study investigated whether children could understand the stepwise structure of the scale and its written representation (Capodilupo, 1991). In this study middle C on the piano was marked in red as a flying saucer and F as a moon. In the actual written melodies C was drawn as a flying saucer and F as a moon. In order to play these first melodies the children simply had to match to sample. There was no need to actually read the music at all. For the second stage the notes D and E were introduced with the description that D was 'one step away from the spaceship', and E was 'two steps away from the spaceship'. The 4-year-olds managed the first stage but not the next, indicating that they could match symbols but not demonstrate an understanding of the 'next step, scale' principle. It would have been an interesting addition to the study if an attempt had been made to discover whether or not the 4-year-olds could play the C F melodies without any pictures of flying saucers or moons. Even without this extra information it is still noteworthy that the 4-year-olds understood the general idea that symbols on manuscript paper could be used to represent playing notes on a piano keyboard. This is congruent with Piaget's observations and subsequent research (see for instance, Crain, 1992) which found that children of this age are beginning to realise that symbols can be used to represent the world around them, and are capable of understanding different forms of symbolic representation (see Levine, 1977; Hughes, 1986).

Even if pre-school children possess the ability to understand the written representation of pitch they will still be unable to apply that skill in a practical way unless they also possess the spatial ability required to understand the layout of an instrument. By looking at the development of children's ability to read maps it is possible to gain an understanding of how their spatial awareness develops. Many researchers have found that children as young as 3 have some ability to understand spatial representations (Blades & Spencer, 1986; Presson, 1982; Bluestein & Acreddolo, 1979). It appears to be the use of landmarks that assists children's understanding of maps. Blades and Spencer (1990) conducted a study where 3 – 6-year-olds were asked to find a hidden toy hidden in one of four boxes. They were given a map that showed the location of the toy, and also the location of a large red bucket. The children were more likely to find the toy when it was hidden in the box next to the red bucket, even if the map was not aligned with the direction of travel.

The importance of aligning a map with the direction of travel to aid children's understanding has been frequently reported. Bluestein and Acredolo (1979) investigated the map reading ability of 3 – 5-year-olds and found that while 3-year-olds could understand maps they could only do so if the map was aligned, and that the ability to understand a map that was rotated did not develop until 5 years of age. Similarly Ottoson (1987) found that children who were unable to follow a non-aligned map were able to follow an aligned map without any problem.

On a piano the name of the instrument on the lid and the position of the chair provide landmarks to identify the middle of the keyboard, while the distinctive pattern of the black notes (a group of two notes followed by a group of three) enables the actual position of the notes to be found. To understand pitch notation requires a complex combination of two differing symbolic skills. Initially the child has to distinguish between differing positions on the stave and understand that each represents a different note on the keyboard. At that point a spatial strategy needs to be utilised in order to locate the actual notes on the keyboard.

The earlier study, which involved 10 children, aged 39.5 – 48.5 months (mean 44.7), revealed that although the children were all taught in the same way they themselves chose different strategies to find the notes. The children were taught, in groups of three, for two 20-minute sessions each week for 11 weeks. The early sessions involved games such as pairing written notes which were the same, finding a particular Note Card from a group of them, finding all the Two Black Note Groups on the keyboard, and finding C by its relation to the central Two Black Note Group. The majority of children went on to find all other notes individually by referring to the two black note group adjacent to Middle C. However a minority only found middle C that way and found subsequent notes by referring to them as 'next step', or 'hop over one'; a method akin to that used by experienced music readers. Others initially found all notes by referring to the Two Black Note Group and then progressed to only finding the first note of the melody by that method, identifying subsequent ones as being 'next step' or 'hop over one'. Observation indicated that the children who did not find the notes individually achieved a higher standard of performance than those that did. Additionally, despite the limited age range of the children, it was observed that the older children appeared to learn more quickly than the younger. It was therefore decided to study the age effect in children's learning in a comparison of two teaching methods, each based on one of the two approaches to learning that had been adopted by the children in the previous study.

The first method, that of calling the written note Middle C 'the one with the little line' and the note Middle C on the keyboard 'the one at the side' is in fact utilising equivalence relations. The child is taught 'the one with the little line - is the one at the side'. The emergent relation that appears is the one which is sought - that of looking at the written note C and immediately being able to play the note C on the keyboard without having to go through the intermediate steps. Equivalence relations are frequently used in books for teaching early reading and foreign language skills (e.g. Joyce & Joyce, 1993; Joyce 1989) and are effective even without intervening practice (Lipkens, Hayes & Hayes, 1993; Saunders, Saunders & Spradlin, 1990).

The other teaching group was taught utilising contextual information. Here the notes are described by their keyboard distance away from the previous one ('next step' or 'hop over one'), the contextual information being paramount. This is a method which is used by experienced music readers, and readers of text (Sloboda, 1976). For this teaching group the music was first introduced as 'vertical music', with the staff rotated through 90 degrees so that the ascending written notes corresponded to the ascending notes on the keyboard.

In this study two teaching groups were compared for the effectiveness of the teaching method. A Control Group was also tested to ensure that any changes in children's skills were not due to maturational factors. Children in the StimEquiv Group were taught using a method based on stimulus equivalence and the Context Group was taught using a method based on contextual information.

The specific hypotheses investigated were:

1. That the children in both teaching groups would achieve significantly higher post-test scores than the children in the Control Group.
2. The children in Context Group would achieve significantly higher post-test scores than the StimEquiv Group. This hypothesis was based on the observation in the earlier

study that the children who used contextual information achieved a higher standard of performance.

3. That following intervention the older children in both teaching groups would achieve higher scores than the younger children within the group.
4. That there would be no decrement in performance for either teaching group at the 7 week re-test, even without practice in the intervening period.

Methodology

Participants

The children all attended a day nursery serving Bangor, Gwynedd, and the surrounding area. Parental permission was sought and obtained. The children were chosen for their age, sex, and availability, and were randomly assigned to one of the three groups. The ages of the children at the start of the study ranged from 39 to 48.5 months for the Control Group; 38 to 52 months for the StimEquiv Group; and 38.5 to 51.5 months for Context Group. Mean ages for the groups were 42.4, 44.2, and 44.3 months respectively. The overall age range of the 29 children was 38 to 52 months (mean 44.6). There were 7 boys and 2 girls in the Control Group; 6 boys and 4 girls in the StimEquiv Group; and 4 boys and 6 girls in the Context Group. All the children at the nursery follow a music curriculum that consists of singing songs, listening, and music and movement, but no music literacy skills. It was verbally established with their parents that none of the children taking part was receiving private music tuition.

Resources

The nursery contains rooms equipped and put aside specifically for research purposes. These rooms are equipped with in situ video equipment and this was used to record all the sessions.

A piano was not available so a 5 octave Yamaha PSR150 keyboard was used instead. In order to help the children identify the middle of the instrument a piece of paper with SAMUELS written on it was placed on the keyboard, as would be found on a piano lid.

Visual Material

The visual material used is listed and described below. Although at no time were the notes named as C D E F G to the children, for ease of communication they will be described as such here. They refer to Middle C and the 4 notes above it.

SimEquiv Group	Context Group
1. Distorted Keyboard.	1. Distorted Keyboard.
2. Note Cards.	2. Note Cards.
3. Normal Paper Keyboard.	3. Normal Paper Keyboard.
4. Blank Stave.	4. Blank Stave.
5. Flappers Keyboard.	8. Hopping Frogs.
6. Animal Keyboards.	9. Vertical Music.
7. Shape Keyboards.	10. Faces Melodies.

Table 8.1: Visual Material

1. *Distorted Keyboard.* This was an altered version of a life size drawing, on A4 paper, of a portion of a piano keyboard with the two black note group in the middle. The distortion was that the gap between the two black note group and the three black note groups either side of it had been widened in order to draw attention to the two black note group itself.
2. *Note Cards.* Each card (14.5cm high by 10cm) had written on it only one note: C D E F or G, with a semibreve being used to represent the note. The lines of the stave were 2cm apart. 15 cards were used, 3 of each note.

3. *Normal Paper Keyboard.* This was a life size drawing, on A4 paper of a portion of a piano keyboard, with middle C in the middle.
4. *Blank Stave.* A stave with lines 2.6cm apart drawn on A4 paper.
5. *Flappers Keyboard.* For this drawing, which was again an A4 size drawing of a portion of a piano keyboard, each white note was covered by a lift up flap. Drawn on the white note, but hidden underneath the flap, was a cartoon character. All the characters looked sad except for one, which was drawn on the note that the children were being asked to find. There were five such keyboards; one for each of the notes C D E F G.
6. *Animal Keyboards.* This was a Normal Paper Keyboard with an animal drawn on one note. There were 10 such keyboards, two for each of the notes C D E F G.
7. *Shape Keyboards.* This was a copy of the Normal Paper Keyboard but with a shape drawn on one of the white notes. Six keyboards were used, 2 for each of the notes C D E.
8. *Hopping Frogs.* On sheets of acetate pairs of frogs were drawn with the written notes for C and E; D and F, and E and G. The acetate was then placed over a Normal Paper Keyboard so that the frogs were sitting on the appropriate notes.
9. *Vertical Music.* A one-line stave, turned through 90 degrees to make it vertical was used to introduce the notes C D. With the introduction of the third note the full stave was used, as shown in Figure 8.1.
10. *Faces Melodies.* These were melodies 4 notes long comprising of 2 faces. The eyes of the faces were pairs of semibreves.

Both teaching groups used items 1-4. Additionally the StimEquiv Group used items 5-7, whilst the Context Group used items 8-10.

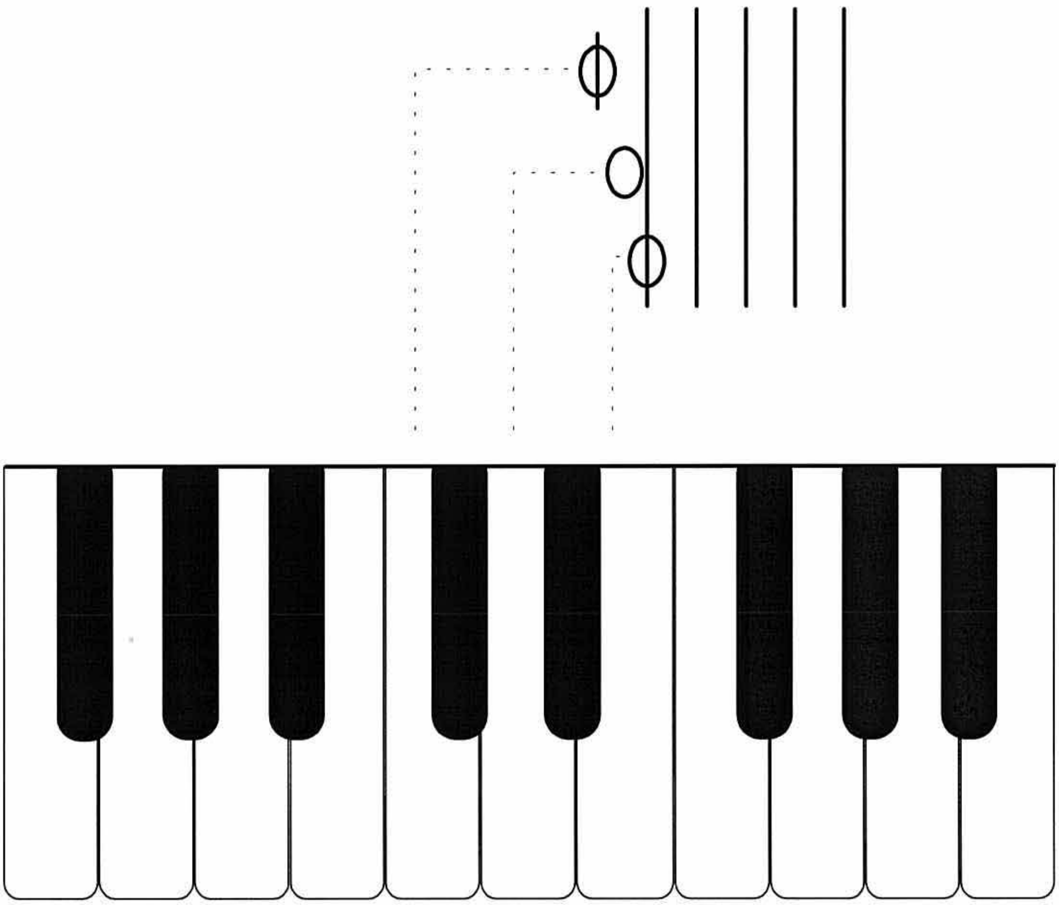

Figure 8.1: Vertical Music.

The tests

The same measurement instrument was used for all groups at each test point. (See Appendix H for a copy of the test.) The children were first shown the appropriate Note Card (see 2 above) and asked to play the corresponding note on the Normal Paper Keyboard, (see 3 above) in the order C F D E G. The remainder of the test consisted of 12 melodies, each between 2 and 5 notes in length that were presented in the same order for each test. The melodies were subdivided into different sections, with 3 melodies in each section:

i) Melodies comprising only of the notes C and D.

ii) Melodies comprising only of the notes C D E.

iii) Melodies comprising only of the notes C D E F.

iv) Melodies utilising all five notes.

For these the children were shown the written melodies and each note pointed to in turn. A child was only expected to play the melodies containing the notes that had been learned during the sessions up to that point. If the most recent note was correctly played twice then the next group of melodies was also played. A mark was recorded for each correct note with a possible maximum score of 55.

Procedure

The Control Group received a pre-test and post-test 10 weeks later, with no intervening tuition. Both teaching groups received a pre-test followed by 20 ten-minute teaching sessions, 2 sessions per week. Additional tests were administered after 8 and 16 teaching sessions, the post-test after the final teaching session (20), and re-test 7 weeks later. The intermediate tests were given in order to investigate the rate of skill acquisition. To test every week, or every other week, would have been impractical and would have risked the children becoming over familiar with the test material itself. To only test once at the mid point would not have given enough information, so it was decided to give 2 intermediate tests with the first being sufficiently far removed from the pre-test to enable learning to have taken place. The decision to give the re-test 7 weeks after the final teaching session was taken so as to have a sufficient time interval for learning to be measured, but not such a large time interval that some of the children would have left the nursery.

A pre-test was used to establish the children's level of understanding of conventional notation. Before administering the pre-test the children were given an explanation of how music is written down. They were shown the C Note Card and where the note is on the actual keyboard. It was then explained how, as the notes on the keyboard progressed to the right, the written note went higher, by steps, up the lines. The pre-test was administered immediately afterwards.

Teaching Sessions

The teaching sessions began within 7 days of the pre-test. The children were taken individually for 2 ten-minute sessions per week for a total of 20 sessions, excluding tests. The StimEquiv Group was encouraged to establish a relation between the written note and keyboard note. Middle C was therefore described as 'the one with the little line', and the corresponding keyboard note 'the one at the side'. D was 'the one that's touching' and 'the one in the middle'. E, F, and G were also named in a similar way.

Figure 8.2 shows the equivalence triangle. The A B and A C relations, represented by solid lines, are both trained. The emergent B C relation, represented by dotted lines, is the one that is sought, and is necessary for the reading of music.

Initially time had to be taken to establish the A B and A C relations, which meant that the keyboard could not be played. The process was complicated by the fact that although the A B relation could be verbal the A C relation had to link the description with the selected note on the keyboard.

In order to establish these relations different games were played:-

1. The child was asked to sort through the Note Cards and put all the ones that were the same together. These were then described in the following manner: 'Yes that's right, these are all ones with the little line'

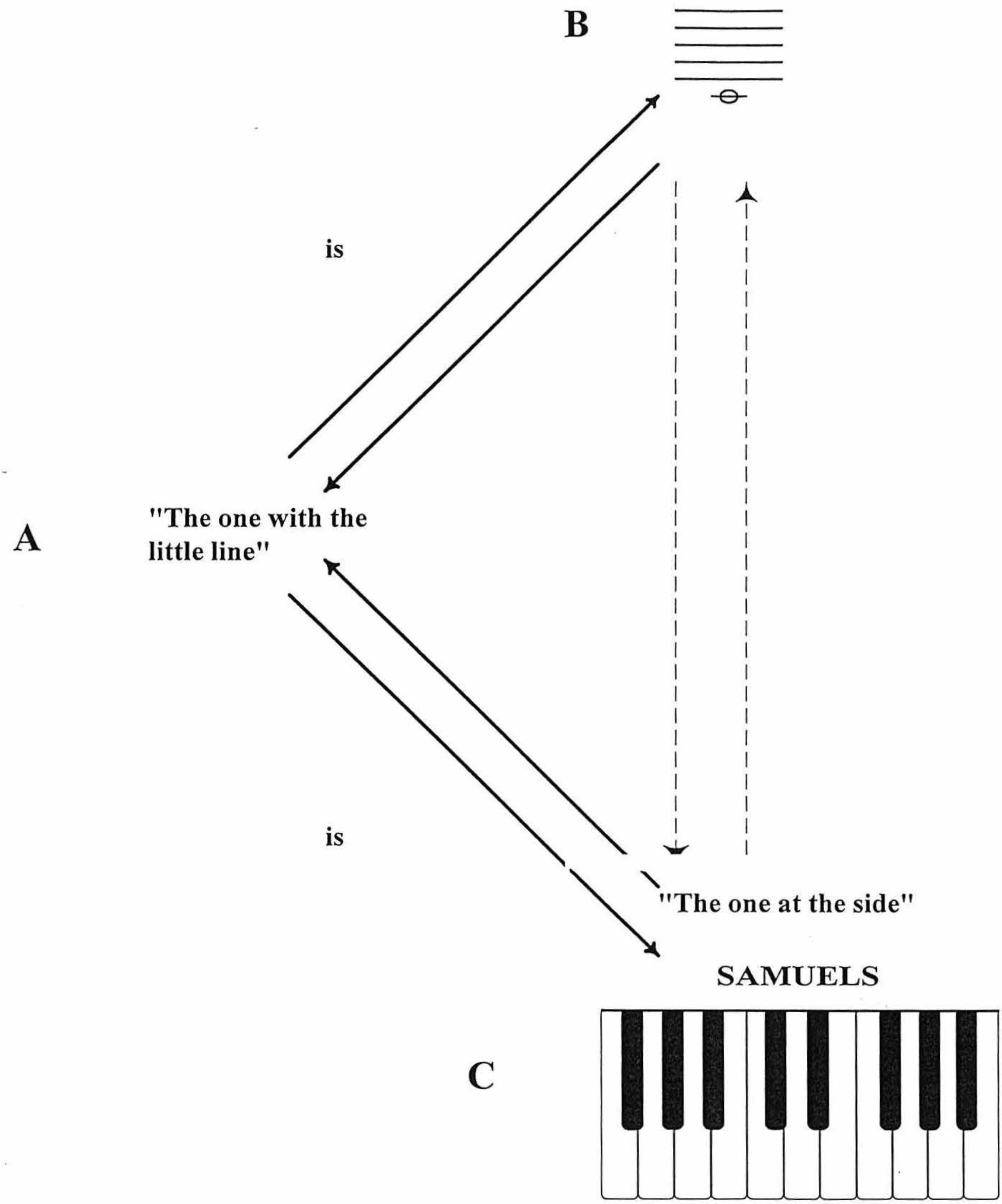

Figure 8.2: The equivalence triangle for music reading.

2. A number of differing Note Cards were placed on the table and the child asked questions such as 'Which one is the one with the little line?'
3. Different Animal Keyboards were placed on the table and the child asked 'Who is sitting on the one in the middle?'
4. The child was asked to choose the appropriate Animal or Shape Keyboard to match a Note Card. This was always achieved through naming. For example, the child would be asked which card it was and when the card was identified as 'the one with the little line' then the completion of the sentence 'and the one with the little line is......(the one at the side)' encouraged.

The children in Context Group were taught that notes were either 'next door' or 'hop over one'. The children were introduced to Middle C as being the one at the side of the two black note group, but subsequent notes were identified by being 'next door' or 'hop over one'. The purpose of the Vertical Music was to align the direction of the written note with the direction of the note on the keyboard. Once the children had learned the position of C different games were utilised to help them understand the 'next step' and 'hop over one' concepts:-

1. The child was asked to go up or down the keyboard.
2. A note on the keyboard was played and the child asked to play either the same note or the next note. As they became more confident this instruction was modified to either 'next note up' or 'next note down'.
3. The children were introduced to 'hop over one' using the Hopping Frogs acetates. The acetate was then removed and the child asked to put their finger on a certain note and then to 'hop over one'.

4. A note on the keyboard was played and the child asked to play the 'hop over'. Again this would then be modified to 'hop over up' or 'hop over down'.
5. Two or 3 melodies were placed on the table and the 'hop over' identified.
6. Notes in a melody were identified as being 'next ones' or 'hop overs'.
7. Identifying and playing the notes in the Faces Melodies.

The children of both teaching groups had some activities in common:-

1. The Distorted Paper Keyboard was used to establish the position of the two black note group. It was then replaced by the Normal Paper Keyboard.
2. Children wrote their own melodies on a Blank Stave by copying notes chosen from the Note Cards.
3. They also coloured in notes on the Paper Keyboards.
4. As soon as more than one note had been learned then games such as 'choose a card', and 'eeny, meeny, miny, mo' were played.

Post8, post16, and post-test.

These tests were administered within 5 days of the 8th , 16th, and 20th sessions respectively. Immediately prior to the test the game 'eeny, meeny, miny, mo' was played at the table using the Normal Paper Keyboard. This achieved two things: firstly it refreshed the children's memories as to where the notes were; and secondly it put them at their ease as all teaching sessions had begun in a similar way.

Re-test

The re-test was administered 7 weeks after the final teaching session. In the intervening period the children received no music literacy tuition.

Results

Table 8.2 shows the mean age and test scores for the 3 groups. Analyses of variance, with Tukey's HSD as a follow up test, were used to investigate the data. A 3 x 2 (group by test) repeated measures ANOVA was used to compare the pre and post-test scores of all three groups. A significant main effect for group was found [F $(2,26) = 19.633$; $p < .001$]. The follow up tests showed that both teaching groups scored significantly higher than the control group at post-test stage ($p < .001$).

test	Control Group mean age 42.4 mnths	StimEquiv Group mean age 44.2 mnths	Context Group mean age 44.3 mnths
pre-test	2.67 (2.6)	1.3 (1.64)	2.1 (3.03)
post8		13.5 (8.45)	18.7 (15.82)
post16		31`.3 (13.86)	30.1 (17.47)
post	2.89 (1.45)	38.3 (13.86)	33.8 (18.15)
re-test		32.44 (14.34)	33.89 (17.98)

Table 8.2: Mean test scores (SD) of the three groups. (Maximum possible score = 55 at each test).

There was no difference between the three groups at pre-test ($p>0.4$), and no difference between the 2 teaching groups at post-test or re-test ($p>0.7$). A 2 x 5 (group by test) repeated measures ANOVA was used to compare all the test scores of the two teaching groups. A significant main effect for test was found [F $(4,64) = 52.371$; $p<0.001$]. There was no significant main effect for group [F $(1,16) = 0.59$; $p>0.8$], and no significant test by group interaction [F $(4,64) = 0.774$; $p>0.5$].

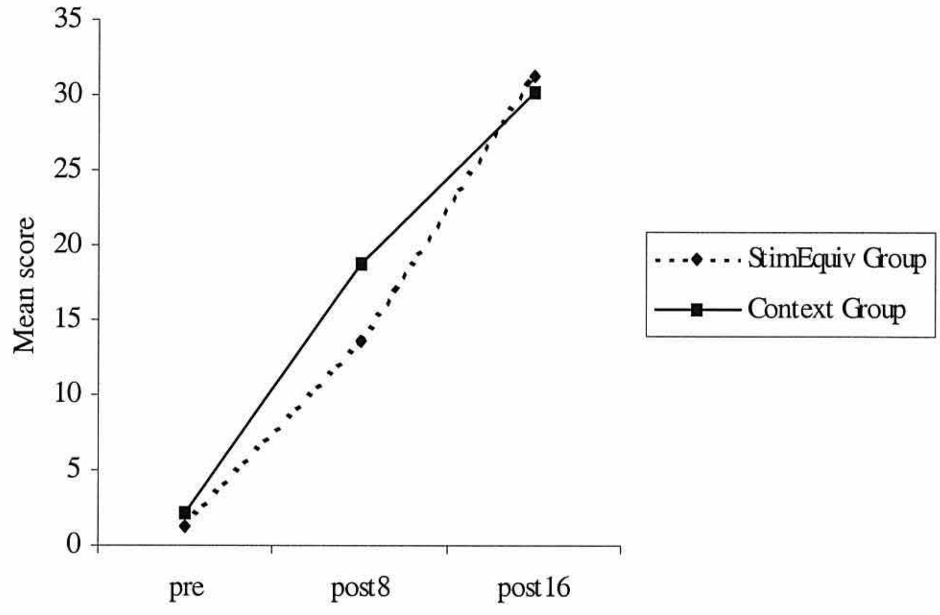

Figure 8.3: Graph showing pre, post8, and post16 test scores

Follow up tests revealed that post16 test scores were significantly higher than pre-test scores for both teaching groups ($p<0.001$). Post16 test scores were also significantly higher than post8 scores for the StimEquiv Group ($p = 0.01$), but not for the Context Group ($p>0.4$). These results are shown above in Figure 8.3. There was no significant difference between the post and re-test scores of either group ($p>0.7$).

	age	pre-test	post8	post16	post
pre-test	.244				
post8	.749**	.449*			
post16	.766**	.318	.774**		
post-test	.687**	.413	.699**	.899**	
re-test	.653**	.246	.595**	.822**	.783**

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

Table 8.3: Correlation matrix for age and test scores

The correlation coefficients for age and test scores were calculated and are shown above in Table 8.3. Age was found to be significantly correlated with scores on the post8, post16, post and re-tests, but not with pre-test scores.

Discussion

This study clearly indicates that 3 – 4-year-old children are capable of acquiring music literacy skills, given an appropriate learning environment. The significant improvement in performance of those who were taught, compared with no improvement in performance of the control group, supports the intuitive view that music literacy skills are not acquired at this age by chance or as a result of maturational processes. The two taught groups had significantly improved their performances after 16 sessions (8 weeks), whilst the control group's performance had not changed significantly by the end of ten weeks. The re-test, a test of learning for the 2 taught groups, indicated that both the StimEquiv and the Context groups had maintained their performance level over time. There was no significant change in performance between post-test and re-test despite a 7 week gap for the children in their experience of reading music, demonstrating that the music literacy skills had been learned by these two groups.

Although the age range of the children in the study was not great, correlational analyses of the data confirmed that the older children learned more quickly than the younger, upholding hypothesis 3. There was no significant correlation between age and performance at pre-test but consistent, strong positive relationships at every other test point (see table 8.3). Whilst this is not surprising it is an interesting finding that confirms what we know about the rate of children's development at this age - even within a year the facility for learning improves. These results do not suggest that the younger children should not be taught music literacy skills as all children in the teaching groups learned to interpret music symbols appropriately.

Of interest was the rate of performance improvement during intervention for the 2 taught groups, as presented in figure 8.4. At no test point were the 2 groups significantly different. The Context group maintained a consistent performance improvement whilst the StimEquiv group was initially slower, to post8 test, with significant improvements between post8 and post16 test ($p<0.02$). Given the small number of children in the groups it is not possible to say with any certainty that the different rates of improvement in performance occurred as a result of the different teaching methods. Both methods were clearly effective in improving performance from pre to post-test and in learning, as demonstrated by the maintenance of skill at re-test. Neither teaching method appears to be more advantageous than the other.

The use of landmarks proved effective for both groups in helping the children to find their way around the keyboard. This supports the work done by Blades & Spencer (1990) on young children's use of landmarks for orientation. Similarly, for the Context group, turning the staff through 90 degrees to aid orientation, as in map reading (Ottoson, 1987; Blades & Spencer, 1990) was a useful learning tool. Following initial practice, if a child was having difficulties with the horizontal staff, temporarily rotating the staff again enabled the child to interpret the direction on the keyboard accurately.

The children in both groups frequently verbalised their thought processes. When asked to play a note in the early sessions the children in the StimEquiv group said the whole sentence 'the one with the little line is the one at the side', or whichever was applicable to that particular note. Later, many were heard to simply say 'the one at the side' when presented with the note card of C for example. All the children in the StimEquiv Group could say the sentences for the notes they had learned when requested to do so. Similarly the children in the Context group could be heard saying 'hop over', or 'next step' when playing the melodies. These verbalisations indicated that the children were actively using the strategies to find the notes on the keyboard.

Collins (1985a) outlined the advantages of introducing young children age 4 or 5 to the piano. She identified their interest in learning new things, and their lack of anxiety about making mistakes as key factors. We too found both these to be the case. The children involved in both teaching groups enjoyed their sessions, and were happy to leave other nursery activities in order to participate. Mistakes were not a problem to them. They were happy to make a number of attempts to 'get it right'.

The question of *can* such young children learn pitch notation has been answered. The question of *should* such young children learn pitch notation has not. The nursery context of the children in this study is worth remembering. All the children were being introduced to written letters and numbers as part of their everyday nursery activities. The introduction of music literacy is an obvious extension to that work. Whether the results would be the same with children who were spending their pre-school years in a different environment would need to be investigated.

There is no suggestion that this literacy work should replace other tasks, or that it is of more importance. Areas of future possible research have been identified, and long-term research is needed in order to ascertain whether exposing children of this age to pitch notation, even for a limited time, results in fewer note reading problems when they do begin to learn an instrument.

Chapter Nine

General Discussion

This chapter summarises the main findings of the research project, and outlines future research directions. I shall begin with the overall findings, before going on to summarise the findings of the individual studies. Finally, implications for teaching and future research are discussed.

One of the primary aims of this research was to investigate whether 3- and 4-year-olds were capable of learning music notation, and of applying that knowledge to perform simple musical phrases. The research findings presented in the previous chapters all indicated that 3- and 4-year-old children are indeed capable of learning, and performing from, conventional music notation. All the children who took part successfully learned to play, from music notation, simple melodic phrases if they were in one of the pitch groups, or simple rhythms if they were participating in one of the rhythm studies.

Other aims were:

i) To provide research-based information that would contribute to filling the void identified by Sloboda (1978a), and quoted on the first page of Chapter One. This aim was also met. All the studies reported contributed in some way to furthering our understanding of the music reading process. Those contributions are, of course, merely a drop in the ocean, as a great deal of similar research is needed before the music reading process can be understood to the same extent as the language reading process. However, what has been demonstrated here is that such research is both possible and, although time consuming, not excessively daunting.

All the children who participated in this project enjoyed and were interested in the activities presented to them, and were always happy to leave another nursery activity in order to participate in the research sessions.

ii) To investigate non-music research literature concerned with children's skill acquisition and learning in other areas, in order to use established, relevant knowledge to assist in understanding the processes involved in learning to read music. The knowledge gained as a result proved to be both relevant and beneficial. By investigating how children learned in other areas, new ideas, which had already been shown to be effective elsewhere, were successfully integrated into music learning. Later in this chapter the resulting methodologies will be discussed in more detail.

iii) Another question investigated was whether any particular teaching method was more appropriate than another. No significant differences were found between any of the teaching groups, suggesting that all the methods used were effective. This issue was discussed earlier, in Chapters Six and Eight, where the conclusion was drawn that there may actually have been differences, but they were not detected. This issue will also be returned to later in the chapter.

Summary of the main findings

The first rhythm study, reported in Chapter Three, used a method based on traditional counting techniques. The method was adapted to take into consideration the age of the children by counting each note individually, rather than the beats cumulatively throughout the bar. The major finding of this study was that very young children can learn to perform simple rhythms from conventional rhythm notation. Although the children counted each note individually, the possibility that they were unaware that they were counting was recognised. Because the notes were counted individually, rather than cumulatively, the actual counting procedure could have become just a label. For example, rather than realising that by counting 'one two three four' in response to a semibreve a length of time equivalent to four crotchets was being measured, the children could simply have thought that 'one two three four' was the note's name, and therefore any word or combination of words would have sufficed.

The next study (reported in Chapter Four) replaced counting with animals and investigated the dual task nature of reading music. In this study the part-task method of teaching was found to be no more effective than the method employed in the first study. Each note value was linked with an animal name of the corresponding number of syllables. For example, a crotchet was paired with a dog, a minim with a donkey etc.. A number of researchers, (see Bebau, 1982; and Colley, 1987, for example) when working with older children had reported syllabic methods to result in improved performance accuracy. In keeping with their findings the children in this study also readily learned the note value - animal relationship. However, the main purpose of the study had been to ascertain whether specific dual task training would result in improved accuracy of performance. The children were taught the note values, but also received training designed to improve their ability to maintain an accurate constant pulse. The rationale was that this separate training on the two components of rhythm performance would, when the tasks were combined, result in increased performance accuracy. A major project in the field of pilot training, the Learning Strategies Project, had reported this kind of part-task training to be very effective (Frederiksen & White, 1989). It was arguably less effective here, and reasons for that, together with ways of improving the teaching methodology, were discussed in the relevant chapter.

The study reported in Chapter Five used a teaching method based on connectionist principles. Once again the children successfully learned how to perform simple rhythms from conventional rhythm notation. Here the children were not given any constant pulse practice, or rules from which to work. The reasoning behind this study was based on research conducted into children's reading. Researchers (see Berninger et al. 1999, for example) have reported children's language reading to improve even without the use of phonics or other rule-based instruction. In those studies the only exposure the children received was the written word along with its correct pronunciation. A similar method, that of exposing the children to a written rhythm and its correct performance, was used here. Two training rhythms were chosen for each note value. Initially the children were exposed to the correct performance of the training rhythm and its written representation, before progressing to performing the training rhythms, and subsequently novel rhythms, from notation. Perhaps counter-intuitively, the children successfully learned how to accurately perform not only the training rhythms, but also rhythms they had not seen before.

A surprising finding of the research, as discussed in Chapters Four and Five, was that no link between various aspects of rhythmic ability (tapping in time with a piece of music, continuing a given pulse, and identifying pairs of rhythmic phrases as being the same or different) and accuracy of performance from notation was found. The implication is that abilities, which may be loosely described as being attributable to a 'good sense of rhythm', are not, in the early stages of learning, important at all. This was contrary to expectation, as intuitively it would seem logical to assume that children with a good sense of rhythm would learn rhythm performance more effectively. Many possible explanations for this were discussed in the relevant chapters, and also Chapter Six, with the favoured possible explanation being that the ability to maintain a constant pulse is one that is acquired through rhythm performance and associated tasks.

The second section of the thesis dealt with the introduction of pitch reading, and again the children found the tasks well within their capabilities. The main aim of the first pitch study, reported in Chapter Seven, was to investigate whether it was possible to teach pitch to 3 – 4-year-old children, without using letter names. The study found that it was possible. Letter names have routinely been used, and, unlike the teaching of rhythm, seemingly no alternatives have been investigated. In this study the written notes were described in such a way as to help the children to remember their position on the stave, and corresponding position on the keyboard. The children successfully learned to play simple melodies, and it was observed that once two or three notes had been introduced they displayed an inclination for learning the remainder by one of two methods: some children preferred to continue to learn the new notes the same way, while others preferred to learn them contextually, by reference to the notes already learned.

The final study, reported in Chapter Eight, explored and compared those two approaches. One group was taught using a method based on equivalence relations, where once again the notes were described in such a way as to help the children remember the position on the stave and keyboard, whilst the other group was only taught to find the first note (middle C) in that way, all other notes being found contextually. For this second group the stave was initially presented to them rotated through 90 degrees, so that the direction of the notes on the stave corresponded to their direction on the keyboard. The decision to do this was taken after investigating the literature concerned with young children's map reading abilities. Bluestein and Acredolo (1979) reported that 3 – 5-year-olds could understand maps that were aligned to the direction of travel, but not those that were not. The ability to find any given note on a keyboard is very much a spatial ability, and so similarities between that process and those involved in map reading are to be expected. The children in the study all coped well with the 'vertical music', and, perhaps surprisingly, were not at all confused when it was turned round to its normal position.

Overall the findings of the research support those (see Andress, 1986; Collins, 1985; Shor, 1989; for example) who have expressed views favouring early exposure to music notation. Such authors, although considering that such exposure should take place, have not presented any research findings in support of their view. That support is given here.

In my role as teacher/researcher I was able to accurately assess the effectiveness of the material used in the teaching sessions, and to discontinue the use of unsuitable material, such as the metronome (in the first rhythm study). Furthermore, in the pitch section, appropriate methodologies were developed as a result of my teaching the early study. Without such 'hands on' involvement I would not have been so well placed to achieve that. However, care was taken to ensure that the restrictions imposed by the research were observed. Each child was taught using only the specific teaching material for the study in which they were participating. Other methods were not allowed. Any potential for researcher bias in marking the tests was off-set by the quantitative nature of the tests. The only grey area of assessment was the first rhythm study, where, as discussed in the relevant chapter (Chapter Three) the use of a stopwatch was impractical, and could have resulted in researcher bias. This was solved by the use of a computer and timing program for the subsequent rhythm studies. Furthermore two musicians, accustomed to working with children, were asked to mark a sample of the tests, and their marks were in agreement with the marks obtained from the computer timings. The view is therefore taken that the dual role of teacher/researcher worked well.ss

Implications

Before discussing implications arising from this project it is appropriate to stress that the particular nursery environment used as a research setting inevitably means that the results obtained here are only applicable to children who are based in a like environment. Children who spend all their pre-school years at home, or attending a nursery or playgroup that does not introduce literacy skills, might reasonably be expected to react and learn differently. Further research, with participants drawn from the different settings is necessary in order to investigate whether the findings reported here are generalisable to all 3 – 4-year-old children, irrespective of their environment.

A wide range of implications ensue from this research. Some can be implemented immediately, whereas others are long-term in nature because they depend on future relevant research being carried out. Most of the research presented here covered completely new ground. It was not concerned with testing whether a sustained belief was indeed true, or extending an established practice in new directions, but with testing whether new ideas were practically as well as theoretically possible. The majority of the implications therefore indicate possible ways forward, rather than prescribe what should take place. For example, although one of the primary aims of the research was to investigate music reading in 3 – 4-year-olds, some of the findings are also relevant to the teaching of older children. However, in those areas more research with older children as participants is needed before teachers can have at their disposal a variety of methodologies from which to choose the most suitable for each individual child.

There is therefore a degree of dependency between the implications for research and teaching, so this section will not be subdivided into one section for 'teaching' and another for 'research'. Instead it will be subdivided into sections for 'rhythm' and 'pitch'. In each of those sections issues concerned with teaching and with research, will be discussed.

Rhythm

The rhythm studies have far reaching implications for the teaching of rhythm, which has traditionally been taught using rules, and with a degree of emphasis on the constant pulse. There is no suggestion here that at some stage the ability to accurately count a rhythm, whilst maintaining a constant pulse, is not an essential ingredient of accurate rhythm performance. However emphasis on the ability to maintain a constant pulse in the early stages of learning may be inappropriate.

Likewise there is no suggestion here that beginners should not, at some stage in the learning process, be taught the precise mathematical relationship between the different note values, just that it may also be inappropriate in the early stages. The verbal responses of the children in the connectionist study indicated that they had understood that some notes were longer than others, and also understood which notes were long and which were short. From this minimum of information they successfully performed previously unseen phrases, indicating that this minimum had been sufficient. The question as to whether it is actually necessary for children to know any more than that in the early stages has to be asked. By attempting to teach the precise nature of the relationship between different note values we may be confusing beginners unnecessarily. It is suggested that, in the early stages, we are actually making the rhythm reading task too difficult by insisting on behaviour that is not necessary until a higher level of competence has been reached. Traditionally beginners, even in the earliest stages of learning, are expected to display the same behaviour as experienced players, albeit with simpler material. The emphasis has been on keeping behaviour the same throughout learning, whilst increasing the level of difficulty of the rhythm task. An alternative approach is suggested here, that of altering both behaviour and difficulty level over the course of learning.

The fragility of the timing process was discussed extensively, from a theoretical standpoint, in Chapter Two. In each of the rhythm studies a practical consequence of that fragility was demonstrated when a child made a mistake, and yet was totally unaware that a mistake had been made. It was not that they were not concentrating, or listening carefully, they simply could not accurately hear what they were playing. The way in which rhythm is taught needs to take into consideration this inherent fragility, and at present it does not. Effective learning needs constant feedback; an error cannot be corrected without it first being recognised as an error. Unfortunately the current custom of beginners receiving a weekly instrumental lesson, at the end of which they are instructed to 'go home and practise', does not make provision for sufficient feedback. Because of lack of exposure to the correct rhythm patterns at home, in reality children are often 'practising' mistakes. Unfortunately teacher led practice is expensive and time consuming, and so would not realistically be possible on a more frequent basis. Therefore, given that teacher led feedback is financially not viable, other possibilities should be investigated. When parents are both able and willing to support practice at home feedback can be provided by them. Another possibility is the use of interactive computer software. This would allow children to receive performance feedback each time they practised, without the need for one to one instruction, or parental intervention.

The effectiveness of the connectionist teaching methodology has already been discussed. Because of that success it is suggested that it is appropriate to explore other areas of learning where rules have successfully been abandoned, such as learning to read, to ascertain whether any such strategies can be successfully incorporated into rhythm learning. Instead of searching for methodologies with 'new rules', a profitable future search may be methodologies with 'no rules'. The rules, in such cases, are understood following and during practice and learning, rather than before.

The performances of the children in the second and third rhythm groups were measured by computer, thus eliminating subjectivity. This is seen as a major step forward in assessing rhythmic accuracy in the test situation, and one that should become more widespread in its use. It is recommended that in future, research that needs to measure the accuracy of rhythm performance uses similar computer technology. Current computing technology is such that the equipment utilised here was neither expensive, nor excessively complicated to set up.

Pitch

The children in the pitch groups learned without the use of letter names, indicating that, for young children, alternative methodologies are possible. Equivalence relations and contextual information were used here, but there are possibly many other means by which pitch notation can be taught. Future research could profitably explore such areas. A primary reason for not teaching pitch through the use of letter names had been the age of the children. Because the 3 – 4-year-olds who took part in the project were beginning to be introduced to letters and simple words, it was decided that to also introduce them to letters as the names of musical notes might be confusing. The ease with which the children learned suggests that future research could investigate whether older children too may benefit from a method not based on letter names. Older children might also benefit from teaching methods based on equivalence relations and contextual information. They might also benefit from a combination of traditional letter name methods and the methods used here. More research is necessary to provide answers to those questions.

The use of the spatial characteristics of the instrument is another area that may be explored, although it is not immediately obvious how spatial characteristics can be used for every instrument, and perhaps they cannot. A keyboard was chosen for these studies because it is both physically easy to play, and visually appropriate for the use of landmarks etc.. It is, however, not immediately apparent how teaching methodologies for other instruments could use such information.

Music teaching

It is this author's opinion that the introduction of music reading activities should occur simultaneously with the introduction of written language and number activities. This view is supported by the success of the children who took part in this research project. The children who participated in the project were being introduced to written language and number as part of their everyday nursery activities; therefore the introduction of music reading was an appropriate addition and did not, apparently, interfere with other developmental tasks.

The success of the children is in accordance with the theories of both Piaget and Montessori, who viewed the ages of 3 - 6 as being crucial for conscious language acquisition. Montessori believed that failure to introduce a skill during its critical period could result in acquisition difficulties later. Hence, if the introduction to reading music notation occurs later than the age of 6 it may be that the 'window of opportunity' offered by the critical period has passed, and learning becomes more difficult. One might reasonably expect this difficulty to be increased if a degree of fluency has been gained in other areas of language acquisition, as happens at present. Children have already gained a degree of fluency in both written language and number before they are introduced to music reading activities, resulting in the music reading tasks being introduced at the 'wrong time'. As has been demonstrated in this study, there is no need to delay music reading activities; they can be introduced at the same time.

Introducing all literacy tasks at the same developmental stage takes into account children's overall learning environment, the importance of which has been stressed. As discussed in Chapter Five with reference to connectionist ideas, various researchers (see Adams, 1990; Berninger et al., 1999; Reason, 1998; Snowling, 1998), when considering the most effective ways of teaching children to read language, have stressed the importance of the complete learning environment, including that outside the classroom situation, and in particular the home environment. As well as being developmentally appropriate it is therefore also environmentally appropriate to introduce music reading as part of a general 'learning to read and write' environment. Those involved in second language teaching have already recognised the importance of introducing second languages at an optimum time, with the custom of introducing very young children to their second language whilst learning their first being well established. (See the report of the Alberta Department of Education, 1991; and Arnberg, 1982, for example.)

The importance of a child's musical environment has also been previously stressed. Michel (1973) emphasised the need to consider a child's overall environment, and he suggested that music educators tend to ignore the fact that children hear a great deal of music as part of their everyday life, and that such exposure has an effect. He stressed that educationalists need to always remember that the life of a child is not *only* what takes place within the educational environment. Pre-school children are familiar, through listening and singing, with a variety of music, so to them learning how music is written down is a natural extension of their experiences, in the same way that the reading and writing of language are a natural extension of spoken language.

The above paragraphs support the idea put forward in the introduction - that initially children should learn to read music in a situation where the music reading task itself is allocated priority, not instrumental playing. It must be emphasised that even when the music reading task is allocated priority, it is still necessary to include practical applications of the task. The piano keyboard used in this research presented no difficulties, and enabled the children to concentrate on the reading process. It is therefore suggested that whatever the child's ultimate choice of instrument may be, it is appropriate that they first learn how to play simple melodies on the keyboard.

Obviously such a step would require radical re-thinking on the part of both instrumental and pre-school teachers. Most instrumental teachers are experienced and confident in dealing with older children, and may not wish to teach very young children, or have the skills with which to do so. Alternatively the responsibility for teaching the basics of music reading could be transferred from instrumental teachers to pre-school teachers, in keeping with the manner in which pre-school children are taught other skills. They are taught to read words and number by the same teacher, so it would be a logical extension to include music reading activities. This, however, would involve a significant change in attitude towards music, which tends at present to be viewed as a specialist area. Just as instrumental teachers may lack confidence with pre-school children, so might pre-school teachers lack confidence with music. This problem is not insurmountable as the melodies and rhythms used in the studies were very simple, being of a comparable difficulty to the language and number activities being undertaken by the children. The pre-school teachers are not mathematicians, but they are introducing number work. Likewise the fact that they may not be musicians should not prevent them from introducing music.

The amount of time invested by the children was very modest – the majority received two individual ten-minute sessions per week for 10 weeks. Furthermore, the children who participated in the first pitch study, reported in Chapter Seven, were taught in small groups of 2 or 3. Many nursery activities are carried out in small groups, and this study indicated that music reading activities could be conducted in a similar way. Also, the children did not practise at all between sessions. Traditionally practice at home is an essential part of instrumental lessons, and it can cause stress for both children and their parents. Evenings at home are already filled with many leisure activities as well as homework. Instrumental practice has to compete with the demands on time made by those activities, so if children can begin their music learning experiences without the need for extra practice, stress can be avoided. The learning experience should thus be a more pleasurable one for all concerned.

Dealing with pitch and rhythm separately simplified the tasks, allowing the pitch children as much time as they needed (within reason) to find the notes. It is likely that this separation of the tasks contributed to the confidence with which the children approached the activities, and therefore their success. Conventionally children are introduced to pitch and rhythm simultaneously, being expected to find the 'right note at the right time' from even the earliest stages. The efficacy of separating the tasks is supported here, and perhaps teachers should consider ways in which the tasks can be separated. This could easily be achieved within the existing structure of instrumental lessons by ensuring that time is set aside each lesson for work on either pitch or rhythm in isolation.

Music research

A long-term project is needed to investigate the overall efficacy of introducing 3- and 4-year-olds to the written musical language. It has been demonstrated that the children who participated in the studies presented here were capable of learning to read music, but the question of whether they *should* be taught to do so was not asked, and therefore not answered. As explained in the introduction, there exists a body of knowledge which strongly suggests that early introduction to music reading activities will be a positive rather than a negative experience, but a long-term project is needed to fully investigate the issue. By introducing a large number of very young children to music reading, and subsequently tracking them throughout their school career, it would be possible to explore whether they had fewer subsequent problems with music reading than those who had not received early tuition. Of course, an argument against this is that whereas everyone needs to be able to read and write language and number, music reading skills are not essential, so it is therefore a waste of resources to routinely introduce them. However, children learn many things at school that they subsequently do not use, and furthermore the actual time input necessary for basic learning to take place has been shown to be minimal. It may be that learning music notation facilitates learning in other areas requiring symbol interpretation. Again this requires further investigation.

It could be argued that a limitation of the present research is that pitch and rhythm were not only introduced separately, but also never combined. Music reading requires the combining of the two skills, and it may be that children cannot combine pitch and rhythm until they are significantly older. Perhaps when they are combined a significantly higher standard of performance will be achieved as a result of the separate early learning. However it is also possible that the children may experience problems in combining the skills to the extent that the benefits of early learning are negated. The research presented in this thesis cannot answer those questions, and indeed it was not designed to do so. It therefore remains as an issue that needs to be addressed at some stage.

One problem to be taken into consideration when planning future research is the number of children in each group. Although this research was not time consuming for the children it was for the researcher, and it is possible that, despite the time input, there were still not sufficient children in each group to reliably identify differences between the effectiveness of the teaching methodologies. It is difficult to see how this problem can be resolved, except of course by financial input. An alternative in future may be to initially train nursery staff to use the methodologies in order that they became part of the nursery curriculum, rather than an extra-curricular, researcher led, activities.

Chapters Six and Eight of the thesis discussed the above problem of insufficient numbers, and also another issue that should be taken into consideration in future: the difficulty level of the test material. The children found the work well within their capabilities, thereby potentially disguising differences between the teaching methods. By continuing the sessions for a greater length of time a higher level of difficulty could be reached, which may yield more information.

Most of the teaching methodologies used in this research are suitable for future use without modification. The exception is the dual task methodology. The limitations of that study were discussed in the appropriate chapters (Chapter Four and Chapter Six), and ways of improving it suggested. Fundamentally, many of the constant pulse tasks were too difficult for the children. It was decided that, in view of the problems experienced by the children, in future the note values should not be introduced concurrently with constant pulse activities, but only when a required level of constant pulse ability had been reached.

Although not a problem in this research, a problem could occur when letter names are eventually introduced. The use of letter names is so widespread that their long-term non-use is simply not practical. Therefore, was the problem merely being postponed? Obviously long-term research is needed to assess whether children can make the transition easily and smoothly, but anecdotally, one of the children involved in the study subsequently received a course of piano lessons from the author and experienced no difficulty whatsoever in changing to the use of letter names. It was simply explained to him that now that he was at school he should call the notes by the names which grown ups use.

Future research should not be limited to work with children, or indeed with people. Researchers (see Hinton & Shallice, 1991; McLeod, Shallice, & Plaut, 2000; for example) have developed connectionist computer networks that are capable of mimicking certain types of dyslexia. There is a strong case to be made for developing networks that can learn to read rhythm. In this way issues such as when (and if) to introduce counting rules, and the importance of the ability to maintain a constant pulse, can be explored. There is no suggestion that this work can replace work with people, rather, it may provide useful supplementary information.

A summary of the main future research questions:

i) Are children who have received early music reading tuition more efficient music readers when older?
ii) Is it necessary to use rules in the early stages of rhythm learning, and if it is not, at what stage should they be introduced?

iii) Are various aspects of rhythmic ability (tapping in time with a piece of music, continuing a given pulse, and identifying pairs of rhythmic phrases as being the same or different) important in the early stages of rhythm learning, and if not at what stage should their importance be recognised?

iv) In order to investigate issues ii) and iii), and others, the development of a connectionist network for rhythm learning could potentially be extremely informative.

v) If very young children are taught pitch by a non-letter name method can they easily transfer to the use of letter names at a subsequent stage?

vi) Is the use of a non-letter name method suitable for use with older children, perhaps those who are experiencing difficulties with conventional instruction?

vii) Are there occasions when the context method is more suitable than the stimulus equivalence, and *vice versa?*

Conclusion

Many conclusions have already been drawn, both earlier this chapter, and in the chapters reporting the individual studies. Rather than repeating those I will conclude by presenting two broad conclusions: that 3 – 4-year-old children are capable of learning to read music, and of applying the skill in a practical situation; and that the findings of researchers outside the music domain can be of considerable help in contributing to our understanding of the music reading process.

The ease with which the children who participated in this research project learned, and their enjoyment of the learning process, strongly support the idea that children of this age are at a stage in their development that is appropriate to the learning of the written musical language. In this thesis many arguments have been put forward in favour of introducing children to the written language of music at 3 –

4 years of age, but it is recognised that it may not always be the most suitable time. It is worth emphasising again that the participants in this research all attended a nursery that introduced written language and number as part of their everyday activities, so the music work was therefore a natural extension of those activities. A child who is not in such an environment may not enjoy the activities, or be able to easily carry them out. It is not possible to conclude from the current research that *all* 3 – 4-year-old children will find the work within their capabilities, simply that children who are already learning other literacy skills are likely to do so.

A considerable amount of the literature reviewed was from outside the music domain, and the usefulness of that literature has already been stressed many times. Until the music reading process is understood to an extent that approaches the depth of our understanding of the language reading process, there is likely to be a continued need for such explorations.

This research contributes to the void identified by Sloboda (1978). It has been demonstrated that research into the music reading process, even with very young children, is relatively straightforward, if time consuming. It is therefore hoped that the success of the children who participated in this research will provide some of the impetus necessary for future research.

In the ideal world the same importance would be placed on the early teaching of music literacy skills as other literacy skills, such as language and number. That is not a realistic proposition. However a significant increase in research into the teaching and learning of music literacy skills could lead to a substantial reduction in both the number and the severity of problems associated with learning to read music. That in turn would enable more people to become full members of musical society by possessing, as described by Sloboda (1978a), the 'irreplaceable asset' of being musically literate.

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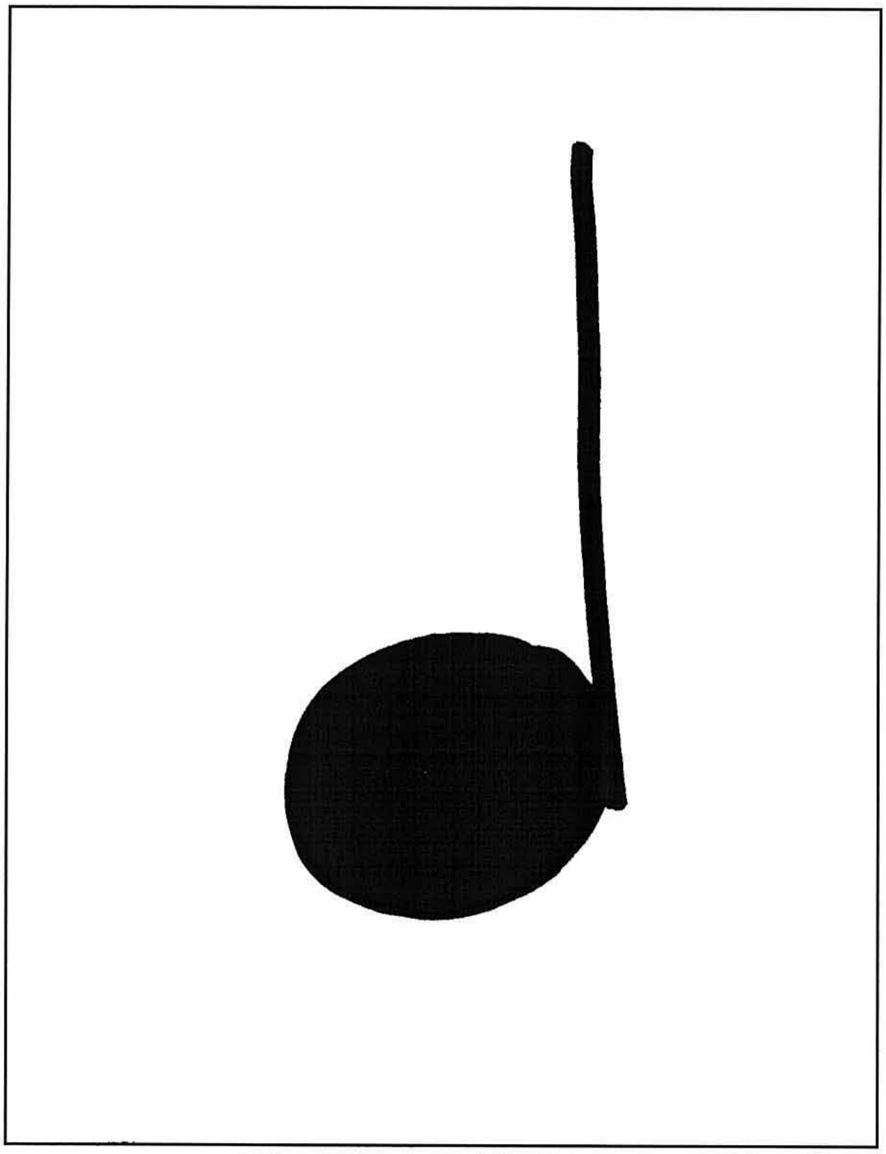
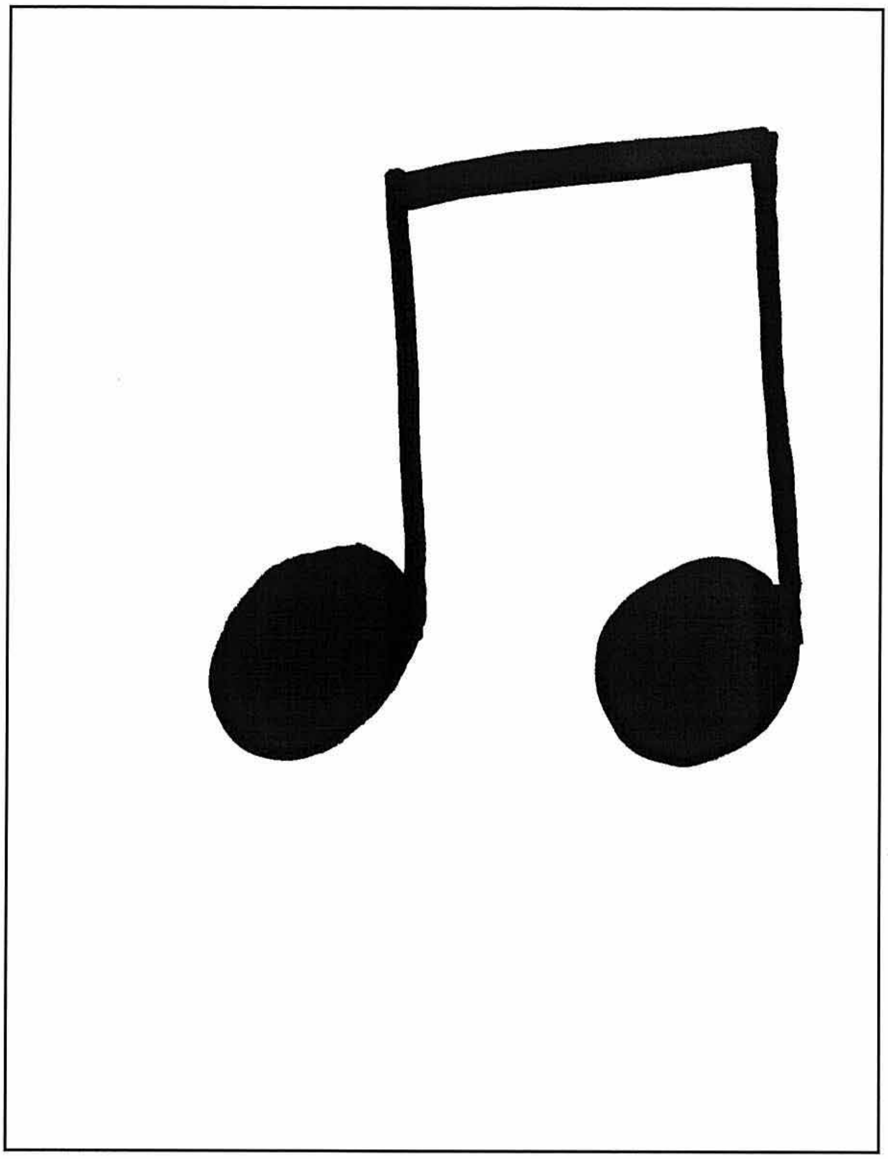
Appendix A

Examples of the Note Cards used in all the rhythm studies

In the first and second rhythm studies 3 Note Cards were used for each rhythm value. A life-size example of the crotchet card and the quavers card is shown below.





Appendix B

Rhythm Performance test material used in the rhythm studies

Q 1 

Q 2 

Q 3 

Q 4 

Q 5 

Q 6 

Q 7 

Q 8 

Q 9 

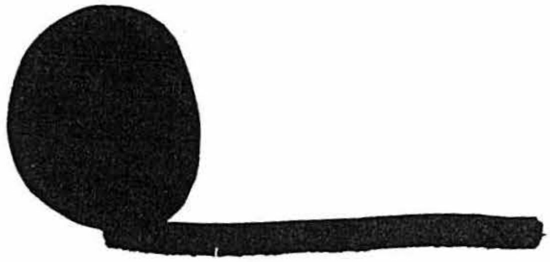
Q 10 

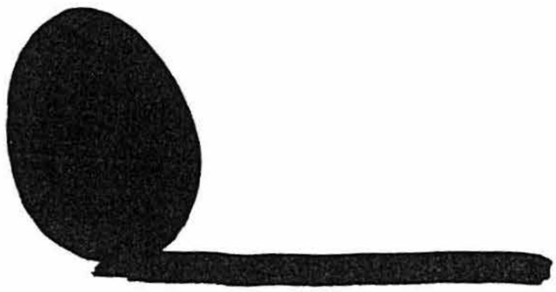
Q 11 

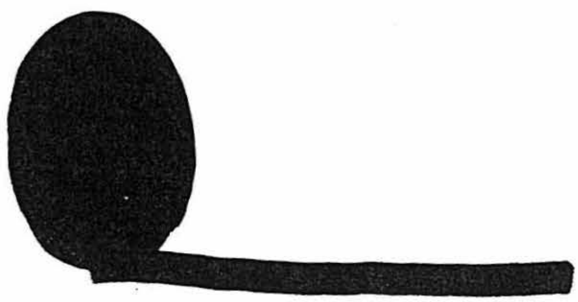
Q 12 

Q 13 

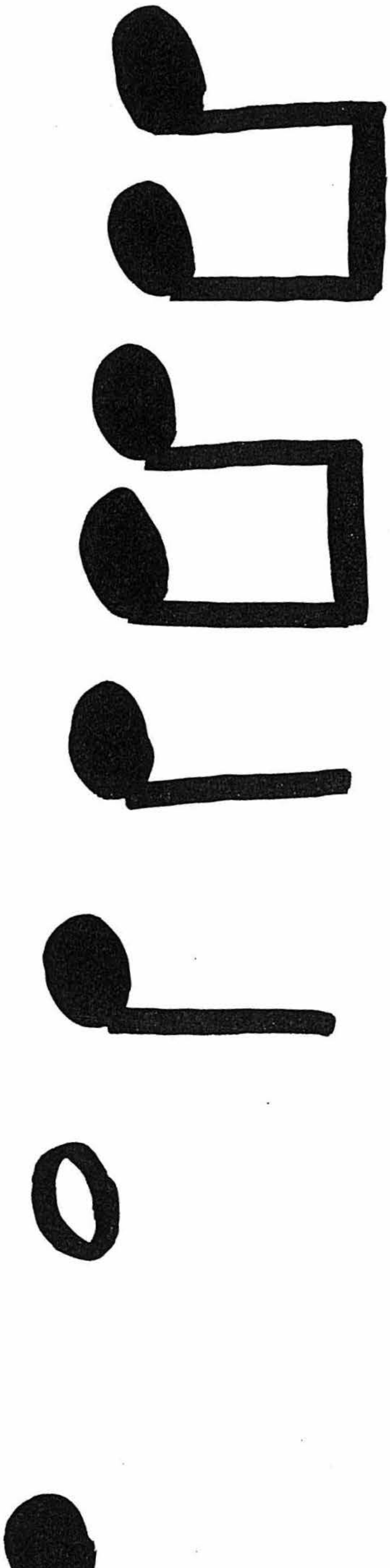
The actual tests were hand written on A4 paper. The actual size of the symbols therefore varied according to how many notes were present in the rhythmic phrase. To demonstrate this exact copies of Questions 1 and 13 are reproduced on the following two pages.







Appendix B



Appendix C

Transcript of Rhythm Performance pre-test instructions

Below is a transcript of the introduction to the pre-test. My explanations are written in *italics,* and the responses of the children in non-italic. Although my description remained constant the children's responses were obviously varied. The responses I've recorded here are therefore representative of the majority of the children.

The child was taken into the research room and invited to sit down at the table. The table was an ordinary low nursery table of suitable height for children. The camera was in situ and had previously been positioned so that it focused on the table top and the child. After some general conversation I said to the child:

"Can you do this?" [I hit the table with one hand at approximately mm 120.]

"Yes!" [The child hits the table.]

"Tell me if I'm going quick or slow?" [I hit the table again.]

"Quick." [Usually while hitting the table again.]

"Now listen to this." [I hit the table at around mm 40.] "Can you do this?"

[Child hits the table slower than before.]

"Well done _____ (child's name) you can! And is it quick or slow?"

"Slow" *(If the child did not answer correctly to the 'quick or slow' questions the answer was given and the child asked to clap again with the encouragement "Can you go quick/slow?", and further examples if necessary.)*

"Oh! What's this?" [As I put a crotchet note card on the table.]

"Oh! And another, and another!" [All three cards now on the table.]

"Don't know!"

"This tells us how to tap the table. We hit the table once for each one. So this [pointing to the three cards in turn] tells us to go - [I tap the table once in front of each card] Can you do that?"

[Child taps the table once for each card.]

"Well done ______ !" [I remove one card] "What do you think you do for that?"

[The child taps the table twice.]

"Good – and that?" [I remove another card.]

[The child taps the table once.]

"Well done, that's SO good!"

(If the child made mistakes they were shown the correct answer with the encouragement to "Hit the table once for each card")

"Shall we do that again?"

"Yes!"

[The three card rhythm was repeated].

"Now.... [putting a minim card on the table] what's this? It's not the same. How is it different?"

"You didn't colour it in!"

"I didn't did I. This one's black [pointing to the crotchet] and it's coloured in, but this one [pointing to the minim] is white and it's not coloured in. I wonder why that is"

"Don't know."

"It's because it's telling us to do something different." [Three minim cards are placed on the table] "These go slow, and we have to count them One two, One two, One two." [I demonstrate by hitting the table on each count of 'One']. "Can you do that?"

"One, One, One Two." (Or another incorrect answer).

"No, listen again, and make sure you tap the table when you say One." [I repeat the previous example.]

"One Two, One Two, One Two" [correct]

"Yes! Well done _______" [I then take one card away.] "Now, how do you think that goes?"

"One Two, [long pause] One Two."

"But you can't stop! Listen again." [I repeat the example again.]

"One Two, One Two." [Correct.]

"Good!" [I take away another card] "How does that go?"

"One Two!" [correct.]

(If not correct then it was corrected in the same manner as before. If the child found it difficult to co-ordinate speaking and tapping then I held their hand and gently tapped it for them a few times. After this they could manage unaided.)

"Good you're doing really well! Let's try that again." [Putting three minims on the table] "How does that go?"

"One Two, One Two, One Two." [Correct.]

(If not correct it was corrected in the same manner as before.)

"Now - " [Turning all six cards face down on the table and mixing them up] "we don't know what they are now! You choose one."

[The child points to one which I then turn over and ask:]

"Is it a white one or a coloured in one?"

"........." [Correct answer.]

"So is it a One or a One two?"

"..........." [Correct answer.]

"O.K. Now choose another."

[The child again points to one which I turn over and ask:]

"Is it a One or a One two?"

[Correct answer.]

"So how do the two of them together go?"

(The child taps the table and counts appropriately. If errors are made these are corrected)

"Good! Let's choose one more to go with them."

[The child points to one which I turn over and ask:]

"Is it a One or a One Two?"

[Correct answer.]

[I place it on the table to complete the row of three cards.]

"So how do all of these go?"

[The child taps and counts. Any errors made are corrected.]

"Now let's just do this one again." [I place the 3 crotchet cards on the table] "Do you remember how this goes?"

"One, One, One" [while tapping the table.]

(Any errors made are corrected.)

"You are doing so well. Now what about these?" [The cards are put on the floor out of sight and the first sheet of the pre-test placed on the table.] "How does this go?"

If the child seemed reluctant because of the change from cards to paper then the explanation: *"They're just the same, but I wrote these on pieces of paper that's all"* was given. Any errors during the actual test were not corrected, and each new sheet was introduced with *"And what about this one,"* or *"And this one,"* or *"We've nearly finished now, you're doing so well"*.

At the conclusion of the test the child was praised again and taken back to the main nursery.

Appendix D

Music extracts used during the dual task group's teaching sessions

Extracts lasting between 90 and 120 seconds were chosen from the following pieces of music:

1. 'Dance of the Knights' from Prokofiev's 'Romeo and Juliet'.
2. The finale from 'Serenade for Strings' by Dag Wiren.
3. 'Karelia Suite' by Sibelius.
4. 'Façade' by William Walton, arranged and performed by the guitar quartet 'Tetra'.

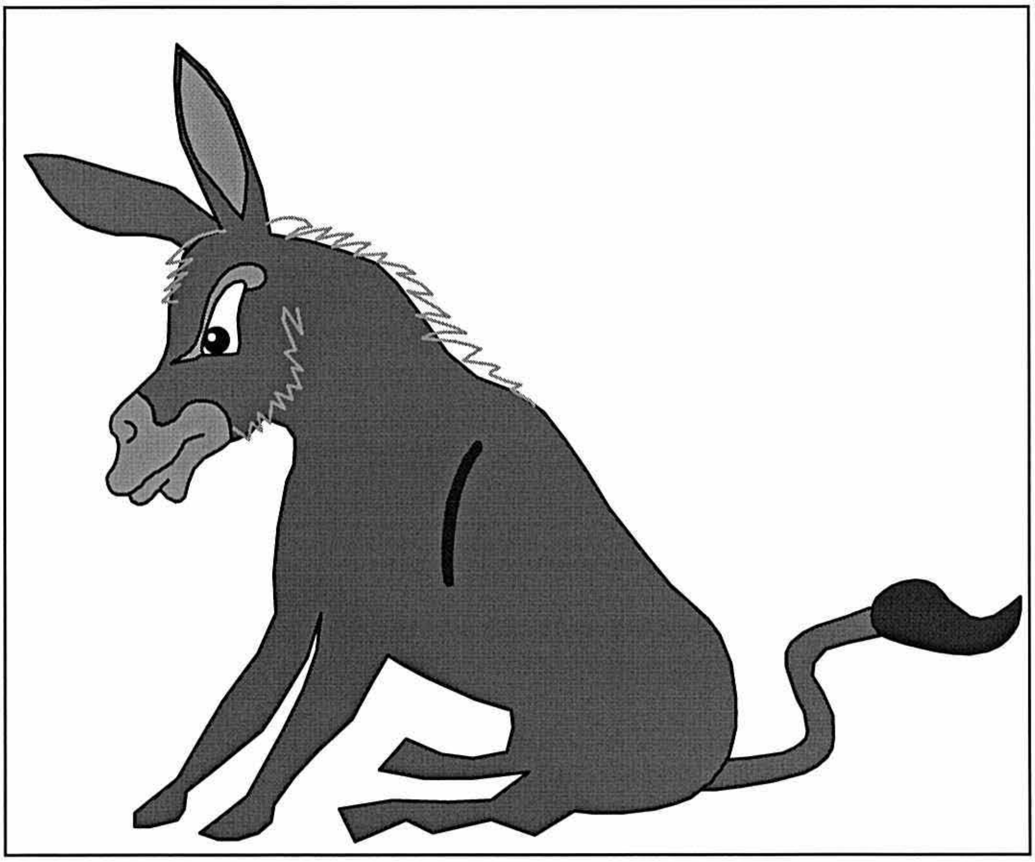
Appendix E

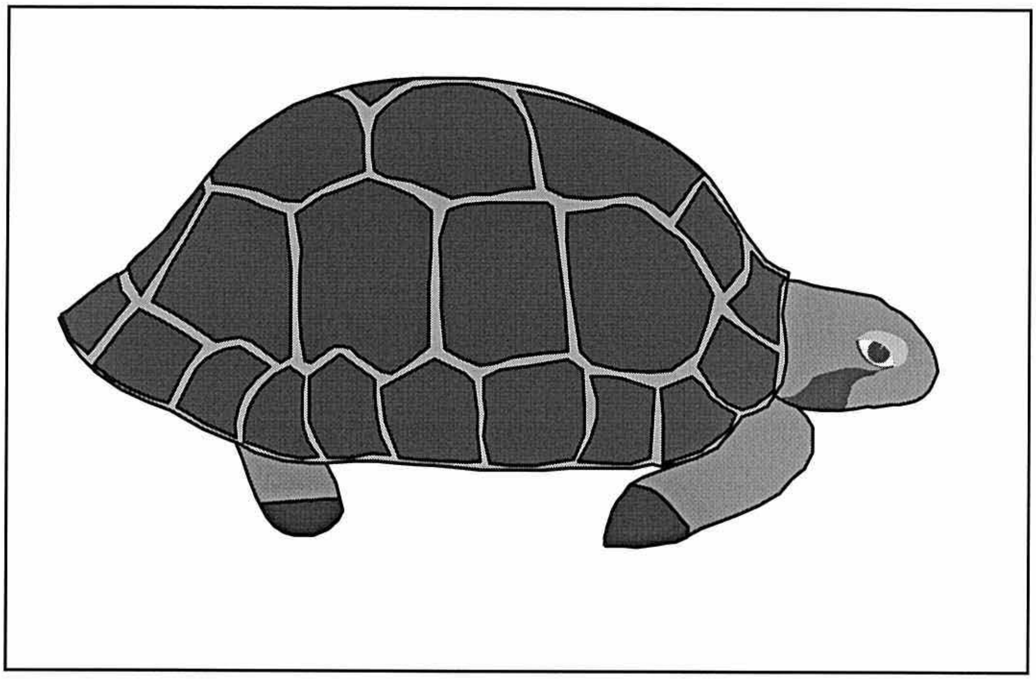
Animal cards used in the Dual Task study

The following animal cards were used:

1. A dog for a crotchet.
2. A donkey for a minim.
3. A tortoise for a semibreve.
4. A teddy for a pair of quavers.

Below are life-size examples of two of the cards, the donkey and tortoise.





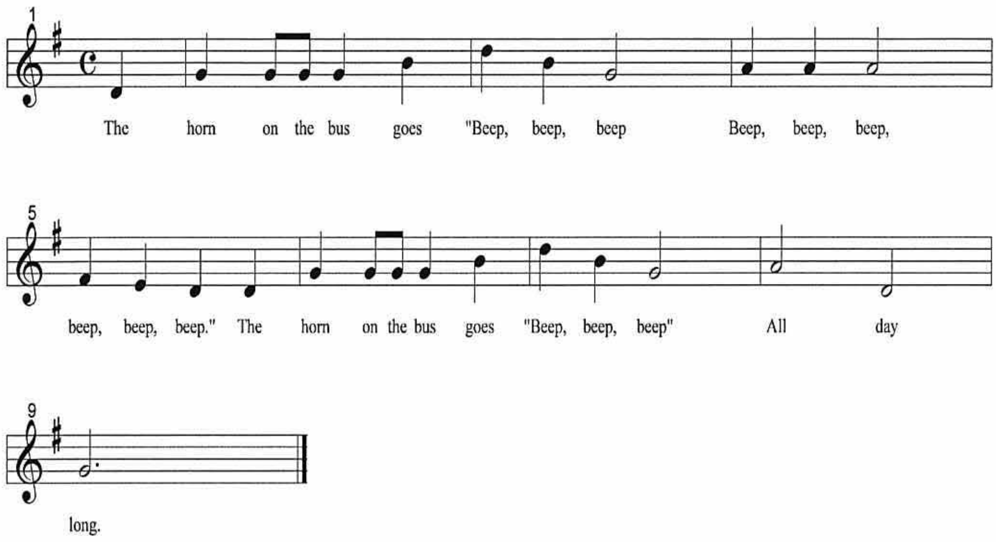
Appendix F

Songs used as training rhythms in the connectionist study

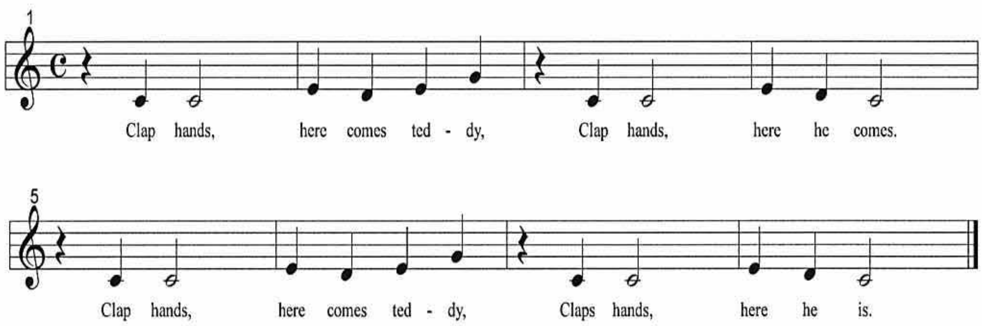
1. "Twinkle, twinkle little star" for the rhythm 

2. "Ding, dong bell" for the rhythm

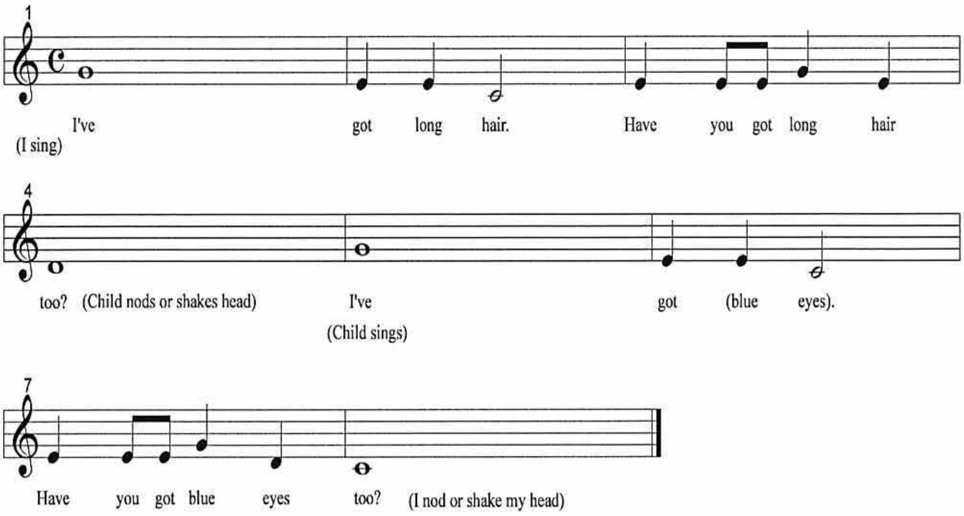
3. “The wheels on the bus” for ♩ ♩ 𝅗𝅥



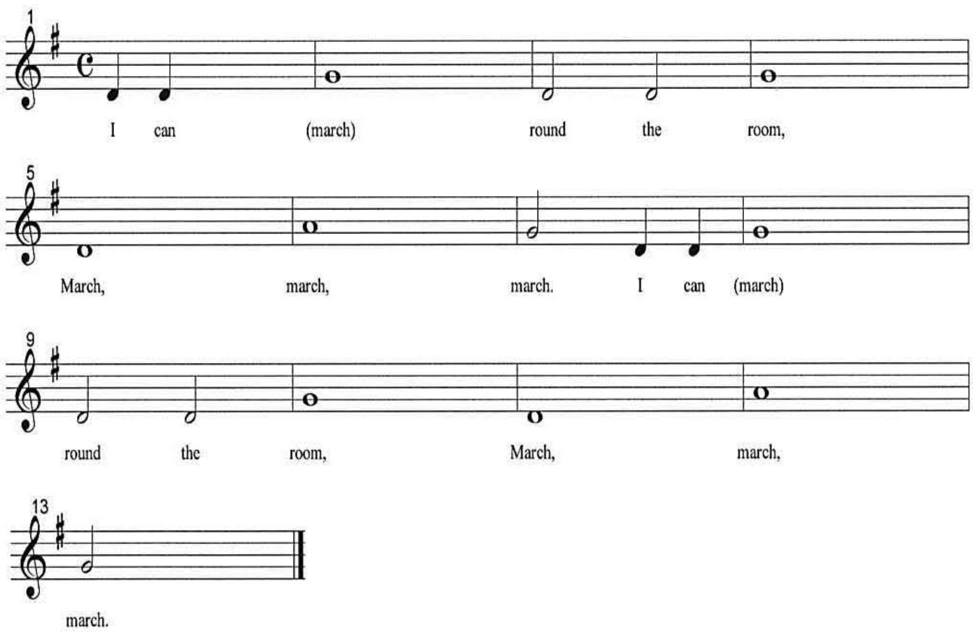
4. “Clap hands” for the rhythm ♩ 𝅗𝅥



5. "I've got….." for the rhythm 𝅝 ♩

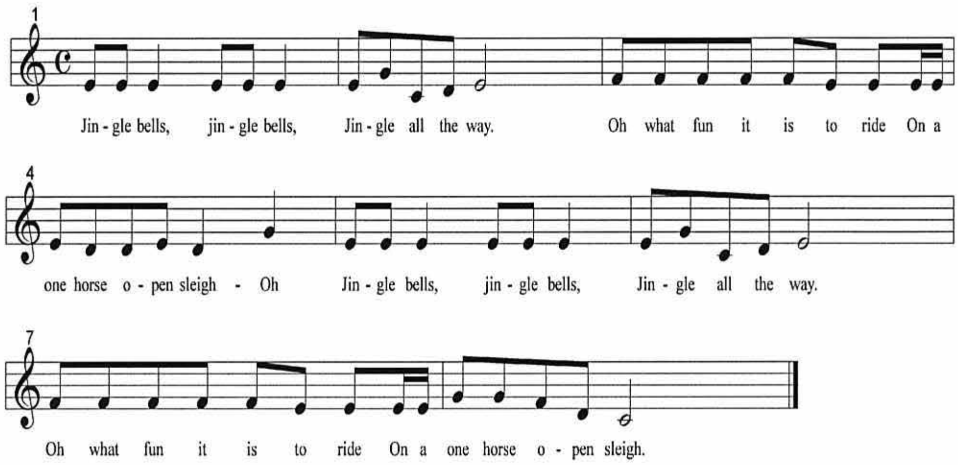


6. "I can ……" for the rhythm ♩ ♩ 𝅝



7. “Mi welais Jac y Do” for 

8. “Jingle Bells” for 

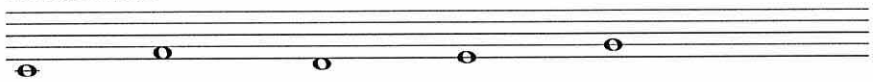


Appendix H

Test material used in the pitch studies

The individual notes were presented to the children as individual note cards. The remaining melodies were presented on A4 sheets of paper. A life-size example of a melody is shown after the test.

Individual Notes



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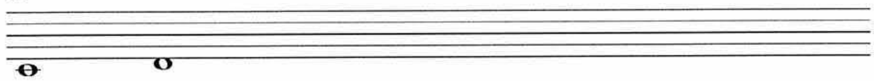
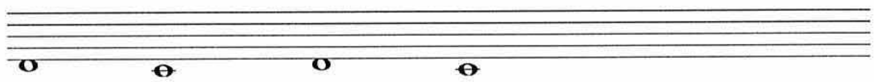
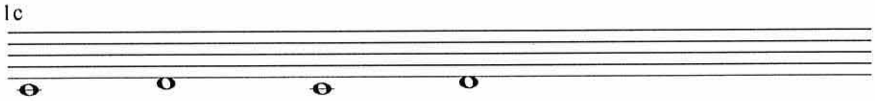


1b



1c



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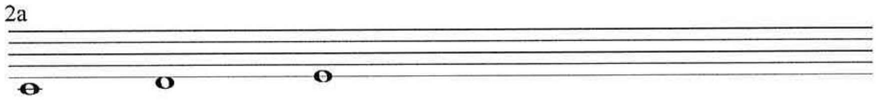

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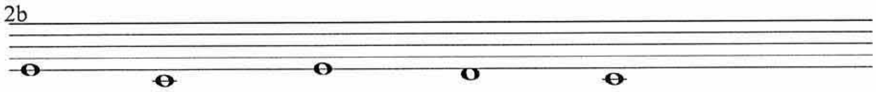

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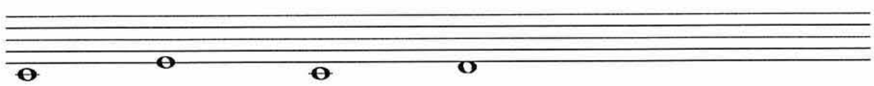

3a

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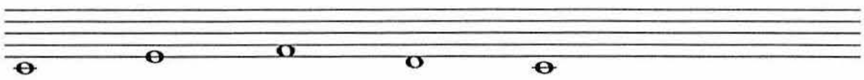

4a

4b

4c