THE EFFECT OF MUSIC THERAPY
ON MOTOR CONTROL OF
CEREBRAL PALSIED CHILDREN

A thesis presented in partial fulfilment
of the requirements of the degree of
Master of Philosophy in Education
at Massey University

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1988

ABSTRACT

In this study, the use of music therapy with cerebral palsied children aimed to establish consistent motor control and extend rehearsal of functional motor actions. Music therapy processes explored the effect of auditory rhythm and pentatonic melody on the quantity and regularity of arm-hand motor action of children with cerebral palsy. Eight children, aged five to eleven years, were involved, each child being considered as a single subject case study. The design of the study was an interrupted time series design (ABACA). A constant beat sound stimulus, emitted by a music-based computer, was determined from the personal tempo of each child and formed a beat-only condition in A sections. That beat sound was joined by child-activated pitched sounds in B and C, together with a third compatible music stimulus in section C, which was singing by the therapist. Pitched sounds and singing were restricted to the five notes of a selected pentatonic scale. Each child was asked to 'play with the beat', making arm-hand contact on a specially constructed keyboard. Measurements were recorded instantly by the computer, which registered number of contacts made, average note duration, note changes made, and three measurements relating to regularity of contacts made.

Results showed that all children attended to the music-based task of playing with the beat. Melody plus rhythm stimuli gave more motor contact actions than rhythm stimulus alone, for all children. Measurements of regularity of motor control, (deviation from beat, average tempo and pulse-tempo deviation), were affected in varying ways by melody plus rhythm. Some neuromuscular delay could be inferred, although anticipation of beat sound and muscle action inherent in a rhythm task was present. This suggests that cerebral palsied children respond to a music-based task with extension of effort and some control of muscle tone.

Results from pre and post tests done using selected items from the Bruininks-Oseretsky Test of Motor Proficiency did not give results that could be regarded as significant. A longer experimental period than three weeks is suggested for similar studies.

Computer measurement of time-based motor behaviour resulting from music stimuli was objective and accurate. Similar type music therapy studies could find this use of a music-based computer for measurement most useful.

Overall the aim of the study was to look at the effect of music therapy on motor control of cerebral palsied children. Regular rhythm was used to provide structure for the required time-ordered behaviour, and the pace of beat stimulus given was personal to each child. In 'playing with the beat' the child attempted to synchronise arm-hand action with the beat-based signal; this process required cognitive anticipation of a sensorimotor action. The ability to make regular contact was relative to degree of neuromuscular dysfunction, age and maturation and affective interest in the task. The independent variables of music therapy, with rhythm and melody, were employed in a planned, sequential order so that the dependent variable, motor control, could be measured relative to the whole task and to rhythmic and melodic components in the task.

The planned processes of a simple music therapy task, using rhythm and melody stimuli, supported extension of rehearsal of a motor task and improvement of motor control.

ACKNOWLEDGEMENTS

The New Zealand Society for Music Therapy encouraged this research project, to support the recognition and development of music therapy in this country. Elaine Sharman shared music research experience from her period as a McKenzie Research Fellow, and Colleen Pilgrim (then senior research psychologist, Department of Education) advised on an acceptable research model.

Palmerston North Teachers College colleagues have been of great support. Barry Jackson suggested, then devised, a computer-based approach that encompassed both the planned music input and the varied presentation of physical ability from children with cerebral palsy. David Hyde helped technically; David Williams constructed the special keyboard used. Keith Paintin, Colin Gibbs and Guy Broadley shared information, Murray Warn filmed sections of the project, and many other staff members gave valued encouragement. The Research Committee of the College gave $200 towards material costs and arranged some support towards travel costs.

Faculty members of the Education Department of Massey University have been most helpful. James Chapman, moderator of this thesis, provided interested, firm opinions from a strong interest in special education. This gave an essential objectivity to a topic which needed a disciplined approach and provided an important area of personal development for which I am most grateful. Ross St George, who moderated while James Chapman was in Canada, also extended my experience with a rigorous approach to methodology and assessment.

Test materials were loaned by Eddie Eggers, pychologist with the Education Department's Psychological Services Division; he and other psychologists helped particularly in decisions relating to test procedures. Pre and post test measurements were taken by Lyn Finn, whose experience with special needs children was of great value in this task.

The Principal and staff of Awatapu Special School allowed the pilot session to take place at the school. The eight children who took part in the study attended seven different schools in Palmerston

North, Feilding and Levin. I thank particularly the children, their families, and the principals and staff at the schools for their consistent interest and practical help.

John Anson provided the computer programming skills for the histograms, Grizelda Blazey and Elizabeth Baxter converted the written material into a well-assembled text.

I am grateful for the support given by all these people, and by my family and friends.

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CHAPTER 1. INTRODUCTION

OUTLINE

Music affects human beings. The nature of this effect needs some exploration as does present psychological and educational understanding of this power of music. This chapter attempts to move from general description of use of music with people to a particular focus on music therapy where planned use of music provides an interactive process in an educational setting.

1.1 HISTORICAL

That music can have a powerful effect on human beings has never been disputed. Alvin (1975) provides a rich summary of historical anecdote regarding the magical, rational and religious healing effect of music. This has appeared in a wide range of literary sources. Philosophers in ancient Greece attributed specific ethical qualities to the scalic modes which formed the basis of vocal or instrumental melody. In Aristotle's time the Dorian mode was believed to have and to inspire a spirit of valour, while the Lydian mode was suited particularly to use with young children.

Chailley (1964) stated that certain lively rhythms unbridle primitive instincts in human beings, which are demonstrated in physical activity as illustrated by early accounts of frenzied witches' dances or tribal rituals. In modern times the introduction of rock and roll music in the late fifties with its solid beat and syncopation inspired energetic new dance styles. These caused consternation among parents and preachers regarding the antisocial behaviour that such gyrations might inspire (Melly, 1970). Through the ages, more even rhythms have been recognised as having a steadying effect as in work songs, or a soothing role, as in lullabies.

Every musical situation involves people's feelings. The effect of melody, rhythm, timbre, harmony, form or dynamics, either separately or in combination, is such that some aspect of intrinsic or extrinsic behaviour is altered. Certain music evokes certain moods and poets, novelists and playwrights through the ages have found a rich source of descriptive material from this connection.

Music has various dimensions. It can be regarded as a rehearsed skill resulting in a performance. This requires physical technique together with ability to read and interpret created music in a way that gives aesthetic experience and enjoyment to an audience. This enrichment, for both performer and audience, can form part of an educative process or can be a chosen part of general life experience.

Music can also be an adjunct to another activity. It can be used as a positive reinforcement for acceptable effort in a behavioural programme both by its presence and by withdrawal of sound until appropriate behaviour is resumed.

Finally, music is used as a therapeutic agent in an interactive process between therapist and client with social, physical, intellectual or emotional needs. In this century more specific study has been made of this use and effect of music on behaviour and learning. This has resulted in the growth of planned use of music for therapeutic and remedial purposes in schools, hospitals, many areas of training and retraining, and in the community where need has been established. The process that has developed from this planned use can be termed music therapy.

1.2 WHAT IS MUSIC THERAPY?

1.2.1 Definitions and Descriptions

The understanding of music therapy is more accessible from participation in music therapy practice than from the descriptive realm of words. This becomes obvious when formal definitions from various professional music therapy organisations around the world are looked at. First, from America:

> Music therapy is the use of music in the accomplishment of therapeutic aims: the restoration, maintenance and improvement of mental and physical

> health. It is the scientific application of music, as directed by the therapist in a therapeutic environment, to influence changes in behavior. (National Association for Music Therapy, U.S.A., 1982).

The leaflet giving that definition went on to reinforce the working relationship between the professional music therapist and other professional analysers, planners and evaluators of procedures used for a client in supporting him/her towards a more appropriate adjustment to society.

Another careers leaflet on music therapy published by the Australian Music Therapy Association (1984) had a briefer description of music therapy: "The planned use of music to achieve therapeutic aims with children and adults who have special needs because of social, emotional, physical or intellectual needs."

There is definite use of the term therapeutic in both these definitions. The American version relates specifically to behaviour change, the Australian definition stresses needs, and the planned use of music.

The Association of Professional Music Therapists, Great Britain (1987) listed various responses to the question "What is Music Therapy?" Their leaflet stated that the ability to appreciate and respond to music is an inborn quality in human beings, and that a skilled music therapist is able to use music to arouse and engage clients, helping them to realise their full potential. Music therapy provides a framework in which a mutual relationship is set up between client and therapist. Thus there is emphasis on an interactive process, with skilled use of music as the interactive medium.

The three information brochures cited contain prepared statements intended to provide, for intending music therapy students and for the enquiring public, access to the principles of music therapy. The brochures give broad, introductory descriptions of music-based interactions between therapists and clients with special needs but make no attempt to give precise reasons for the effectiveness of music in an intervention situation. Early music therapy practitioners (Alvin, 1975; Gaston, 1968) also made statements about music therapy in general philosophical terms rather than giving analytical reference to musical components. Their music therapy practice was documented in case-study form or as anecdotal evidence of observed behavioural change. In these earlier days of a developing profession the need for empirical research was not a priority. Music therapists concentrated first on music therapy practice, in order to demonstrate the effectiveness of music therapy, and secondly on the establishment of professional training courses.

It is important, however to try to define more precisely what does happen in music therapy practice that leads to observed change. Music-making happens through time, is made up of many elemental sound components and is primarily a non-verbal means of communication. Discussion of these aspects of music in relation to music therapy practice will give further definition to the nature of music therapy.

1.2.2 The Nature of Music Therapy Practice

A succinct overview of the practice of music therapy was given by Boxill (1985). Beginning with a definition of music as structured tonal sound moving in time and space, Boxill identified the basic elements of music as rhythm, melody, harmony, pitch, tempo, dynamics, timbre and the text of song. These can be considered to have impact singly, in different combinations and as a gestalt. Therapy, when applied to the treatment of mental, psychological and behavioural disorders, becomes, according to Boxill, interchangeable with the term psychotherapy. She considered music therapy an amalgam of music and therapy:

> When music, as an agent of change, is used to establish a therapeutic relationship, to nurture a person's growth and development, to assist in self-actualization, the process is music therapy. In this process, music is consciously used for the enhancement of living, being and becoming. Broadly defined, music therapy is the use of music as a therapeutic tool for the restoration, maintenance,

> and improvement of behavioral, developmental, physical and social skills - all within the context of a client-therapist relationship. A non-verbal treatment modality that is applicable to both the verbal and non-verbal person, it serves those of a wide age range and with a wide diversity of disorders (p. 5.)

Listing fundamental reasons for the effectiveness of music as a therapeutic agent Boxill continues:

> * It is a cross-cultural mode of expression.
> * Its non-verbal nature makes it a universal means of communication.
> * As a sound stimulus it is unique in its power to penetrate the mind and body directly, whatever the individual's level of intelligence or condition. As such, it stimulates the senses, evokes feelings and emotions, elicits physiological and mental responses, and energizes the mind and body.
> * Its intrinsic structure and qualities have the potential for self-organization of the individual and organization of the group.
> * It influences musical and non-musical behavior.
> * It facilitates learning and the acquisition of skills.
> * It is an eminently functional, adaptable and aesthetic modality applicable to all client populations. (p. 6.)

Also, the writer described music therapy as both an art and a science. Both are acts of discovery, imagination and inspiration that give rise, on one hand, to symbolic and aesthetic expression, and, on the other, to verifiable and investigative expression.

Duerkson (1981) tackled the question of how to investigate music as a non-verbal form of communication during music therapy sessions.

He suggested evaluation can be based on examination of two different facets of client behaviour:-

1. What does the individual do with the musical activity?
2. What does the individual do during the musical activity?

The client's actions with the music activity can be examined in respect to attention (selectivity, distractability, span), auditory perception and discrimination, physical dexterity, co-ordination, endurance and strength, vocal control and inflection, short- and long-term memory, sequencing skills and acculturation. In evaluating client behaviour during the music therapy session the situation can be organised to examine activity level, reality orientation, attitudes towards self, others and music, physical behaviour, interpersonal and social behaviour, and general approach and avoidance responses. Following these evaluation categories, Duerkson lists intervention possibilities using music where therapeutic objectives can be set. These interventions can support cognitive, affective, psychomotor, social, perceptual, self-image and creative development, also development of self-reliance.

Duerkson (1981) set out logical categories for planning and evaluation of music therapy practice, showing that an expressive, aesthetic experience such as music-making can be looked at objectively in terms of what the client does. He affirmed the opinion of Gaston (1968) who, in comparing music education and music therapy, stated that the music educator is more concerned with the musical behaviour of the child whereas the music therapist is more sensitive to the non-musical behaviour of the child. The music educator working in special education uses music in a directive style. The music therapist working in the same client area provides a similar structure but operates in a more divergent musical style to match the perceptual cognitive, social and affective needs of the client.

The construct and process of music relative to therapy was classified by Sears (1968) as experience related within structure, in self-organization and in relating to others. In other words the client performs or listens in a music session with a therapist who provides structure by being there, supports choice of response and becomes an interactive agent in the process of relating through music. Music itself provides structure because it occurs through time and can be repeated in content and time.

Music shared between therapist and subject becomes a communication channel through which ordered and structured messages can pass back and forth. These sound messages can use perceptual, cognitive, motor or affective channels to initiate a music cue or cause response to one. The interactive nature of such messages relies on some form of learning, some level of conceptual awareness and understanding.

Content of music therapy sessions can use composed material or improvised sound-making to promote musical interaction. A wide range of composed resources is available; songs, instrumental pieces, individual and group playing and moving to sound, and listening. All styles of music are accessible and valuable in music therapy because the process of making a cue-based musical connection relies on personal responsiveness to some sort of chosen sound by the client. Music therapists therefore need flexible music skills to provide immediacy of response or initiative to the client's music statements. Live music has more therapeutic potential than recorded music (Nordoff and Robbins, 1973). The inflexibility of recorded music, especially in respect to rhythmic pace, does not allow for a music process that meets and matches a client's capabilities and varied responses. Music therapists, working on a one-to-one or small group basis, therefore need musical and personal skills to devise varied strategies for communication using both composed and improvised music. This is especially important in working with handicapped children where physical, intellectual, social and emotional needs are not separate entities and the child has different levels of capacity to make verbal or non-verbal contact with others.

Every human being 'knows about' music; even the deaf can observe the periodicity of rhythm in a musical or movement task (Korduba, 1975). Yet children, and most adults, are not able to describe this knowledge. This is an important point for both music education and music therapy practice. In both fields the structure of rhythmic and tonal music is stable and organized. The teacher or therapist utilizes a framework of composed or improvised sound and encourages rehearsal and understanding of simple, then more demanding, skills and concepts. There is secure, repeatable music structure within which a participant can perceive then demonstrate that perception and understanding through a gestural or vocal response or even by a small physical movement in response to rhythm. This is recognized as a specific response to a sound stimulus and the response signifies a change. Also the participant may respond to the emotional appeal of the music thereby releasing potential for change that cannot be reached by an intellectual challenge alone (Cameron, 1970). The trained music therapist recognises and encourages appropriate change through music and knows how to plan music content relative to diagnosed need.

SUMMARY OF SECTION 1.2

Music therapy aims to acknowledge, challenge and support, through music, a child or adult with special needs. The elements of rhythm, melody, texture and harmony, together with dynamics and form, are used to enhance perceptual and cognitive processes through auditory, visual, tactile and proprioceptive channels of interaction. Even the simplest of elemental music experiences involves a complex gestalt of doing and feeling, and it is the affective power of music that forms the heart of music therapy.

As stated earlier (Boxill, 1985), music therapy owes much to a relationship with psychotherapy. The next section overviews briefly the impact and influence that psychology generally has had on the development and style of music therapy practice.

1.3 INFLUENCE OF PSYCHOLOGISTS ON MUSIC IN THERAPY

1.3.1 Writers on Psychology of Music

Until recently psychologists have not written about the effects of music in a way that is useful to music therapy. Rather they studied specific emotional, physical, perceptual or cognitive aspects of human response to the production of sound.

Lundin (1967) reviewed the writings of psychologists on music crediting the 19th century acoustic studies of Helmholtz and, later, Stumpf, as laying the experimental foundations of the psychology of music. Lundin stated that major earlier 20th century studies (Mursell, 1937; Seashore, 1938; Schoen, 1940) were largely subjective contributions which centred on the mind and its reactions to music.

Later psychologists contributed more directly to the planned use of music, and various aspects of their work are useful to music therapy. Buck (1944) stressed the need to develop performance skill through rehearsal. Davies (1978) explored the nature of human need for, and love of, music. Later he postulated an internal template theory for perception of musical events; inner groupings of pitched notes, with rhythm, give recognition or learning of tunes (Davies, 1983). Radocy and Boyle (1979) provided a behaviouristic perspective on what people do with musical stimuli. This provides a good overview for music therapists exploring reasons for client behaviour.

A social psychologist, Farnsworth (1969) made observations of relevance to music therapists. He looked at applications of music to industry and therapy and pointed out that the student who looks for scientific validity in the medical and industrial worth of music will be offered little besides anecdotes and legends. Data can be shown which demonstrate unmistakable emotional adjustment or improvement in work output; then the student learns that a host of other therapies or changes in industrial atmosphere were present. One is left to puzzle over the part music may have played in the process, wondering whether it was really the music that induced the changes, or another therapy, person or circumstance.

It is interesting that Farnsworth used the phrase "medical use of music" and later in the same chapter questioned why the "curative qualities" of music are not more easily demonstrated. Acknowledging that music can alter both the moods and some basic physiological processes of many persons he associated music therapy with hospital situations where a research programme can only be incidental to the prime focus on cure, and where a variety of therapies are utilized in what he termed a "buckshot" policy of effecting cure. Besides the difficulty of isolating the effect of one therapy by itself, the friendly supportive attention provided by the therapist or caregiver may be the active agent towards subsequent "cure". Nevertheless Farnsworth did credit music with the capacity to lessen boredom and extend endurance in doing repetitive physical exercises. He also stated that listening to music is used to re-establish contact with reality for a withdrawn person, that interpersonal music-making is a resocializing agent and that musical performance gives a sense of achievement and prestige.

Deutsch (1982) drew together foremost authorities on musical processing in terms of perceptual and cognitive studies relating to neurology, psychoacoustics, subjective effects of sound, temporal aspects of sound, pitch relationships, musical ability and performance and the role of music in every-day life. Contributors provided condensed summaries of major research findings and projections in their field of speciality, and the volume is a valuable resource for music therapy researchers and practitioners. Information on rhythm and tempo (Fraisse, 1982) and melodic information processing and development (Dowling, 1982) have been of particular relevance and value to this project, and will be referred to again in a later section.

In trying to relate research in the cognitive psychology of music to the actual practices of musicians, Sloboda (1985) pointed out that many psychologists lack musical training, that theoretical developments in the psychology of music have been slow, that psychological research has been dominated by processes involved in perception of single entities rather than larger musical structure, performance or composition, that psychologists in trying for rigorous control and measurement have opted for too finite a musical dimension and that they have not related to or addressed themselves sufficiently to practicing or academic musicians. His book helps the psychologist break an interdisciplinary barrier to encompass this wider perspective of music itself. This may encourage psychologists to become more aware of the nature of music therapy which does not restrict its processes to use of single entities of music.

Bruscia (1987), a psychologist and music therapist, has given a detailed synopsis of over 25 models of improvisational music therapy developed over the last 30 years. He pointed out that music therapy practitioners who write substantially about their work have widely differing approaches, with few stating a direct affiliation to one or more psychological theories. Priestley is one exception, describing her approach to analytical music therapy in terms of various psychodynamic theories especially those of Freud and Klein. Bruscia (1987) attributed existential/humanistic orientation to the work of Gertrude Orff and termed his own experimental improvisation music therapy as having strong existential leanings. He noted that Alvin's approach is strictly musical and that music therapy is considered as a developmental process planned and implemented in segmental stages of growth. Nordoff and Robbins too use music itself as the principal therapeutic agent in interaction between therapist and client.

In Music therapy and its relationship to current treatment theories, Ruud (1980) examined four models used in psychiatry and psychology to see how different procedures in music therapy are related to general trends in treatment thought and to various philosophical orientations. The four models examined were medical, psychoanalytical, behavioural and humanistic-existential. He found little connection between music therapy practice and a medical model which is based on biological man and treatment of disease. He noted the emphasis on behavioural theory in music therapy in America since the foundation of the National Association of Music Therapy which prompted a strong demand for more research. To meet the demands of a prevalent scientific attitude, music therapists explored behavioural techniques in their work and research in an attempt to establish procedures along more scientific lines. Ruud thought that some reconciliation of constraints and processes between behavioural and psychodynamic models in psychology is a possible base for a conjoint approach. He acknowledged however that music therapy can never establish theories and procedures separated from those within the fields of psychology and philosophy. Music therapy differs from psychology in that music therapy is concerned both with man and the relation between man and music, giving it unique status. Thus research procedures in music therapy focus on concern for man, and music therapy is the science of man and his music.

> Facts from anthropological sciences differ ontologically from the facts of natural sciences.

> Natural phenomena react, man acts, it is said. Introducing the concept of action into a field of science means in this case that at the same time as the scientist is contributing something to the knowledge about himself, he is at the same time transforming the knowledge about himself. (p. 70.)

Ruud (1980) took a stance that bears some resemblance to the cybernetic model in psychology which views the individual as a purposeful, self-regulating biological system which is kept in balance by feedback in the cycle of perception/input and action/output. Spender and Shuter-Dyson (1981) consider this model appropriate to music experience. It can be observed in music therapy that aural, tactile or multi-sensory input and output can be influenced by the actions of client or therapist with the therapist supporting the client towards what Ruud terms "transforming the knowledge about himself."

Ruud (1980) advocated that music therapy should operate in an open field where different models of understanding collaborate with one another. He concluded that procedures within music therapy ought not to be judged on the basis of whether they are humanistic, true or scientific, but rather on the basis of their consequences.

Theories and models in the psychology of music field both respond to and catalyse specific research. Much of this has come from the base of educational or clinical psychology without necessarily including music-making as a component. Yet research such as response to a basic beat or single tone may provide fresh insight into a working process in music therapy practice.

Many studies in the large and diverse area of music research can provide information helpful to the development of music therapy. For this study reference will be made only to research that has relevance to music therapy with younger special needs children and to cerebral palsy.

1.3.2 Relevant Research in psychology of music

(a) Extent of research

In 1971 Eagle and Dubler gathered current figures on publications in psychology of music research. Psychology of music referred to music "affecting the organism"; 68 American journals had published 223 relevant studies in the previous 10 years. In coverage of American and foreign journals, research was considered relevant if it "was concerned with the influence of music on human behaviour". Nine categories were distinguished in journals using computerized key-word groupings:

1. Dimensions of tone (loudness, pitch, timbre, time) (55)
2. Combination of tones (32)
3. Learning and remembering music (23)
4. Affective response to music (13)
5. Measurement of musical behaviour (20)
6. Performance reactions to music: by type or kind (25)
7. Performance reactions to music: by instrument (31)
8. Music on work tasks (10)
9. Music in therapy (135)

Numbers in brackets total the studies listed in each category.

The music in therapy category had 3 sub-categories: physical (59), medical (14) and psychological and neurological (62). There were three cerebral palsy studies in the psychological and neurological sub-category.

Eleven years later Eagle (1982) compiled a music therapy based bibliography comprising 501 annotated entries from a computer bank source of over 10,000 pertinent citations to music therapy. Of the 501 entries, 17 related to cerebral palsy.

In the 1971 Eagle and Dubler project research relating to musical development was not categorized even though education journals were included in the survey. Since that time however there has been a marked increase in research on perception and cognition relating to music elements.

(b) Research related to Piagetian developmental concepts

Much research in musical development in recent years has been given a conceptual framework from the theories of Jean Piaget (Cohan, 1984). Most attention has gone to the principle of conservation, looking at the ability to recognize the constancy of one aspect of a stimulus while other aspects change.

Looking for a cognitive assessment tool for music, Rider (1977) developed two auditory conservation tasks involving perception of changes in rhythm and tempo in music; these were modelled on Piaget's visual assessment tasks. Later (Rider, 1981) a developmental sequence of 15 auditory tasks was established for children aged two to 12 years. Rider stated that ability to conserve rhythm and tempo is achieved by a child when he/she is about to enter the Piagetian developmental level of formal operations. Learning disabled subjects could experience delays in acquisition of these temporal concepts particularly where there are difficulties in vocal or motoric control. Rider suggested, however, that comparative assessment for some handicapping conditions could be possible using his auditory assessment tasks.

Further research relevant to this project included a study of developmental sequence in acquiring rhythmic concepts by Zimmerman (1984). First, beat is recognised, then rhythmic pattern, then at about age nine years and six months the concept of metre is conserved (metre is constancy of time-based measure in music even when durational values of individual sounds within the time-span of each measure vary).

A 1980 review of Piagetian research in music by Serafine related aspects of Piaget's theory of stages and theory of structuralism to cognitive development in music. Later, Serafine (1983) in a full rationale of cognition in music, proposed several cognitive processes - global, temporal and non-temporal - as fundamental across musical styles and as fruitful areas for research. She placed music firmly in the activity area of cognitive or mental processes. Serafine confirmed the premise that performance of a music task improves with age. As yet well-defined stages are not identified though the effect of task training progresses from a negligible level (at the pre-operational stage) to a positive level (at an older age). There is little research information about the effect on task performance of variables such as environment, experience, memory and aural perception. Serafine also confirmed a positive relationship between music conservation tasks and Piagetian conservation tasks.

(c) Acquisition of music concepts related to melody

The research quoted earlier (Rider, 1981; Zimmerman, 1984) gave some indication of the acquisition of rhythm concepts by children. Melody, also an important and recognisable feature of music, is another major focus for developmental research. Dowling (1982) summarised the developmental sequence of a child's ability to relate to tonal difference. A baby can distinguish gross features such as melodic contour and pitch level and gradually the child develops ability to distinguish more subtle features of key change and small interval alteration of pitch. Krumhansl and Keil (1982) studied age-related perceptions of tones (sequences of which form melodies). Using tones that were components of chords they determined that children aged six to ten years were more sensitive to simple, physically defined properties of tone stimuli. Whereas adult musicians value complexity (Griffin and Eisenman, 1972) and may tend to use complex melodies, younger children like simple melodies that end on 'home' notes in a given key.

(d) Music and the brain

In a study that involves cerebral palsy some reference to cerebral hemispheric function in music is relevant. Cerebral palsy can involve brain damage which could inhibit not only motor control but also perception of rhythm or melody.

Rainbow and Herrick (1982), while researching a process strategy theory for music and hemispheric activity, tested musicians and non-musicians with pitch and rhythm cues. Non-musicians related better to rhythm cues than pitch cues. It was suggested that non-musicians may centrate on rhythm, a more innate process than pitch centration.

Borchgrevink (1982) summarized a series of studies on the cerebral processing of speech and music. By selective anaesthesia of successive hemispheres it was demonstrated that musical rhythm and the act of singing were processed by the speech hemisphere while reception of pitch and tonality were supported by the non-speech hemisphere (the right hemisphere for right-dominant subjects). As production of rhythm and voice activities and reception of pitch and tonality are controlled by different cerebral hemispheres almost any musical performance implies extensive integration and co-operation between the hemispheres. Wilson (1985), a clinical neurologist, wrote of the capability of music to provide "one of the most powerful experimental tools we have ever had for studying the workings of the human brain." (p.40). Implications for cerebral palsy subjects relate to both physical and perceptual reactions to music stimuli which may be determined by the position and amount of cerebral hemispheric damage in the brain. Performance of certain music tasks could be affected. Conversely, this performance could assist in assessment of brain damage, as Wilson inferred.

SUMMARY OF SECTION 1.3

(Other research studies from the psychology of music literature relating to the use of rhythm as a learning medium in music and music therapy will be presented in a later chapter. Rhythm has particular relevance to this study and is central to the practical process used in the research.)

The influence of psychology on the use of music in therapy has been of value to both disciplines. Psychologists explored the effect of sound on people primarily through an awareness that visual perception, the most accessible area for perceptual research, has interesting comparisons with auditory perception. Also educational and social psychologists have observed specific effects relating to behaviours and music; music modifies certain actions and reactions.

Music therapists know from continuing practice and observed results that the medium of music is their effective tool for change, yet music therapists have difficulty in explaining how or why change takes place in a wide range of behaviours. The work of psychologists and musicians together gradually is interweaving theory and practice to produce some constructs which give a basis for some explanations. The prime change of emphasis from a medical model to a humanist-behaviourist model when relating music's effect upon persons provided a major catalyst (Ruud, 1980). Instead of music being considered as a global entity which seemed to effect various degrees of 'curative' improvement, the use of music became accepted as part of an interactive process.

Then interest grew in an analysis of the components of music. Rhythmic recognition is obtained in a developmental sequence which goes from simple beat to more complex patterns (Rider, 1981; Zimmerman, 1984). Components of rhythm and melody make individual contribution to an interaction between sound and person. Serafine (1980) confirmed that music, of all styles, is an active mental pursuit; this adds strength to the premise that music is an effective learning medium. The three studies reported above related to Piagetian concepts and helped determine for this study the preferred age for subjects, also gave some guidance to aspects of rhythm content and need for some rehearsal of task. Some of the problems relating to motor control with cerebral palsy subjects were signalled by Rider (1981).

Music has a repeatable structure, a predictable security in time which reassures the person. New discoveries about bilateral processing of music in the brain (Borchgrevink, 1982) lend credibility to its influence on perceptual and cognitive processing modes. Therefore the brain damage often associated with cerebral palsy will affect performance and understanding of a physical task based on music stimuli to a degree that will vary from subject to subject.

Music findings relating to developmental stages of tonal and rhythmic concepts should influence music therapy resources and processes chosen and used. Single-line or open-textured accompaniments to melodies rather than dense chordal accompaniments, use of harmonies that enhance simple melodies - these are some of the musical approaches that should be considered in interactive music therapy at earlier stages of child development. Children and special needs children and adults thereby have direct access to a sound-based process which can provide extension of many forms of learning.

Following this consideration of relevant research from a psychology of music base, it is now appropriate to focus more precisely on the historical background and nature of music therapy then later to explore processes of music therapy.

1.4 NATURE AND DEVELOPMENT OF MUSIC THERAPY

1.4.1 In America and Britain

There are many general statements about the nature of music therapy; they differ in emphasis depending on the philosophical and historical base from which they come.

Gaston (1968) regarded music as an essential form of human behaviour which has both biological and psychological concepts. Music therapy therefore rests on secure foundations as it strives to organise, classify and describe until a system emerges that is behavioural, logical and psychological.

Michel (1976) termed music therapy a behavioural science based on research. It is not performance of music as an end in itself, but is concerned with all aspects of human behaviour and what brings about changes in that behaviour.

Michel and Gaston are pioneer American music therapists, both based strongly in the behaviourist tradition. Music therapy in America developed in an identifiable way after World War II, when the effect of music on war-injured servicemen was observed to be very supportive to physical and psychological rehabilitation. E. Thayer Gaston was among those responsible for the gathering together of music practitioners who were working, with success, in areas of music remediation with handicapped children and adults, geriatric and psychiatric clients. Meetings of clinicians led to the formation of the National Association for Music Therapy and the enunciation of basic principles for the discipline of music therapy, its theory, practice and research. These were published in Music in Therapy (Gaston, 1968), still an essential text for music therapy students; it represents a considered distillation of opinion on music therapy effect, based mainly on observations by well-experienced practitioners. Writers in the book acknowledged the need for definitive research and a section on possible research procedures was included, thus giving music therapy research a much-needed impetus in America.

Another base for music therapy development was provided by Juliette Alvin, a practitioner and writer in Britain. Born in France, she was a professional solo cellist before pioneering music therapy in Britain by founding the British Society for Music Therapy in 1958, and founding a postgraduate training course in London in 1964 (Campbell, 1983). British music therapy practice uses a broad repertoire of musical performance and elicitive skills including a strong emphasis on improvisation techniques and individual and group participation in musical activities. Bunt (1984) pointed out that this produces literature based, for the most part, on the descriptive case study or on philosophical speculation. While respecting the importance of such pioneering work, Bunt stressed the need for specific outcome research methods to be devised to establish links between treatment and outcome. In his own work at City University, London, he developed a rating scale to measure changes of behaviour observed by filmed music therapy programmes. Observed common criteria listed were increased eye contact, more social interaction, more general arousal, increases in vocalization, playing time (with specific instruments) and reaching behaviour. Time and frequency measures used to record changes in a programme with 18 handicapped children from three special-case day nurseries in two matched groups obtained significant statistical results. In 1985 Bunt was the first recipient of a music therapy doctorate from a British university and he is a lecturer at the postgraduate music therapy course at the Guildhall School of Music and Drama, London.

1.4.2 Influences in New Zealand

Music therapy growth and status in New Zealand owe much to the work of two Americans, composer Paul Nordoff and his co-therapist, Clive Robbins. These two men practiced in the United States and at Goldie-Leigh Hospital, London, on a regular basis and lectured and demonstrated extensively on music therapy throughout the world, first working in New Zealand in 1974.

Nordoff and Robbins had a remarkable impact on music therapy practice in New Zealand. They emphasized the use of full musical resources (including movement) and of original composition. They stressed the need for quality in all sound used, and used improvised and specially directive music to elicit or support response. Their mix of behavioural and humanistic approaches to 'the music child' in each child gave diversity and balance to their professional style (Nordoff and Robbins, 1973, 1975, 1977).

New Zealand music therapy development has been influenced by the visits to this country of both American and British music therapists and also by the training, primarily at the post-graduate music therapy course at the Guildhall School of Music and Drama, London, of six music therapists by 1987. The Guildhall course reflects strongly the original influence of Juliette Alvin who taught that the nature of music therapy was creative experience. This music-based experience should help any child or adult discover and extend any ability possessed and may be directed towards other ends than purely musical ones (Alvin, 1975). Guildhall graduates have been schooled in sound and movement improvisation and learn first-hand the powerful self-awareness that comes from these musical explorations.

As more interest in music therapy has developed and more music-based work attempted, the New Zealand Society for Music Therapy began negotiations in 1980 for professional recognition for music therapists in education and health fields. This involved many discussions on the value and definition of music therapy with professional groups. As part of this ongoing discussion, a New Zealand Education Department working party of musicians, music therapists, psychologists and educationists published this definition of music therapy:

> Music therapy is a powerful and useful tool in establishing communication with children and adults and in supporting learning and relearning in intellectual, physical, social and emotional areas of need. (A Department of Education brochure 1980, p.1)

This rationale requires a broad understanding of the practice of music therapy. It has taken some time for music therapy to develop this understanding through professional processes of observation, evaluation and planning for future work. It is important to realise the historical sequence of growth of music therapy process and practice to accept the present state of development of the profession in New Zealand.

SUMMARY OF SECTION 1.4

Music therapy is a new discipline in the professional sense. The National Association of Music Therapy, America, was formed in 1950, the British Society for Music Therapy was founded in 1958, the New Zealand Society for Music Therapy began in 1975 and the other music therapy organizations in the world (Australia, Japan, Denmark, France, West Germany, Finland and small groups in South America) are all comparatively new groups. Each new music therapy group has developed a professional practice style reflecting the background experience of its own culture and of its music therapy training. In early development the therapeutic nature of music was recognised intuitively and music therapy practice was uncritical, usually relating to current treatment methods and ideas from other disciplines. Music therapists looked for supportive theories upon which to base their positive practice findings. As Bonny (1984) put it, "Again we come to the 'cart before the horse' dilemma: practice precedes therapeutic design".

Where music therapy practice has used behaviour modification techniques that style of research is possible. New Zealand has taken a more eclectic approach to the nature of music therapy because of training influences; its developing training styles reflect this, as will research. For instance, the nature of improvisation in music is not compatible with the demands of empirical research because improvisation consists of a wide and changing content of both music variables (rhythm, melody, texture, dynamics, form) and client-therapist interaction. Also, the nature and content of music therapy changes considerably from client to client, and can change from session to session. What provides an appropriate music interaction in a music therapy session for an emotionally disturbed adolescent can be totally different to a rhythm-based task used for physical rehearsal effort with a person who has cerebral palsy.

An attempt must be made however to analyse the actual process of music therapy, to look at its inner content and wide client application. This is done next by a review of writings about these aspects of music therapy.

1.5 PROCESSES OF MUSIC THERAPY

As mentioned previously, Gaston (1968) exerted a strong influence on the early development of music therapy in America and his encouragement towards research led to a systematic investigation of behavioural sciences by music therapists. However Gaston felt that psychological theory with no relationship to organismic states was certain to result in false theory pointing out that music had been shown to alter physiological states - galvanic skin response, heart beat and breathing. Heading therefore towards a biodynamic theory of human behaviour he stated that

> music therapy, using a behavioral approach, should be buttressed at every strategic point and in every critical area with whatever will be helpful from other sciences and fields of knowledge. (p. 9)

The nature of research processes therefore, rather than support for a single philosophical stance, was the prime reason for the emphasis on using music in therapy as a behaviour modifier or reinforcer or as contingent reward.

Gaston also championed the recognition of aesthetic needs in human beings and the capacity of music to meet those needs. Aligning this need to a developmental schema he stressed the importance of exploration of sights, sounds, shapes, textures and rhythms, particularly for children. Many music experiences, such as movement to sound or playing of instruments give these experiences which Gaston stated were essential to normal growth and development. Music, as a broad-based sensory experience, can thus enhance a learning process.

Sears (in Gaston, 1968) outlined three classifications that underlie the constructs and processes of music therapy as

1. experience within structure
2. experience in self-organization
3. experience in relating to others.

He developed this further. Structure in music demands time-ordered behaviour, therefore reality-ordered, immediate and continuously objectified behaviour. Self-organization involves self-expression, enhancement of pride in self from successful experiences, opportunities for socially acceptable reward and non-reward and compensatory endeavours for the handicapped subject. Experience in relating to others uses music as a socially acceptable agency, allows for individual choice of response in groups, encourages responsible behaviour, enhances verbal and non-verbal communication and provides for learning co-operative, recreational and realistic social skills and behaviour patterns.

Sears' full analysis of music therapy application is a useful referrant for planning music therapy content relative to established client need in behavioural terms.

Emphasis on self-awareness for the client has been consistent in much music therapy literature since 1970, reflecting a growth of interest in a humanistic model for music therapy.

In work with handicapped children, Nordoff and Robbins (1975) regarded music therapy interaction as a growth process to be initiated by the child. They contributed greatly to the interest in interactive musical procedures in the developing field of music therapy, often using improvisational music. In a musical situation where there is active participation from the child (who is playing a drum, cymbal or pitched percussion instrument in a free way) Nordoff improvised music at the piano to cue into the spontaneous musical statements being given him. Simple "improvised" sound statements from the child were matched, challenged or answered by the music improvised by the therapist:

> The right music, perceptively used, can lift the handicapped child out of the confines of his

> pathology and place him on a plane of experience and response where he is considerably free of intellectual or emotional dysfunction. (p. 239)

Previously, Boxill's (1985) linking of music therapy with psychotherapy is described. Another writer, Ruud (1980) attempted a psychotherapeutic explanation of the music therapy process based on theories of the development of the ego. From a basis of Freudian thought that the ego arose from conflict between the id, superego and reality, Ruud suggests that a consistent ego or consistent positive concept of self comes from a behaviour repertoire that is both differentiated and flexible. Such a repertoire can be established, extended or modified through the planned use of music.

SUMMARY OF 1.5

Whether the process of music therapy is considered from the behavioural, humanist or psychotherapeutic theoretical standpoint, music therapy depends on the use of a wide repertoire of musical activity which involves a diverse range of musical ingredients. From this develops an interactive process between client and therapist. Each individual has an access point for musical dialogue. It is the job of the trained music therapist to initiate or respond to the right melodic, rhythmic, textural or harmonic cue and to work with a subject from that entry point. Recognition by the client that the therapist has done this is given, usually by a musical response. This recognition and the sort of music made by the subject has direct relationship to improved self-image.

All writers cited in the above section stress the importance of positive self-esteem as a goal for music therapy practice. Gaston (1968), in advocating an eclectic approach to music therapy, emphasised the satisfaction to be obtained from sensory experience. Nordoff and Robbins (1975) work with musical initiatives made by child clients, and Ruud's (1980) emphasis on a consistent self-concept also confirmed the central place that a good self-image has in music therapy practice.

Overall the process of music therapy is based on a planned use of appropriate and accessible music to effect an alteration of behaviour or self-image that is both possible and desirable. In this non-verbal dialogue the medium of music provides a flexible and enjoyable communication process.

1.6 MUSIC THERAPY LINKS WITH EDUCATION

1.6.1 Early developments in music education relevant to music therapy

Music educators, prior to 1970, seldom considered that music in special education programmes was anything more than a training process for rhythmic and muscular development and for enabling participation in group experiences like rhythm bands (Graham, 1975). It made some attempt to follow the precepts of philosopher-psychologist Edouard Seguin (1812-1880) whose sensorimotor training for the retarded advocated teaching in context, teaching by relations towards concepts rather than by rote, and using the materials and sounds of daily life in both intellectual and moral instruction. Graham named Seguin as "the fountainhead of the field of music education with exceptional children" (Graham, 1975) and noted that educators like Montessori and Dalcroze (both of whom included auditory perception and discrimination in their work) were influenced directly by him.

Music therapy seems to have been a term once reserved for music with emotionally disturbed children. Graham (1975) found ambiguity in the role of music educator and music therapist though both had the ultimate goal of helping the child towards overall personal development as well as towards musical goals.

The American behaviourist development in music education and music therapy was not paralleled in approach by Alvin (1975) as she began her more holistic work in 'remedial music' with handicapped children. Her opinion was that remedial music helped the mental, perceptual or emotional growth of the handicapped child, irrespective of his/her musical aptitude or ability. She looked to music realizing basic needs of love, acceptance, security and success and providing means of self-expression. Alvin in her later years used the term music therapy for this work.

1.6.2 Effect of advocacy for rights of special needs children

In 1975, Public Law 94-142 in the United States basically guaranteed a free public education to all children, including special needs children. Music educators and music therapists had to re-examine their roles in the light of this legal requirement. Jellison (1979) took an extremely functional view of the possible future role of the music therapist in the educational setting, suggesting an input in non-music and music areas of the curriculum at home, school and in the community. She gave detailed educational strategies for the music therapist to follow with guidance for development of course content and evaluation. Alley (1979) pointed out that in American society, music is a revered, highly normalising activity, enjoyed in a group situation where there is reinforcement of self and group esteem and where aesthetic experiences promote its positive value. She identified music educators as the persons responsible for teaching the knowledge and skills of music itself, and music therapists as responsible for teaching academic, social, motor and language objectives through the use of music. While having separate roles both professions have the same objective, to enhance the growth and development of the child.

Suggested amendments in 1987 to the Education Act (1964) in New Zealand would make equality in educational opportunity mandatory. All children should learn in the most supportive environment. Normalisation will be developed as far as is appropriate to the nature of special needs observed. It is important therefore for musicians to plan the delivery of educational content in a flexible way that meets the individual needs of each child. Both educators and therapists using music support the development of the "whole" child through processes using music skills, receptive listening and movement. Research which confirms this developmental and supportive role of music will be considered next.

1.6.3 Music and Music Therapy Theories and Research Related to Relevant Educational Objectives

Much present-day research attempts to validate claims about the educational effect of music or music therapy. Studies in perception, cognition, affect or motor activity usually try to isolate one measurable variable from separate or conjoint elements of music and then measure change resulting from the use of that variable. Little is understood yet about how or why change occurs.

(i) Some frameworks for planning education or research

Lathom (1971), linking concepts of information theory in a relationship with music therapy, pointed out that for communication to occur a receiver must understand a message, so it must be presented in a manner which allows arrangement of the incoming stimuli in some order. The message, music, may be given increasing degrees of order until it becomes so redundant that it no longer demands full attention and other tasks can accompany it; then an educational effect can be observed.

Cameron (1970) in looking at the uses of music to enhance the education of the child with brain damage said:

> Basic learning abstractions may be practised and promoted circuitously by the application of intrinsic music symbols, starting with learning at the most elementary level. (p. 32.)

Preparation can take place for learning to write, for reading skills and for development of number concepts in an acceptable social outlet, namely music-making. This presents simple material in logical steps in many ways, with frequent repetition and a large number of supportive clues for learning. Cameron stated also that the emotional appeal of music may release potential which is not reached by intellectual challenge alone.

In a more recent study, the relationships between cognitive and affective growth in children were described in music learning by Nelson (1983) as cyclic. Children experience, then formulate, then label music. Music can provide new and exciting experiences which lead to formation of ideas about textures, melodies and rhythms. These are then identified and understood as concepts as different music experiences take place. It is important to appeal to both affective and cognitive readiness, and music can offer a variety of channels by which to do this.

A structural analysis of music and paralleled learning progressions in music is given by Moog (1984). A single sound is the simplest unit of musical learning; it possesses timbre, duration, volume and dynamics and is non-relational. Next comes awareness of relational temporal elements of music, of the duration and accentuation of rhythms (which are relational to a succession of single sounds). A further step in music cognition involves the relational element of pitch change, so awareness of melody is added to the sound and rhythm recognition. Finally harmony, hearing sounds simultaneously and making connections between them, is included in this hierarchy of music learning.

Moog's theory provides a useful framework which confirms a more graded elemental content approach in music where there is difference in developmental level.

(ii) General research relevant to development of this study

Much research has been done showing the positive effect of music therapy on language development, reading skills and mathematical response. While these learning areas are important in education, considerations of this large area of research literature is not central to this study. More directly useful is material to support the need for structure in a therapy programme, the goal to improve motor control, new work using sensory integration principles and interactive processes in music which support social learning.

(a) Structure in music therapy

Working with special needs children is not effective if there is no structure that has relevance and accessibility to the child or group. Differing needs for external structure by mild, moderate and severe emotionally disturbed children were explored by Gibbons (1983) using a rhythmic imitation task. She decided that rhythm work could have assessment value for such groups; subjects in the mild need for structure group performed significantly better than subjects in the moderate and severe need for structure groups.

(b) Motor development for special needs

The research in this section does not relate to cerebral palsy children specifically (this will be dealt with later) but does point to positive work done using music to improve motor control.

The effect of a motor development programme on motor and intellectual abilities of trainable mentally retarded children was studied by Harkins (1971) over a six month period. Levels of motor development improved, with gains by the experimental group in body perception, balance and locomotor agility. Karper (1979) used music as background to learning a novel motor skill; style of music selections heard (popular music or classical music) did not influence learning of the motor skill. Holloway (1980) taught two behaviours to eight severely retarded children and adolescents each with contingent music listening (a passive reinforcement) and contingent rhythm instrument playing (active motor reinforcement). The study aimed to increase pre-academic and motor skills; both passive and active music reinforcement had a positive effect with a tendency for more behaviours to meet the criteria during active reinforcement. This result is consistent with Madsen and Forsythe's 1973 study (in Holloway, 1980) for normal subjects using listening and active music contingencies.

(c) Sensory integration

Little research in music therapy relates specifically to the theory of sensory integration, but this is an important area for consideration.

Sensory integration as a model for music therapy practice and research has been put forward by James (1984) who pointed out that in theories of perceptual-motor development developed by Kephart, Cratty and others, children first interact with their environment motorically. Motoric actions enable sensations to be produced and received. Following this 1984 statement, and relating also to Ayres' (1972) work on perceptual motor development, James, Weaver, Clemens and Plaster (1985) looked at the influence of paired auditory and vestibular stimulation on levels of motor skill development in a controlled study within a severely mentally retarded population. The experimental group showed significant gain in motor skills following a programme which combined beat-based music stimuli with movement on a swing giving varied body positions in space. The results reinforced the premise that provision of auditory stimulation through music provides a key channel to processes of intersensory integration.

James stated that subjects' effectiveness in processing sensory information is directly related, before birth and throughout life, to the amount of interaction that occurs with their environment. Sensory integration is a receptive process, but its evaluation and assessment occur through the expressive mode. Higher functioning levels may develop only when certain prerequisite abilities are integrated. Where normal sequential patterns are not always followed (this can happen with mental retardation and cerebral palsy), therapeutic intervention must enter an existing abnormal pattern and work around disabilities which may have been present for many years.

(d) Music therapy and social learning

The use of music therapy to improve social skills and modify incompatible behaviour has a large body of supportive literature. Madsen and Wolfe (1979) review much of the related work recorded, then discuss a study which used interrupted music during a reading task, a listening task, an incompatible response using rhythmic movement and a negative practice-listening procedure. The four experimental conditions were used to investigate those variables on bodily movement and attentiveness of normal subjects. Results indicated that when a task requires an individual to attend to music there is a high degree of participant involvement, thus creating a reduction in the "other" behaviour. Alternatively where music becomes a competing factor to another task (such as reading) the music may actually be phased out of awareness in order for the person to attend to the primary task.

Effective use of the work of innovators in music education such as Orff and Kodaly has been transferred with positive results to music therapy. Both Orff and Kodaly use simple, practical music-making with children, in a developmental approach with sound and movement content that was derived originally from folk material. Four studies which have used Orff and Kodaly interactive processes effectively are Bevans (1969) with multiply handicapped, blind children, Hollander and Juhrs (1974), with autistic children, and Ponath and Bitcon (1972) using behavioural analysis processes with handicapped children. These three studies used Orff-Schulwerk, a speech-sound, body image, instrumental music programme which has full participation and flexibility as its landmarks. A fourth study from Lathom (1974) applied Kodaly concepts (using song and rhythm) in music therapy work.

SUMMARY OF 1.6: MUSIC THERAPY LINKS WITH EDUCATION

Early developments in music education for special needs children and music therapy showed more congruence than diversity in respect to music content and process. Whether the approach was based on behavioural or humanistic theory, a range of needs-based approaches was used to interact with children, using music. In America, the mandatory Public Law 94-142 forced a more conscious use of music in education and therapy to pursue educational objectives, and there followed a more considered differentiation between the nature of music therapy and music education in the special needs area (Jellison, 1979; Alley, 1979). The extra component that music therapy has to offer relates to the way it uses elemental or more complex sound in an interactive process which nurtures and extends special needs children in learning areas not related to music skill development.

It has been difficult to recognise fully this particular interactive role of music therapy in qualitative terms. Early music therapy research established music's value to encourage and extend general personal development in intellectual, physical, social and emotional areas of need. There followed an increased volume of research which, understandably, headed towards areas where quantifiable measurement was possible. Specific areas of learning development researched with music therapy therefore related to motor and language development, reading skills, mathematical response and social learning. Assessment was often based on music used as a contingent reward for successful task completion, on improvement in time-based measurement of task completion, or on gains in responses of identifiable units such as words or numbers. In recent years there has been more acceptance of validity of qualitative measurement of affective response to music. Music therapy should be a process where change of mood or enjoyment is possible and this can be assessed in a comparative way by music therapists (Simpkins, in Bruscia, 1987).

Music education theory and psychological theory have led to music models which do not use music as the primary focus in therapeutic intervention. Some music educators assume an exclusively behavioural stance using applied behaviour modification techniques where music becomes the contingent reward for approved behaviour or removal of unwanted behaviour. Studies of this type seldom cite the actual music used beyond sometimes stating that it is music of the client's choice. The music chosen could be folk tunes, beat-based pop or rock music, classical opera or instrumental music or a solo pan-pipe, depending on listening experience. While this personal selection could reflect mood it is based on generalised choice of known music. Its mood is not necessarily related to the particular and present environment. Matching of content, style and mood of music to immediate identified need is a skill developed by a music therapist through observation and interaction, often using original music, improvised sound or adapted music. It is essential to do this in music therapy.

The model of sensory integration theory (James, 1984) has much appeal for music therapy practice. As an auditory integrator music can facilitate learning of direction, distance, sound level and sound differentiation concepts. Thus auditory discrimination and auditory memory can be developed. Music also involves tactile experience when instruments or body sounds are used, and music-based action involves proprioception. Visual perception and motor control combine for many music tasks. Sensory integration is therefore much in evidence in music making.

A positive influence from psychology to music therapy has been the development of psychotherapeutic techniques and diagnostic skills with which to facilitate interaction. From music education comes a positive approach to planning and later related evaluation of music sessions. Also, from both disciplines, the emphasis on consultation with other colleagues, giving a team-based approach to goal-based planning for special needs, has been important for music therapy.

Many psychologists and music educators subscribe to the humanist tradition. Rather than being considered as an adjunct to intervention, or as a passive ingredient in a curative process in a medically-orientated treatment model, music therapy is now more properly regarded in its own right. It is seen as a dialogue process where a planned approach uses music to make a non-verbal connection to the client thus activating that client in a direction towards supporting self-identified need.

CHAPTER 2. REVIEW OF THE LITERATURE

Outline

There are four components in this literature review:

2.1 An outline of cerebral palsy aetiology and treatment options is given, followed by research about cerebral palsy relevant to this study.

2.2 The use of music as an intervention with cerebral palsy is reviewed by a range of anecdotal and research-based material.

2.3 The particular music element focussed upon in this music therapy study is rhythm. Its importance as an auditory stimulus that has to be anticipated is recognised. Personal tempo, sequences in development of rhythm recognition and motor control response, and the affective value of rhythm are described.

2.4 As this study involves a computer, some comments are included about the use of computers in music therapy research.

2.1 CEREBRAL PALSY

2.1.1 Description of Cerebral Palsy

A straightforward description of cerebral palsy (Bell and Klemz, 1981) calls it

> a group of conditions characterised by disorders of movement and posture and following lesions in the brain which may have occurred before, during or after the birth of the child (p. 47).

Mild physical handicap is present at one end of the continuum of neurological damage; at the other end severe cerebral palsy is associated often with a multiplicity of physical and mental handicaps.

2.1.2 Definition of Cerebral Palsy

Vining *et al*. (1979) note,

> Cerebral palsy encompasses many facets of disease but is not a specific disease state with an accepted cause, pathogenesis, pathological picture, clinical presentation, treatment or prognosis. (p. 43.)

From a background of confusion about definition, terminology and classification, some agreement has been reached. Thus the definition used by developmentalists at the Kennedy Institute (Vining *et al*., 1979) provides a useful functional statement:

> Cerebral palsy is a non-progressive disorder of motion and posture due to brain insult or injury occurring in the period of early brain growth (generally under three years of age). (p. 43.)

This definition implies that no active disease is present at the time of diagnosis, and that the causative insult or injury takes place in the early development of the central nervous system from intrauterine life through early childhood; the upper age limit is not strictly defined but varies from three years to eight or nine years, relating to the perceived plasticity of the brain until that age.

2.1.3 Types of Cerebral Palsy

Two basic groups within cerebral palsy are identified:

1. Pyramidal - spastic
2. Extrapyramidal - non-spastic, usually athetoid.

Elements of both groups are present in a large number of cases, forming a third mixed cerebral palsy group.

Group one - Pyramidal - spastic cerebral palsy.

Spasticity is characterized by involuntary tightening of the muscles which slows down motion and makes it clumsy and stiff. More specifically the spastic limb or limbs will spasm in a 'clasp-knife' way, will display many involuntary reflexes and convulsions, and show a marked tendency to develop contractures which may require surgery to straighten the affected limb or limbs. Spastic cerebral palsy can present as hemiplegia (two limbs on the same side), double hemiplegia (all four limbs affected, the upper more especially), quadriplegia (all four limbs with lower limbs slightly more affected) and diplegia (all four limbs affected, the lower limbs markedly so).

Group two - Extrapyramidal cerebral palsy

The term extrapyramidal stresses a contrast in movement to the jerky pyramidal movement of spastic cerebral palsy. Especially in athetoid cerebral palsy there can be marked variability in posture movement, muscle tone can have steady increase or decrease during flexion and extension although hypertonic tone often relaxes to a floppy state during sleep. When lower cranial nerves are involved grimacing, drooling and dysarthria (difficulty in chewing and swallowing) may occur. Contractures do not characteristically develop, although some imposition of fixed position may lead to an apparent 'set' in that position over time.

Group three - Mixed cerebral palsy

Vining et al. (1979) quoted 20% of cases as being in the mixed cerebral palsy grouping. People with primarily spastic or extrapyramidal condition but who also present two or more criteria of the other form are categorized as having mixed cerebral palsy.

2.1.4 Causes of Cerebral Palsy

Factors during pregnancy and in the perinatal period which place a child at risk for cerebral palsy include:

(a) Maternal rubella during the first three months of pregnancy.
(b) Anoxia, during and immediately after birth; this is a common cause. A neonatal history of severe anoxia, convulsions, cyanotic episodes or difficulty with feeding is often found; 30% of hemiplegia is a result of post-natal insult (Vining et al., 1979).
(c) Eight percent to 10% of children with cerebral palsy are from multiple births and usually are diplegic.

(d) Premature birth and low birth weight, abnormal position of the foetus and intracranial haemorrhage during and immediately following birth due to difficult delivery.

(e) Meningitis and encephalitis, both infections of the brain, can be post-natal causes.

2.1.5 Presentation of Cerebral Palsy

Developmental observations, often made first by parents, can lead to diagnosis of cerebral palsy. Delayed motor development, strong right- or left-handedness before 12 months, a non-active infant moving one limb less than others or with fisted hand position (after three months), toe-walking or shuffling are observable cues. The severe spastic form of cerebral palsy can be recognized by developmental paediatricians within the first few days of life; the athetoid form may not be recognized until the characteristic movements develop, which is usually after 18 months. Primitive reflexes form early 'markers' for child development and changes and delays in the maturation sequence of these give main test references for cerebral palsy.

Cerebral palsy disability is most obvious as motor handicap, and therapy from occupational and physical therapists provides non-surgical modes of treatment tailored to the individual child. Orthopaedic and/or neurosurgical intervention is sometimes required, often to allow limb alignment to become more regular. Cerebral palsy is also associated with disturbances in perception and capacity to react to stimuli. Auditory defects (deafness or hearing loss) are observed in around 15% of subjects, visual defects are present in 25%, the most common being strabismus (squint condition). Speech problems (dysphasia) can be expected in many cases. The incidence of epilepsy in the cerebral palsy population is around 35%; Foley (in Vining _et al._, 1979) evaluated 165 children with cerebral palsy to study the incidence of seizures and abnormal electroencephalographic findings. His results showed that approximately 50% of spastic children and 12% of athetoid children had seizure disorders. The deficit most commonly associated with cerebral palsy is mental retardation, occurring in 50% to 70% of subjects. It is often difficult to ascertain the extent of intellectual limitation because of the sensory-motor deficits exhibited.

The cerebral palsy child can be at risk for emotional and personality disorders. The restrictions imposed by their disability prevent full participation in recreational and social activities. Awareness too of limitations within a learning situation can evoke a tendency to non-adaptive or labile behaviour. Also the cerebral palsy child often appears more sensitive to comment and intervention demands.

2.1.6 Physical Treatment for Cerebral Palsy - the Bobath Programme

In relation to this study the treatment programme developed by the Bobaths is of interest. They (Bobath and Bobath, 1964) presented a theory of reflex postural adjustment which aims, by physical therapy, to inhibit abnormal reflex activity and facilitate normal motor patterns. The child with cerebral palsy is hindered by abnormal patterns of posture and movement. These must be stopped by sensori-motor treatment which gets active automatic reactions from the child to specific techniques of handling. At the same time as inhibiting the abnormal reactions the handling stimulates and develops normal reactions; always the therapist must be guided by the child's response.

Bobath (1967) advocated very early treatment of cerebral palsy, in the first nine months if possible. Plasticity of the brain, especially in the first 18 months of life, the importance of sensori-motor experience for learning, the prevention therefore of perceptual disturbance (from deficiencies in sensory experiences), the early inhibition of abnormal postural reflex activities, the prevention of contracture and deformities and the overriding belief that quicker and better results are obtained make the advocacy for early treatment a strong one. Bobath (1971) further emphasized the importance of movement, its effect in general development and its use in treating developmental and neurological deficits together for cerebral palsy subjects. With movement a child discovers self, learns about space, explores the environment and in doing so develops perceptual and visual-motor skills.

The Bobaths stated that for the older child with strong spasticity or athetosis, with already established faulty motor patterns, the sequence of normal child development cannot be followed so closely. However it is still important to use similar techniques of handling to obtain a more normal muscle tone, possibly helping the child to acquire the most important patterns of postural adjustment which have been missed in earlier development.

2.1.7 Psychological, Physical and Developmental Research in Cerebral Palsy

Research in cerebral palsy relevant to this study has been selected and a brief summary of pertinent findings follows:-

(a) Perceptual and visual-motor disorders

Abercrombie _et al_. (1964), comparing perceptual and visual-motor disorders with motor handicap, squint and specific sensory disorders, produced three main findings. First, poorer performance in Wechsler Intelligence Scale for Children (WISC) tests by many spastic children is not due simply to lack of motor experience. Secondly, using the Frostig Test of Visual Perception, visual perception disorders were found to be very high in incidence with spastics and not with athetoids; these disorders were not shared by non-brain-damaged children who had been motor-handicapped from birth, so limitations of spatial experience could not be entirely responsible. Thirdly, all cerebral palsied groups tested showed poor right-left discrimination.

A psychological study of cerebral palsied children by Nielsen (1966) suggested that visual-motor development is not impaired but only delayed compared with normal children of the same age. Visual-motor skills were related to intelligence, not to the degree of handicap. In learning efficiency tests cerebral palsied children needed many more trials than did the control group before they could complete the test. Significantly more failed to learn, more forgot what they had already learned ($p < 0.05$) and hemiplegic children performed less well than paraplegic.

A study of auditory-visual integration in brain-damaged and normal children (Birch and Belmont, 1965) suggested that there is a primary defect in auditory-visual integration in cerebral palsied children unrelated to age or intelligence. The results were not due to deficiency in auditory memory (another study in a series had controlled for that).

From the above studies it becomes apparent that cerebral palsied children have a particular disadvantage in visual-motor areas related to the nature of cerebral palsy itself rather than lack of spatial experience or memory factors. The degree of physical and mental handicap also influences the response. Music tasks which involve eye-hand coordination therefore could be more difficult for them because of this.

(b) Developmental studies

Birch and Bortner (1967) used a matching of function task to study stimulus competition and concept utilization with cerebral palsied children. Results showed that, when chronological and mental age were held constant, normal children tended to match on the basis of class and function more frequently than cerebral palsied children. All the cerebral palsied children performed better when stimulus grouping of form and colour were absent. The findings suggest that brain-damaged children <u>can</u> think in abstract terms, but this expression is inhibited by the 'first signal system'. Distracting stimuli compete for their attention, and this should be taken into account in planning their education.

(c) Muscle control processes

Physical therapists and occupational therapists traditionally use processes of movement in habilitation or rehabilitation of motor control. Where neurological deficiency or damage has been responsible for lack of muscle control there appears to be some difference of approach between traditional physical therapy and therapy processes based on neurological-developmental perspectives (such as the Bobath method mentioned earlier). Hourcade and Parette (1984) gave an annotated listing of 18 studies of motoric changes following therapeutic intervention with infants and young children who had cerebral palsy. The authors' overall evaluation of the 18 studies suggested that research-based enquiries into the effectiveness of traditional physical and occupational therapies and neurodevelopmentally-based interventions were at present deficient, quantitatively and qualitatively. A closer look at each group classified reveals some of the problems to an evaluator.

In group 1 (no control group/descriptive studies), 10 studies showed treatment to have positive effect, three using Bobath-style techniques, seven traditional physical therapy. Three of the studies correlated improved test scores with higher intelligence scores.

Of the four studies in group 2 (contrast design) the first showed greater progress for children with higher IQ's and who had received surgery, the second found that Bobath-style intervention produced significantly greater gains than functional treatment, and the third study noted that a younger age group developed the observed skills distinctly earlier than did the older group. The fourth study found that all subjects responded better to active than passive therapy, that spastic individuals responded to treatment better than athetoid, that individuals with IQ's higher than 70 responded better than lower functioning individuals and that the degree of motor handicap was a contributing determinant of response to treatment.

Group 3 (control group design) contained four studies, three of which showed no significant difference in gain scores, the other, where a neurophysiological approach was used, showing superior gains to the treatment group in motor status, social maturation and home management by parents.

All these 18 studies involved younger children and point to the multiplicity of factors to be considered in comparative studies. While Hourcade and Parette (1984) note that "utilization of the more rigorous methodology of a control-group design is relatively recent in the literature" (p. 524) it is apparent that the varied environments and aetiology of cerebral palsy subjects makes rigour in control group study extremely difficult to achieve. The study quoted Parette and Hourcade (1983) as warning that therapists who provide the same therapeutic intervention to <u>all</u> children diagnosed as being cerebral palsied may be unnecessarily inhibiting the cognitive growth of the child without achieving the anticipated motoric gain. Different presentations of muscular control by spastic and athetoid subjects for instance require totally different physical intervention.

This question of difference in muscular control was considered by Neilsen and McCaughey (1982) in an experimental reflex training programme devised for four young adult cerebral palsied subjects with a mixture of spacticity and athetosis. Over 18 months, measurements of contraction level and tonic stretch reflex sensitivity from the triceps brachii muscle were shown to the subject on meter displays. Achievement of goals was sensed automatically and activated a cassette tape of favourite music of the subject. All four subjects learned to self-regulate spasm and spasticity at the elbow and to regulate tonic stretch reflex sensitivity independently of contraction level. These subjects were severely disabled with negligible arm function. They were asked to "reduce muscle activity to zero" rather than "to relax", as a conscious effort is often required to inhibit involuntary muscle activity; relaxation as a directive may not be the key to reduction of muscle activity level. The study, being a long-term project related to severity of disability, used the music as a reinforcement for achieved small step set goals which led to graphed improvement. Although spasm and spasticity were reduced, improvement in functional control of movement was very poor. This is consistent with results from Neilson and O'Dwyer (1981) cited in Neilson and McCaughey (1982) where it was felt that movement disability in cerebral palsy results primarily from an inability to formulate and communicate appropriate motor commands to muscles rather than simply overcoming the tendency for voluntary movement to be disrupted by spasm and spasticity.

(d) Effect of biofeedback

Certainly the Neilson and McCaughey (1982) study demonstrated the effectiveness of immediate feedback as well as reinforcement for progress. A 1976 report (Goldberg) on the effects of electromyographic biofeedback on the development of voluntary muscle control in spastic cerebral-palsied children showed reduction during the study processes, but permanent improvement in voluntary control did not occur. Mroczek (1976) looked at biofeedback effects on biceps or wrist extensors of hemiplegias resulting from cerebrovascular accident and found that both biofeedback and physical therapy were equally effective in producing an improvement in movement range. She concluded that biofeedback was not a therapy in the sense of producing function, but rather a stimulus modality which can be used to motivate and thus facilitate function within a therapist-patient interaction.

SUMMARY OF 2.1

Cerebral palsy is a condition that has varied causes and widely differing presentations. It is not surprising that treatment is not uniform in style, nor that research does not reveal a uniform pattern of response to stimuli or physical intervention. Factors of age, degree of physical impairment, intellectual level and amount of reinforcement of a task affect the results of physical responses tested.

Also there are basic problems in realistic measurement for cerebral palsy subjects because of the diversity of physical and mental presentation from each subject, coupled with a lack of appropriate measurement tools that take this diversity into account. A cerebral palsy subject may in fact be able to control involuntary spasm if relaxed (Nielsen and McCaughey, 1982) and if that does not happen it may relate to a neurological inability to shape and send the right message to the right muscles. The principle of biofeedback providing positive stimulus for continued interaction has direct relevance to the use of music which can be regarded as possessing, in itself, a biofeedback modality.

It is therefore appropriate now to look at the limited research that has been done using music with cerebral palsy subjects to see what effects music might have on the condition, and also what potential for comparative assessment has been established using music.

2.2 MUSIC AND CEREBRAL PALSY

2.2.1 Early Papers

(a) Responses to music by cerebral palsied children

Writings about cerebral palsy and music therapy are not plentiful. Some pertinent commentaries were made by musicians working in the education and health fields about the physical capabilities of children with cerebral palsy. May (1956) reported on work with music done in a school for children with various types of cerebral palsy - athetosis, spasticity and ataxia. In the nursery group the music activities included listening, creative rhythms, singing, finger plays and rhythm bands. "The finger plays and rhythm band are an excellent medium to improve grasp and finer co-ordination of the fingers, hands and arms." (p. 321). For the senior group May commented "Songs with a rapid tempo seemed to be more challenging and hold interest for them", and regarding action songs "There seemed to be less involuntary motion associated with these actions than with those actions upon which they had to concentrate" (p. 323).

This anecdotal approach, relative to the developmental state of music therapy at that time, is apt. Schneider (1956) however pointed out that such reports do not indicate the type of music used, for what purpose specifically, or with what types of cerebral palsied children. Also, assumptions had been made that cerebral palsied children would respond to music in the same way as non brain-damaged children. Physically sedative music, with flowing melodies, smooth rhythms and moderate tempos, had been assumed to have relaxing qualities, beneficial to performance behaviour. Physically stimulative music, with marked rhythms, staccato type melodies and syncopated musical figures, had been assumed to produce tension and thus be a negative influence on performance behaviour of cerebral palsied children. Quoting his own doctoral research, Schneider indicated that not all cerebral palsied children respond in the same way to the same type of music. Generally, children diagnosed as spastics responded to physically stimulative-type music, with marked rhythms usually, with improved motor control and attention and quieter, more stable emotional tone. Physically sedative-type music (flowing melody, slower tempo) tended to develop or increase tension. Conversely athetoid children, with stimulative music, were increasingly distractable and showed impaired motor control; and with sedative music athetoid children appeared to relax and had better behaviour.

Schneider stressed that not all cerebral palsied children are affected in this way by music. The differential diagnosis of the disorder (relating to the extent and degree of neuromotor and psychological impairment), age, and amount of therapy received, are variables which can influence behaviour. His results do indicate that caution must be exercised in style of music used with motor activities for cerebral palsied subjects.

Alvin (1961), influenced strongly by Schneider's research, was of the opinion that further research of this kind could give useful diagnostic information. The reactions of specially selected subjects to different kinds of music could add to the dimensions of motor control tests. Her work, with physiotherapists, used music that blended melody and rhythm to give a feeling of regular, continuous music.

> A traditional minuet would provoke movement without increasing excitability, a reel would be too strong a stimulant. The music should first fit the type of response required from the child and the condition of the child. (p. 256.)

She pointed out that the rhythm and duration in music can be linked with motor control in time and space. Regular recurrence of accent and the continuity of melody may help the child co-ordinate movements to more sustained effort and further physical extension.

Another earlier study (Holser and Krantz, 1960) also quoted Schneider's warnings about sedative and stimulative music and differential effects. Unlike Alvin who used instrumental music predominantly, these music therapists included group singing as well as rhythm instrumental work in a programme planned with occupational therapists. They noted as well the need to keep pitch levels low; natural pitch first displayed ranged between A below C and D above middle C.

Early comment and research point out important parameters for the use of music with cerebral palsy subjects; that the stimulative/non-stimulative style of music chosen was of great importance to avoidance of muscle spasm and was relative to type of cerebral palsy (Schneider, 1956); that vocal and instrumental music was more effective if there was regular melody and rhythm (Alvin, 1961) and that lower pitch was preferable (Holser and Krantz, 1960).

An early focus for musicians and therapists was the training of cerebral palsied children for general life tasks.

(b) Music and training of cerebral palsied children

Snow and Fields (1950) produced an excellent article on the use of music as an adjunct in the training of children with cerebral palsy.

> We are concerned both with the physical and emotional aspects of the child. The habilitation program in cerebral palsy is not one of re-learning lost patterns of co-ordination, but the development of patterns that have never existed. (p. 147.)

They saw that a combined emotional and physical approach was needed to reduce tension, give immediate satisfaction and so engender a feeling of security to proceed with a given task. The authors described this approach as functional music, music used to accomplish a specific purpose other than entertainment. They stressed the importance of rhythm, of using the right rhythm for the particular child, noting that overstimulation gives uncontrollable motion which actually prevents the child from doing the very thing he desires. Snow and Fields advocated selecting the most positive element in any motor pattern that the child can use and matching that with an appropriate instrument (for rhythm band work) and appropriate pace. Also the length of time of music playing should be judged carefully, to just below the threshold of tension.

Functional music with cerebral palsied children is discussed also by Weigl (1954) who commented on the value of music as a means of emotional expression, as an outlet for aggressive feelings and as an integrator with a group through adjustment to the tempo of others. Live music, rather than radio or record reproduced music, elicited better response; the live performance of well-known music from records or TV gave much satisfaction because of the pleasure of recognition and familiarity. More and better performance in "physical exercises" was noted.

(c) Rhythm patterns of cerebral palsied children

Sato (1962) reported a full study made on rhythm patterns of cerebral palsied children. The article was descriptive but nevertheless made some strong points:-

(i) Cerebral palsied children can explore a limited area of rhythmical expression only.

(ii) In giving rhythm training to cerebral palsied children with a view to developing their ability in musical expression, selection of proper tempo is of utmost importance.

(iii) It is extremely difficult for the cerebral palsied child to develop normal ability in musical expression and no high expectations should be made. There is urgent need for earlier musical training in rhythmical movement and sense of rhythm although the effects it will have on the children are limited and of varying degree. The cerebral palsied children of low intelligence in particular will achieve only limited adaptation to different rhythm patterns.

<u>SUMMARY OF 2.2.1</u>

Work with cerebral palsied children using music has been happening for a number of years; early writings and research contain guidelines that are still relevant, especially to music therapy. The style of music chosen can produce or reduce physical and emotional tension which controls spasm; the cerebral palsied child can be encouraged to find satisfaction in a training process which includes music; rhythm work needs to use selected tempos.

Functional music, as described by Snow and Field (1950) and then Weigl (1954) seems to foreshadow the definition and practice of music therapy as being music used to achieve a specific purpose.

2.2.2 Later Research on Music and Cerebral Palsy

(a) Visual-motor sequencing and music

A 1971 study (Berel, Diller and Orgel), "Music as a Facilitator for Visual Motor Sequencing Tasks in Children with Cerebral Palsy", looked at first to have a direct contribution of relevance. The study however did not specify sufficient detail of music content used to make it useful. It receives comment because it appears in many references on music and cerebral palsy.

(b) Music as contingent reward and reinforcement

Two studies have used automated interrupted music as a reinforcement to encourage proper head posturing of cerebral palsied individuals. The first, Ball, McCrady and Hart (1975), with two cerebral palsied children, used transistor radio music as contingent reward. Dropping the head forward automatically stopped the broadcast music. A comparison of baseline and treatment phases showed that contingent music encouraged strong control of head orientation.

The second study by Wolfe (1980) worked with 12 children and adults with spastic cerebral palsy measuring the effect of automated interrupted music on head posturing. An ABAC individual subject design had two baseline conditions of music and two treatment conditions - interrupted music/silence and interrupted music/tone. A tilt of the head of 20 degrees or more interrupted the music and replaced it with silence in the first treatment condition. In the second, when the head was improperly positioned a 493 Hz tone would replace the music until the head was lifted; then music would resume. Head control improved for four subjects, one subject seemed to respond only to the music/tone condition, and the remaining subjects showed minimal improvement in head posturing throughout the experimental conditions. In the discussion Wolfe pointed to several important real-life problems for the study - time on task was too long, a shaping procedure would have been better (especially for those with hypotonia), there were problems in focus on a central auditory stimulus without being distracted by surrounding noise and the subject's retardation levels possibly precluded sufficient awareness of the nature and process of the task. Profoundly retarded subjects may have a degree of cortical damage which distorts the processing of various auditory stimuli. This study is a full and comprehensive statement with results that are promising for the use of music as a contingent reinforcer for cerebral palsy and motor control.

Linking the findings of several researchers (Mroczek, 1976; Ball, McCrady and Hart, 1975 ; Goldberg, 1976; and Wolfe, 1980) Scartelli (1982) looked at the effect of sedative music on electromyographic-assisted biofeedback relaxation training of spastic cerebral palsied adults. EMG biofeedback training can be beneficial to relaxation which may be central to the education or re-education of muscle tissue which exhibits tension due to neuromuscular disorders like cerebral palsy.

(c) Early developmental experiences in time and sound

Three studies from non-music sources which deal with the necessity for early use and reinforcement of rhythmic sensory input are of interest for cerebral palsy, because they point to what children with neurological damage may <u>not</u> experience. Robertson (1982) found that healthy, awake babies have intrinsic temporal patterning in their spontaneous movement of between 0.24 and 1.86 cycles per minute. The second study, Demany, McKenzie and Vurpillot (1977), looked at rhythm perception in early infancy and showed that skills of temporal analysis (recognition of different speeds between sound intervals) and synthesis are present well before the stage of speech and are prerequisites for operating within the sequential dimension of language. Early experience of time and sound therefore is more complex than generally realised. Barnard and Bee (1983), authors of the third study, observed the impact of temporally patterned stimulation on the development of pre-term infants. Infants born prior to term were given kinaesthetic rocking and auditory stimulation; at eight and 24 months the experimental infants scored significantly higher than a control group on the Mental Development Index of the Bayley Scales (1967). Early environmental stimulation therefore contributes positively to infant development.

<u>SUMMARY OF 2.2.2</u>

This later relevant research contributes mainly to the use of music as a contingent reward. Wolfe's work (Wolfe, 1980) in this contingent area however highlights difficulties of providing non-distracting environmental conditions for cerebral palsy subjects, also the possible difficulties of understanding of task requirements by brain-damaged subjects. The advocacy of shaping behaviour for such subjects is a reminder that tasks need to be simple and straightforward.

More positively the early developmental studies relating to time and sound, show that babies and young children have a rich 'bank' of time-based experiences from which to continue learning; brain damage that was caused by accident rather than birth damage could mean a remainder of some of this 'bank' being available for learning.

A full experiential sensory development scheme for babies and children with cerebral palsy would provide as full and varied a proprioceptive, visual and auditory environment as possible to compensate for the physical and possibly mental impairment caused by damage to the central nervous system. While all forms of music-making provide full and varied sensory experiences, the need for simple music tasks that promote learning related to motoric skill development turns attention to a particular base component of music, namely rhythm.

2.3 RHYTHM

2.3.1 The Importance of Rhythm

Whether one thinks of rhythm as a regularly occurring impulse as in a heartbeat, or as a regularly recorded response as in the cardiograph of a heartbeat, there is a common factor in both event and response - both happen through time. Neither heartbeats nor their resultant charts present themselves as uniformly symmetrical entities. Though there is a basic outline in sound or shape that repeats itself in a regular and recognisable way, there are differences within that aural or visual structure. Rhythmic events maintain this characteristic of difference within an expected constant. The combination in regular motion of differing time factors of speed and distance is a prime factor in human body movement. Neurological prediction or response to stimuli makes this movement possible.

Rhythm therefore has an essential element of anticipation (Fraisse, 1982), and this is a major component of the function of rhythm in music therapy. The planned use of rhythm uses the prior perception of rhythm to motivate and extend the rehearsal of a motoric task, as in this study. Or it can promote a perceptual and cognitive framework for learning about temporal order with the effect of motivating and sustaining a learning activity. Temporal structure, as experienced for instance in musical games which have regular rhythm, provides a major support in educating the growing child towards comprehension of a temporal map of the world as it is, and as it will be in the future.

This important idea of rhythm as anticipation will be returned to in a later section (Synchronisation and motor induction).

2.3.2 Definitions of Rhythm in Music

Music therapist Gaston (1968) called rhythm the organizer and the energizer.

In music, rhythm involves organisation of sound through time. Cooper and Meyer (1960) list ingredients of this temporal organisation in architectonic levels. First pulse; a pulse is one of a series of regularly recurring, precisely equivalent stimuli. Pulses mark off equal units in the temporal continuum, are usually supported in sound by objective stimuli but can be subjective. A sense of regular pulse, once established, tends to be continued in the mind and musculature of the listener even though the sound stimulus has ceased. Other levels of temporal organisation involve metre, the measurement of the number of pulses between more or less regularly recurring accents, and what Cooper and Meyer (1960) term specifically rhythm, the way in which one or more unaccented beats are grasped in relation to an accented beat.

Alternative musical terms in temporal organisation are beat (for pulse) and pattern (for Cooper and Meyer's rhythm). Because most of the relevant literature from musical and non-musical sources uses rhythm as a general term for temporal organisation of sound, and uses beat and pattern (instead of pulse and rhythm as above) the terms just stated rhythm, beat and pattern will be used in this study. In the later method section of this study, pulse will be used as a special term to refer to the standard deviation of the time between physical contacts made.

Rhythm, then, is organisation of sound through time. As Schafer (1967) put it, "I am rhythm. I am here, and I want to go there." (p. 21). Beat is regular sound or impulse occurring at precisely equivalent intervals of time. Metre is the term used for perception of regular grouping of beats between regularly occurring accented beats. Pattern is the experience of sound or impulses with and between beats in a time continuum.

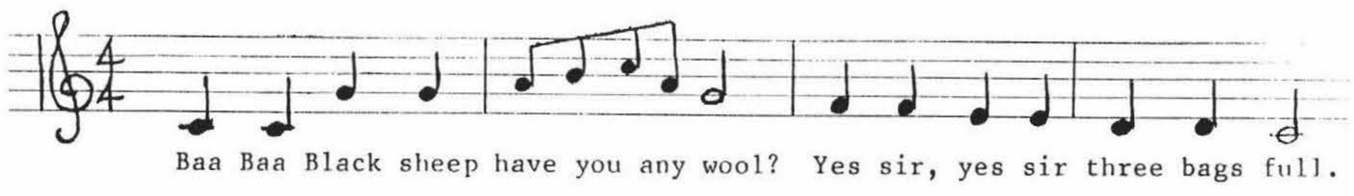


Diagram 1. Example of music showing beat, metre and pattern.

The beat, experienced in the four even sounds opening "Baa, Baa, Black Sheep" (Diagram 1), becomes established externally (by singing, clapping, conducting etc.) and continues as an inwardly-perceived impulse throughout the piece whether the individual sounds experienced are longer or shorter in time value. Four beats are experienced in one unit, then a small accentuation of sound marks the beginning of the next unit of four beats (a unit is called a bar of music). The metre therefore is four beats in a unit; in this example the metre is, in musical terms, four crotchet beats to a bar. The pattern in "Baa, Baa, Black Sheep" is the experience of <u>every</u> sound along the time continuum; a physical response to pattern would result in 16 actions.

2.3.3 Rhythm and perception

Some attempts have been made to analyse what children perceive from auditory rhythm. Moog (1979) pointed out that rhythm is a factor according to which auditory phenomena are shaped in a meaningful way; that hearing of rhythm requires first, sufficient mental awareness, secondly, memory to perceive and present items for combination, and thirdly, the ability to organise acoustic items in actual, available time. His study compared the perception of rhythmic forms by both physically handicapped children and those of low intelligence with the perceptions of non-handicapped children. Moog formulated four hypotheses:-

1. The perception of one-bar rhythms is easier than the perception of two-bar rhythms.
2. Presentation of rhythm with notes of different pitch makes the perception of rhythms easier.
3. Simple inner structures are easier for perception than those with complicated structures; (this refers to the amount of pattern in the rhythm).
4. The perception performances of the three subject groups will differ from each other overall and also on bar length tasks, pitch-form tasks and difficulty level tasks.

His results were clear for the first hypothesis. The length of rhythmic shapes influences perception - shorter is easier. Divided results for hypothesis two showed that perceptions by low-intelligence and non-handicapped participants are better if rhythms are heard together with melody. It was felt that pitch differences cause not only greater attentive behaviour but also become the primary forms of experience for physically handicapped children; due to their handicap they have more limited sensory experience of rhythm. With hypothesis three the research showed that internal structure of rhythmic form is of no importance for perception achievement performance. The fourth hypothesis results showed that both low intelligence and physical handicap correlate with significant underachievement in rhythm perception. Moog's study, in practical terms, suggests that task material presented by a music therapist for a perceptual development programme should include simple songs with some rhythmic pattern for low intelligence subjects, and similar content for motor performance activities with physically handicapped children. This study also showed the long-term effect of limitation of muscle movement on rhythmic perception; it reduces the capacity for rhythmic perception.

Results from another study in an area of sensory deprivation, deafness, give further pointers towards the way a perceptual rhythm task can be experienced. Korduba (1975) looked at the duplication of rhythmic patterns on drums by deaf and normal-hearing children while a regular metronome sound was heard. Deaf children scored twice as well ($p < 0.5$) as hearing children in duplicating beat measures using visual and kinaesthetic channels of attending and imitating. The scores for rhythmic pattern duplication indicated no sizeable difference in mean error scores however. These findings suggest a developmental continuum of skills relating to rhythm perception with accurate beat response at the more primitive end of the continuum and pattern perception at the more sophisticated end. Korduba stated that the small quantity of research in rhythmic responses apparent in 1975 may be due to the lack of measuring devices which could give precise measurements of temporal-spatial impulses. She also noted that auditory impulses, not relevant for deaf children, seemed to hinder accurate rhythmic patterning in normal learning children. These latter, in their attempts to follow the metronome sound and drum sound stimulus used, would always fluctuate between accurate responses, close approximations and deviant responses thereby producing responses scored as rhythmically accurate, but deviating slightly from the established beat impulse. The deaf children, relying heavily on visual and kinaesthetic sensory channels, had attended to the task through those non-auditory modes, and had given regular responses. Korduba recommended that eye contact to stimuli or the experimenter, plus kinaesthetic imitation of the experimenter are attentional measures that should be addressed in design of further studies for normal-hearing children.

Another study added the dimension of fast or slow pace to the perceptual approach to rhythmic experience. Investigating the perception and performance of beat, identified as the basic element of rhythm, Tee (1985) tested 450 four to five year old children on three separate beat tasks graded in difficulty of 'beat perception'. The children had to beat a drum in time with the tester's played drumbeat the rate of which was established by an electric metronome, a task similar to that in Korduba's study. The three beat tasks were recorded on an event-recorder over a range of tempi, 80, 100 and 120 beats per minute. Results indicated that the fastest beat-rate was easiest to match and the slowest was hardest.

The three studies above on the perception of rhythm give focus to some areas of rhythm experience that indicate preference for subjects who have sensory deficits. Moog's (1979) lower intelligence or physically handicapped children preferred short, simple rhythms that were accompanied by some pitch difference. Korduba (1975) suggested that normal-hearing children should be able to see the stimuli or experimenter so that they can identify what sound source is there or what role model to follow. Tee's (1985) results showed preference in a beat-matching task for faster rather than slower rates of beat.

2.3.4 Rhythm and General Motor Response

From an approach specific to beat and rhythm perception it would be useful to look at a general motor response to rhythm within various special needs areas. Rhythm, used in a series of actions in a sustained presentation, can be looked upon as a unifying agent.

Working with a younger age group of mentally retarded children, an intense four-week training programme in rhythm skills gave marked improvement in use of instruments and in control of body movements (Ross, Ross and Kuchenbecker, 1973). This study stated that temporal attention is task specific. When a child can maintain a rhythmic tempo he or she is more able to develop skills in task areas over a wider range of general activities than previously.

The effect of rhythm-based rehearsal was well tested in a physical needs area in a study by Staum (1983) where superimposed music, beats and marches, facilitated proprioceptive control and coordination in walking.

Rhythm span scores from a beat imitation task gave a comparative basis for assessment of auditory memory for mentally retarded persons with speech and articulation needs in a study by Maranto, Decuir and Humphrey (1984). Music tasks can be presented non-verbally where such verbal deficiencies are present, and response also can be presented and scored from a non-verbal base. The motor response becomes the measurement tool.

2.3.5 Rhythmic Development and Motor Control

Rhythm is an important factor in a musical event. Lundin (1967) made the point that rhythm is both a perceptual and a motor response involving the whole organism; he considered this to be a learned response.

(a) Use of motoric skills as a test measure

The difficulties involved with establishing test measures in music have been related to the number of elemental sound components within music. There needs to be an accurate breakdown of individual physical components of response as well. Motor response to rhythm appears to be a contained area of experience with inner components.

An important study by Gilbert (1979) looks at motor skill development within a musical context. Previous studies on rhythmic ability (Groves, 1969; Rainbow, 1977; Smoll, 1974 and Smoll, 1975) showed that improvement in spatial and temporal accuracy was related to maturation, but the tasks were not related to use of music-based skills. Gilbert's tasks involved striking a musical instrument (drum, tone bar, xylophone) with a mallet through use of vertical arm and hand motion. Having defined these striking skills, various song and activity sources were analysed to record and describe musical tasks which required similar skills. 312 items selected from these musical scores all contained forms of motor pattern co-ordination. Gilbert further refined the selection of items until she had five sub-tests, reliable and valid, to give the Motoric Motor Skill Test base. These subtests involved motor pattern co-ordination, eye-hand co-ordination, speed of movement, range of movement and compound factors. All children tested displayed significant age-related improvement ($p < 0.0001$) in all sub-tests. There was significant sex difference in three subtests where girls improved to a greater extent than boys, in motor-pattern co-ordination ($p < 0.0001$), eye-hand co-ordination ($p < 0.001$) and compound factors ($p < 0.0396$). Internal consistency of each subtest was high (0.78 to 0.89) as was test-retest reliability for small numbers of children who were retested 30 days after the original test. Correlations of from 0.50 to 0.78 were obtained when the subtests were compared with selected items of the Lincoln-Oseretsky Motor

Development Scale. (A development from this Scale is used in this study.) The Motoric Music Skills Test (MMST) therefore provides a sound, reliable and appropriate measure to assess certain motoric music skills in young children. Unfortunately, despite enquiries to the source of publication, it has not been possible to obtain Gilbert's test battery yet in New Zealand.

In 1981 Gilbert published results of a longitudinal investigation in motoric music skill development in young children using striking skills in an instrumental music context, and using some of the children from the earlier 1979 study. A year from first scoring 87 children on the MMST a further series of subtest scores was taken and mean scores for Year 1 and 2 were computed. Confirmation that individual improvement in motoric music skills was age-related was obtained. Significant age-related differences in gain scores was established, with the youngest subjects demonstrating the greatest absolute gains in performance skills in every subtest. The gain scores of the four-year-old group were significantly greater than those of the seven-year-old group. Gilbert points out that this result confirms the claims of general motor theorists that most fundamental motor patterns emerge before the age of five, and after that age motor skills are merely stabilised.

(b) Factors of pace

A study of the micro-structure of tapping movements in children (Schellekens, Kalverboer and Scholten, 1984) looked at goal-directed movements and identified two control processes:-

1. A rapid-movement phase primarily to get through distance (therefore not as accurate as 2).
2. A homing phase, with a sequence of finer adjustments under visual control.

This study also pointed out that children are slower information processors than adults; developmental studies show that movement time decreases with increasing age caused partly by a decrease in the homing phase time. Movement speed therefore improves with increasing age.

Morrongiello, Kulig and Clifton (1984) confirmed that developmental change occurs with children in relation to pace. More time is required for younger children to process temporal information which in their study was related to judgement of onset time of two brief acoustic events.

For children with no major physical or intellectual handicaps, the above studies indicate increase of motor-control with age, with the strong reminder that fundamental motor patterns develop before the age of five years. From Gilbert's (1979) study, which broke down the inner components of a steady 'hitting-of-instrument' music performance task, there was both an analysis of the many skills involved together with innovation, where the possibility was explored of motoric skills being measured by a rhythm task. This could be a major breakthrough area for the research base of music therapy.

2.3.6 Rhythm and Personal Tempo

The first musical attempts of a child using an upper-body physical action are characterised by a "regular, unaccented beating", probably physical in origin, according to Moorehead and Pond (cited in Shuter-Dyson and Gabriel, 1981). A little later the child will begin to introduce

> accentuation within the regular series of beats which he has set up, such accentuation being most often irregular. His rhythms, therefore, are not repetitive nor necessarily symmetrical, but their structure almost inevitably is related to the fundamental pulsation. (p. 113)

Moorehead and Pond also remark:

> The child has great ability to maintain his own rhythmic concepts against all competition and interference. When he plays simultaneously with other children each child is likely to go his own way. (p. 114)

In an early study on personal tempo, Rimoldi (1951) discovered that spontaneous speed in various kinds of performance is a highly stable characteristic.

> Each subject seems to adopt a certain temporal pattern for a particular group of activities and this is the best definition of his personal tempo. (p. 302.)

Fraisse (1982) used the term spontaneous tempo, measured by the natural speed of tapping and with a duration of 600 milliseconds as its most representative measure. Fraisse found great variability in this tempo between individuals, from 200 to 1400 milliseconds. But individual variability was slight, between 3% to 5% which is within the range of differential threshold for durations of this type. Spontaneous tempo of the forefinger had a good correlation with that of the palm of the hand, with the swinging of the leg when seated and the swinging of the arm when standing.

Fraisse defined a difference between spontaneous tempo and preferred tempo. He categorised the latter as belonging to a succession of sounds (or lights) that appears to be the most natural, neither too slow nor too fast. The most frequent measurement for this has been about 600 milliseconds. An individual does have a constant preferred tempo but the correlations between the constant preferred tempo and the constant spontaneous tempo of an individual are not higher than 0.40.

Fraisse also pointed out that although the rhythm of the heart, of walking, of spontaneous and of preferred tempo are all around 500 to 700 milliseconds, it has not been established that one of these rhythms acts as a pacemaker for the others. It had been verified several times that acceleration of the heart beat does not correspond to an acceleration of spontaneous tempo (Tisserand and Guillot, cited in Fraisse, 1982). There had been however a noted correlation between the rhythm of walking and of spontaneous tempo (Harrison, 1941; Miskima, 1965, in Fraisse, 1982). But one cannot be explained by the other despite the narrow range of frequencies of natural, or voluntary, rhythms and of preferred tempo.

However it would be realistic to establish and use preferred or spontaneous tempo for an individual, and then to rehearse real-life physical activities involving movement using that tempo. This study attempts to work within this framework of rehearsal.

2.3.7 Synchronisation and Motor Induction

Fraisse (1982) had other important statements to make about rhythm: spontaneous motor tempo and preferred tempo are often associated; people can readily accompany a regular series of sounds with a motor act. By one year, often earlier, a child rocks to rhythmic music. From three to four years the child can accompany a metronome beat, synchronizing a tap with the sound (Fraisse et al, 1949, in Fraisse, 1982).

This simultaneous occurrence of the stimulus and the response is a remarkable exception in human behaviour. Instead of a motor response coming after the stimuli, in synchronising the reaction with the sound a motor command is anticipating the stimulus production. The signal for the response is not the sound stimulus itself but the temporal interval between sound signals, which are periodic. Chang and Trehub, (1977) found that this anticipatory effect in perception to rhythmic sound stimuli appears very early in life, at five months.

As the child develops, learning to inhibit involuntary movements occurs when rhythmic stimuli are experienced and motor-control over actions is achieved. Experiments where a tap was required for each sound in a regular series of sounds produced a spontaneously synchronised sound and tap (Fraisse, 1966 in Fraisse, 1982). But when asked to respond after each sound instead of synchronizing with the sound, all subjects found this task difficult. The anticipation is part of beat matching. Fraisse also showed that synchronisation of tap to sound stimulus occurred very quickly, from the third beat (or pattern) sounded, onwards.

Synchronisation is possible not only in the the range of preferred tempi but also across the whole range of spontaneous tempi being most regular for intervals of 400 and 800 milliseconds. If the frequencies are faster or slower, then the separation between taps and sounds is more variable. The range in which synchronization is possible is at sound intervals of 200 to 1800 milliseconds between the sounds. Fraisse (1982) found an interesting variability between hand and foot synchronisation and the sound stimulus. In measuring the temporal separation between a forefinger tap and the sound (about 30 milliseconds - an error which the subject does not perceive systematically) and the synchronisation between foot and sound, he found greater error in the foot's response. Possibly the criterion for synchronisation is the coincidence of the auditory and tactile-kinaesthetic information at the cortical level. The movement of tapping has to precede the sound in order to allow for the length of the transmission of peripheral information, and it is more accurately conveyed to and from the brain from the hand than the foot.

This difference in accuracy of response relates to physical distance. It could be suggested that brain damage at the cortical level, as in cerebral palsy, may interrupt synchronisation and lead to error in response.

Little is written about brain areas and rhythm. Henson (1977) in discussing neurological aspects of musical experience, had this to say about rhythm and brain function:

> It seems generally agreed that rhythm depends on subcortical activity, and full appreciation demands an intact motor system at least on one side of the body. A hemiplegic musician may be able to conduct or play the piano with one hand to concert performance level, but the minor hemisphere is usually affected in such cases ... Cerebellar or basal ganglion dysfunction might be expected to interfere with rhythmic sense, but there does not appear to be any published work on this point. (p. 14.)

Looking at control mechanisms for timed rhythm responses Kolers and Brewster (1985) rejected a theoretical concept of a central clock co-ordinating behaviour in all sensory modalities and response modes. Kolers and Brewster's study gave detailed results pointing to the employment of different strategies when the task is presented in different modalities. Performance was most varied in a rhythmic tapping task with visual stimuli and least varied with auditory stimuli. The participants had to first synchronize tapping responses with brief auditory, tactile or visual stimuli and then continue to tap at the same rate on their own.

SUMMARY OF 2.3.6 AND 2.3.7

The concept of a personal tempo has more credibility within a musical framework than a non-sound one. This tempo is dependent on a process of anticipation, perceptually and motorically, and has a more secure identity within a certain range of speeds for regular synchronization to take place. Hand movements can synchronize closer to a beat than can foot movements. It can be suggested that use of a personal tempo, a preferred tempo, would facilitate more consistent regular motor response to a sound stimulus.

Next it is important to look at processes in rhythmic learning, to establish the most suitable sound source for rhythmic tasks.

2.3.8 Rhythmic Processing

(a) Rhythm and melody

Sink (1984) provided an excellent review of the scarce quantity of research literature on the psychology of processing of rhythm and melody; the findings are disparate. Petzold (1966, cited in Shuter-Dyson and Gabriel, 1981) stated that increased complexity in sound caused different auditory perception responses but that melody/rhythm together did not affect children's ability to perform rhythmic patterns. However Gabrielsson (1973, in Sink, 1984) was of the opinion that it was hard to concentrate on rhythmic information amidst melodic information. Moog (1979) stated that some melodic information supported auditory processing of rhythm. Sink (1984), considering the three studies just quoted, gave some adult subjects rhythmic processing tasks in monotonic (same-note) settings and some in melody/rhythm context. She discovered no difference in rhythm processing for some subjects; for others the introduction of melody influenced their task judgements of rhythmic differences. Sink decided that when rhythmic concepts are to be the focus of learning, it initially may be of benefit to some subjects to use single tone rhythm rather than have a melody with the rhythm. However having regard to the complex nature of teaching and learning rhythmic concepts in music, initial stability of melodic information may be acceptable for individual learners; attention to a stimulus reached its optimal level when there is a balance between simplicity and complexity. The author finally pointed to the need for further research in individual differences and musical alteration effects in auditory processing of rhythmic information.

(b) Rhythm and language

Although Attenbury (1984) was focussing on normal and learning disabled readers aged seven, eight and nine, in her study of rhythm discrimination and performance, the results have relevance to this study. They showed that rhythm performance requires discrimination, integration and a motor response. All children discriminated rhythm patterns better than they performed them. All children did better at discriminating tapped and spoken rhythm patterns than patterns which were just tapped. The addition of language therefore makes rhythmic discrimination and performance easier for seven, eight and nine year olds.

Another study looked at the use of speech stimuli within a music-based task. Thaut (1985) showed that subjects aided by auditory rhythm and rhythmic speech performed with significantly better motor rhythm accuracy than a control group using visual modelling for proprioceptive control only. Gains in synchronization, where the motor response coincided with the external beat, correlated significantly with gains in motor rhythm accuracy. Thaut conducted a concentrated three-week experiment using auditory rhythm and rhythmic speech to aid temporal muscular control in children with gross motor dysfunction. Again a significant difference between experimental and control group was found. When auditory rhythm was faded no performance difference was found between treatment and control conditions.

2.3.9 Muscle Activity and Auditory Rhythm

Muscle activity can be affected by auditory rhythm. Safranek, Koshland and Raymond (1982) studied changes in electromyogram (EMG) patterns of two antagonist muscles in the forearm when subjects performed a motor task of hitting a target with and without an auditory rhythm. The results of this 1982 study and the processes used within it have particular relevance to the present study.

It was found that the subjects, 24 adult women, performing the motor task without the rhythm, demonstrated a common and persistent personal tempo and a common electromyogram pattern.

During Session One the subjects demonstrated a reciprocal agonist-antagonist muscle activity working at preferred tempo. When an even auditory rhythm was imposed in Session Two, the subjects in effect were being asked to learn a new skill. There was increased EMG activity showing cocontraction of biceps and medial triceps muscle activity and a significant increase in duration of biceps muscle activity. Another difference between the two sessions was of particular interest. In Session One biceps muscle activity began <u>after</u> target contact but in Session Two biceps muscle activity began <u>much before</u> target contact. (This bears out Fraisse's theories on rhythmic anticipation mentioned in an earlier section.) It could be said that there has been a major change in the role of muscle activity from reflexive to volitional. A further Session Three in Safranek, Koshland and Raymond's study used uneven rhythms as the auditory stimulus. While both even and uneven rhythms gave a similar change in initiation and duration of EMG activity, the two rhythms produced different changes in the variation of EMG activity used for each target hit. The uneven rhythm increased variation significantly, while the even rhythm decreased EMG variation significantly. This latter may be explained by a more efficient recruitment order of motor units than that usually seen in skilled performance of motor tasks; there has been "progressively more successful repression of undesired contractions" (Basmajan in Safranek, Koshland and Raymond, 1982, p. 167).

The authors pointed out that these rhythm-based changes in motor activity could be applied to therapy planning for encouragement of performance of a motor task. Imposing a rhythm makes the task a new skill to be learned, resulting in longer duration of muscle activity with increased co-contraction, that is, increased stability of muscle action. They state:

> if a therapist wanted to decrease the inconsistent activity of a muscle (e.g. in a hypertonic muscle) the therapist could design a repetitive task to an even beat. This would enhance decreased variation

> in muscle activity and produce more efficient recruitment of motor units. (p. 167.)

The authors also pointed out that their study using one even and one uneven rhythm of equal duration was compared to a control condition which used the personal tempo of the subject. They suggested further studies using other modifications of rhythm, also matching the personal tempo exactly, when the sound of the rhythm stimulus would be the only added variable. This latter suggestion from Safranek, Koshland and Raymond has been incorporated in this study.

2.3.10 Rhythm and Affective State

In recent years there has been a growing awareness of the influence of affective states on subject response.

Bower, Gilligan and Monteiro (1981) stated that mood-congruent material promoted recall of a similar experience, thus promoting learning. Nielzén and Cesarec (1982) supported the view that music is an efficient signal in transferring emotional messages.

It is therefore important to appeal to affective readiness as well as cognitive readiness in learning processes involving music. Nelson (1983) referred to Giblin's theoretical model for affective development which parallels descriptions of cognitive growth, also in Piagetian theory cognitive and affective growth are regarded as mutually interdependent.

One study relating rhythm with affect, Berlyne (in Spender and Shuter-Dyson, 1981) said that "metrical accentuation means a rise in arousal potential" (p. 409). Regular beat is the stable measure against which diversity or complexity is experienced and is part of the arousal effect. Rhythm can provide for the neurologically arousing surprise or complexity of a pattern within the control and dependability of a regular beat.

SUMMARY OF 2.3

Rhythm, a central part of life experience, is a major catalyst for music perception and physical response. Auditory beat provides a constant sound stimulus with which to encourage rehearsal, assessment and measurement of motor control. The most effective pace for auditory beat relates to the use of personal tempo which enhances performance of a motor control task. The initiation of motor response to auditory stimuli is neurological; the mind predicts, for instance, regular beat, and directs the musculature to prepare and attempt an accurate and regular physical response to that beat. This sequence is unique in human beings who usually make a physical response after a sensory stimulus.

The use of language, which has rhythm and pitch, with rhythm, improves motor response generally. Songs therefore could be presumed to be supportive to motor learning.

Noting the development of rhythmic response from infant involuntary rhythmic movements to later voluntary muscular control, cognitive and clinical psychologists recognise the close relationship of muscular control to the perception and ordering of time (Spender and Shuter-Dyson, 1981). This could be related to Freud's reality principle, a realisation of the immediacy of time and place. The inherent temporal structure of music with its inner rhythmic components of beat, pattern and metre can provide security. By its very metrical nature an affective component is provided in music. Then the arousal effect (spoken of by psychobiologists such as Berlyne) adds another affective ingredient, one of excitation of interest in rhythm with the consequent interest in sustaining either the rhythm task itself or the activity associated with it.

2.4 USE OF COMPUTERS IN MUSIC THERAPY

Educators and therapists are beginning to realise the potential value of computers especially for individualising instruction. Personal typewriters and computers are now introduced into learning environments, and computers support accurate measurement for assessment purposes.

In music therapy microcomputer technology has been used to analyse client and therapist behavioural interactions (Hasselbring and Duffus, 1981). This was a qualitative and quantitative study of the therapy process. A computer brings a new dimension to interactive processes which is, as yet, little used in music therapy practice. It gives greater versatility of recorded information and immediate information for feedback and analysis (Greenfield, 1985). An alpha-syntauric synthesizer was used as a music therapy device for training handicapped students in basic music skills, including rhythm training by matching a pre-recorded pattern (Osguthorpe and Ditson, 1985).

Another source of basic computer information is a handbook about the use of microcomputers in special education (Berhmann and Lahm, 1984) which cited three major areas in which technology can assist learning by enhancing environmental interactions. These are communication, environmental control and environmental manipulation. Multiple impairments, particularly those involving both cognitive and sensory impairments, need intensive and systematic strategies to implement an effective educational intervention. Computers can be vehicles for this approach to educational intervention, and they can provide accurate quantitative control in an experiment.

The same inference can be made regarding effective therapeutic intervention, that computers could be vehicles for intensive and systematic strategies and measurement. This seems particularly relevant to rhythm and motor control where a keyboard-based action can be promoted as in this study.

SUMMARY OF REVIEW OF LITERATURE

The nature of cerebral palsy, with its complex aetiology and consequent differing approaches to treatment and support of muscular control, makes structuring of a music-based task a challenge. There is sufficient evidence that music itself is rewarding and that the presence of music during a task promotes a time-ordered sequence of behaviour and task continuance. Use of rhythm, in the form of regular sound impulse, necessitates neurological anticipation of the sound in order to activate a required physical 'response'. This sequence is central to promotion of motor control, as is the use of personal tempo to provide optimum pace for both the time-based sound signal and the motor action that is synchronised to it.

Cerebral palsy subjects, therefore, may relate with interest to a rhythm-based motor control task and they are more likely to do so if the task appeals to them. Music provides this appeal, through its structure and rhythm. An effective ingredient in task environment and for assessment could be provided by the use of a computer.

CHAPTER 3. RESEARCH PROPOSALS

OUTLINE

This section begins with a hypothesis for the study followed by a rationale for that hypothesis; this expands on reasons for the particular intervention planned for cerebral palsied children together with a statement on the research design selected. The operational definitions of independent variables (music therapy, rhythm and melody) and dependent variable (motor control) are given, and a short statement of the significance of the study completes the section.

3.1 HYPOTHESIS

Cerebral palsied children will demonstrate improvement in motor control by undertaking a motor control task which is supported by processes of music therapy. This improvement will be identified by a series of rhythm-based measurements in an interrupted time-series experiment which uses single subject design. The measurements will relate to regular time periods during which two music stimuli will be introduced at different stages:

1. Regular rhythm, which will be sustained throughout the task.
2. Melody, which will be added to the rhythm at two stages during the task.

Rhythm, and rhythm with melody, will provide aural cues to support more consistent motor action from cerebral palsied children.

The experiment will take place over three weeks, and measurements will be taken from ten completed sessions.

3.2 RATIONALE FOR HYPOTHESIS

3.2.1 Cerebral Palsied Children and Motor Control

From the definitions and descriptions of cerebral palsy outlined in Section One (Vining, Accardo, Rubenstein, Farrell and Roizen, 1979) it is clear that the condition is not uniform in its presentation.

Neuromuscular dysfunction differs, yet disorders of motion and posture are common to all persons with cerebral palsy. Recognition of associated problems and deficits is necessary. For cerebral palsied children, a major deficit is motor control. It is important to maximise their degree of functional movement in all parts of the body (Bobath, 1971). Upper-body fine motor control is important in order to promote skills in self-care and communication. Children need to reach as full a potential as possible in independent functional living skills such as dressing, eating and mobility. Abilities to write on a page or operate a computer, to turn pages of books, to use and manipulate classroom learning resources are desirable for communication and learning.

Children with cerebral palsy have varying degrees of muscle dysfunction, and suitable regular motor task rehearsal is advocated for increase in motor control. However there are other areas of concern in planning such task rehearsal. Cerebral palsied children have difficulties with right-left discrimination (Abercrombie et al., 1964), as well as vision problems. More than usual task rehearsal is needed to compensate for impairment and delay in visual-motor development (Nielson, 1966). Birch and Bortner (1967) indicated that tasks set cerebral palsied children should have few stimulus distractions. Taking these identified difficulties into account this study devised a simple, repetitive motor control task for hand-arm movement. The motor action required would provide rehearsal for useful life skill tasks.

3.2.2 Age of Children and Relevant Developmental Theory

The original aim of the researcher was to involve children with cerebral palsy aged from seven to eleven years in the study. To obtain larger numbers it was decided to extend the age-range to five years.

As stated in an earlier section, Rider's work on auditory tasks for children aged two to 12 years (Rider, 1981) was based on Piagetian developmental concepts, particularly conservation. Rider looked for conservation of rhythmic pulse (ability to recognise a constant beat) and conservation of tempo (recognition of constant pulse when there are one or two sound sources). In Rider's view, a child that can conserve rhythm and tempo has developmental learning potential around the Piagetian stage-level of formal operations. A child with cerebral palsy that can demonstrate understanding of a perceptual or cognitive time-frame by a motor action shows a definite stage of learning potential.

Pflederer-Zimmerman (in Serafine, 1980), reviewing age-related ability in musical tasks, pointed out that eight-year olds perform better than five-year olds and that training for these tasks is better at ages five to seven years. Later (Zimmerman, 1984) she reported evidence of a definite sequence in development of rhythmic concepts. Beat is recognised first, then pattern, then metre which can be recognised around nine years six months.

Although age-stage development in music is still being explored in research, the studies referred to above give some direction towards appropriate choice of rhythm task and age-range for this study. The use of a simple, motor control action related primarily to rhythmic beat would be suitable for children aged five to eleven years. Cerebral palsied children may present developmental delay related to the degree of cerebral palsy present. If they can perform the set task, that could provide an indication of optimum learning potential for other tasks relevant to their needs.

3.2.3 Music Therapy Support

Music therapy is the planned use of music to support identified needs. In this study the primary identified need is physical; it is hoped that improvement in motor control will result from the experiment. A constant hand-arm motor control action is asked for, with a constant beat sound given as auditory stimulus; at certain times this beat sound is joined by a melodic stimulus. The regularity of the rhythmic beat stimulus encompasses the child with aural experience of temporal order and encourages, therefore, a time-ordered behavioural response. At certain time periods in the experiment, melodic stimulus is included. This inclusion is supported by Moog (1979) who considered that melody enhanced a rhythm task, although Gabrielsson (in Sink, 1984) was of the opinion that melodic information required a person to concentrate consciously on rhythm information. It was decided to include melody in this study because it is an important, recognised elemental component of music and music therapy. It presents a new modality to rhythm during the motor task and could therefore encourage children to employ a different response strategy and stay on task thereby.

Constancy of music stimuli promotes and extends rehearsal of the motor control task; Safranek, Koshland and Raymond (1982) imposed a rhythm on a muscle activity motor task and obtained longer duration and stability of that muscle activity. It is expected that increased rate or constancy of motor action will occur during the present experiment.

As well as the aural impact of music, the child is supported by the music therapist, seen by the child as organiser and controller of the task, and as direct provider of some of the music stimuli. The music therapist and child are thus involved in an ongoing interactive process.

3.2.4 Time Period of Research

Two periods of working time were selected, each of three weeks. Up to ten sessions were spaced over each three-week period and several lessons were recorded at each session. There was a twelve week gap between the two working periods.

Thaut (1985) used a three-week period to study auditory rhythm with rhythmic speech to aid temporal muscular control in children with gross motor dysfunction, and some significant difference was found. Children were better able to synchronise motor action to an external beat when rhythm and speech supported their efforts. This experiment influenced the time-span selected for the present study. It was also recognised however, that children in Thaut's study had motor dysfunction only. Neuromuscular dysfunction associated with cerebral palsy could require an extended time-span in order to demonstrate improvement in motor control.

3.2.5 Rhythm-based Measurement and Computer

Section 2.3 contained full reference to writings and research on the analysis of rhythm and use of rhythm in music therapy. Most importantly motoric 'response' to regular rhythm requires anticipation of the auditory stimulus rather than physical action following the perceived stimulus (Fraisse, 1982). There is therefore an expectation of synchronisation of sound stimulus and physical action in this study; the motor task asks for hand-arm movement to "play with the beat".

Precise measurement of attempts toward synchronisation, or increased rate of action or some other indicator of improvement of motor control for cerebral palsied children can be registered most accurately by computer (Berhmann and Lahm, 1984). This removes human error in use of timing devices. Also graphic representation of measurements can be immediate and is consistent (Greenfield, 1985).

3.2.6 Research Design

Each cerebral palsied child can present a different set of physical, intellectual and emotional needs. Some are spastic, others athetoid; some have intellectual impairment, others do not. Visual defects are present in around 20% of the cerebral palsy population (Bobath, 1971). These factors would make a control group approach in research extremely difficult (Hourcade and Parette, 1984), therefore a single-subject design, where the subject provides his/her own control, is more suitable. In a single-subject design each subject is acknowledged individually. Parsonson and Baer (1978) affirmed this, stating that the resultant functional analysis of behaviour emphasises direct, individualised and repeated demonstration of experimental control.

Parsonson (1979) added further emphasis to the flexible and pragmatic nature of single-subject research designs. They combined flexibility of approach with on-going graphical analysis of data to give uniquely responsive research procedures. Parsonson stressed the inclusion of replications in these studies. Where a baseline condition A is established (by observations made without the independent variable) and is then followed by a 'treatment' or B section (which contains the independent variable) observations may show changes of behaviour. These changes in an unreplicated AB design are often attributed by therapists to therapeutic intervention when this is coincident with the onset of 'treatment'. Parsonson stated that correlation does not equal causation. Only replication can increase the behavability. Applied behaviour analysis is characterised by replications with different arrangements and elaborations of the basic AB sequence. This approach excludes attributing any changes in behaviour to either the experimental intervention or concurrent extraneous events. Graphic representation of the data gives visual evidence of whether or not there is a time-based association between changes in target behaviour and the researcher's manipulation of the independent study. Parsonson quoted Sidman (1960) who pointed out that replication is intended more firmly to exclude alternate explanations of the obtained effect, and to provide data on the generality of the phenomenon of interest.

Kazdin (1980) uses the term "intra-subject replication design" for a research format akin to what Parsonson terms single-subject design with replication. Kazdin affirms that the designs are quite applicable for clinical work where the individual can be studied intensively and where effective treatments can be designed and evaluated for the individual situation. The advantages over case study or group research are listed by Kazdin as

(a) the clients will not be subject to nonveridical or control procedures that are unlikely to produce change

(b) the designs provide tools for evaluating treatment effects by evaluating what one is doing rather than subject the client to either different interventions or unevaluated treatments.

Parsonson's (1979) warning about the attribution of therapeutic intervention to change when using just an AB design is important. He advocated the use of multiple component designs which introduce one or more additional treatment variables to identify effective variables from those making a lesser contribution. This idea is relevant to research involving music. One effective elemental component of music, rhythm (particularly in the form of beat stimulus), can be acknowledged as being music. But there is more general recognition of an aural stimulus source as being music if more than one elemental component is there, for example if beat and melody are there. Moog (1979) found for instance, that presenting rhythmic beat together with notes of different pitch made the perception of rhythm easier.

This study, therefore, planned a design that would provide as supportive a musical environment as possible while enabling measurements to be made of actions based on response to auditory rhythm stimulus. The design is best termed an interrupted time series design (Campbell and Stanley, 1966). It uses a time-constant baseline where the constant beat stimulus is interrupted at regular intervals by the addition of a time-based pitch stimulus.

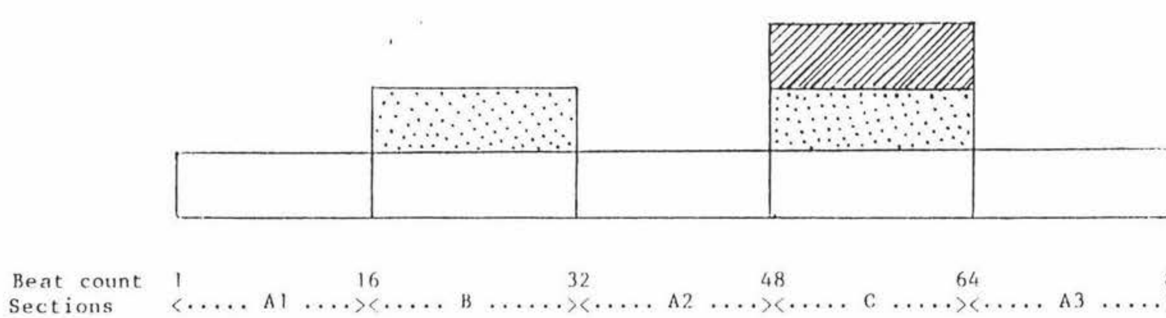


Diagram 2. Design of study

Section 1: Computer beat only - A1
2: Computer beat plus possible computer pitch - B
3: Computer beat only - A2
4: Computer beat plus possible computer pitch plus vocal pitch - C
5: Computer beat only - A3

The design could also be termed a multiple baseline design (Parsonson, 1979). Baseline A, beat-based and continuing throughout the experimental session, is joined at section B by a further stimulus component, namely pitch. After a return to baseline A, a second interpolation of pitch from two sources joins the beat for section C, then a final baseline A section concludes the session. During this ABACA sequence, the child is asked to make regular physical contact with the keyboard surface. In all A sections no sound is activated by this physical contact; in section B the contact activates pitch sound and it does this also in section C. A further ingredient is added in section C by pitched vocalisation from the therapist. There is therefore a differential 'layering' of stimulus input which provides a multiple baseline.

The interrupted time series design however is more appropriate for this experiment with its particular music ingredients. A regular, time-based sound stimulus, namely beat, occurs throughout the experiment and is interrupted at regular time-based intervals by a further music stimulus, pitch. The prime music stimulus, beat, has been organised from a subject-based determination of personal tempo, or preferred pace, which is a temporal factor. Also the main subject response expected is regular, physical contact with the keyboard which requires anticipation and response to a time-based signal.

3.3 <u>OPERATIONAL DEFINITIONS OF THE VARIABLES</u>

3.3.1 Independent Variables

(a) Music therapy is the planned use of music to support identified social, emotional, physical or intellectual needs. In this study the prime need identified was improvement of physical control by cerebral palsied children. Other areas of need were present. Some children had intellectual impairment. Because of limited mobility some were unable to participate in activities around them and lacked social development. All children with disabilities can display a range of emotional needs, and this was apparent with some children. The use of music therapy aims to encompass the range of needs of each individual person by means of an interactive process.

(b) Rhythm is a general term used to describe temporal order; in music it is identified through sound impulses. Rhythm is experienced through neuromuscular channels where an aural impulse is identified and an appropriate rhythmic response is anticipated, and a motor action can take place.

Two rhythmic components were necessary to this study. First there was pre-planned regular sound emission from the activated computer which was termed the 'beat'. Secondly, the children were asked to 'play with the beat'. Each child's experimental task was to anticipate the regular beat sound, plan and execute a regular physical action, thus executing a rhythmic action.

(c) Melody is planned pitch from a music source.

The two melodic components used in this study produced the same pitch base, a five-note pentatonic scale. At certain times during the experiment the computer could be activated to emit notes of the scale when the child made contact on the keyboard. The second melodic music sound was the therapist's voice, singing some or all of the designated five pitches from the pentatonic scale.

3.3.2 Dependent Variable

Measurement was made of motor control over a consistent time-frame; this motor control was the dependent variable. The given task involved neuromuscular anticipation of a regularly sounded beat so that an attempt was made to coincide a physical contact action with that beat. This contact information was recorded immediately by the computer.

The study aimed to measure consistency of matched effort, also possible improvement in regularity of motor control.

3.3.3 Operational Restatement of the Hypothesis

Each child was set the same rhythmic task of providing a regular physical action to a regular temporal sound cue. It was expected that each child would demonstrate improvement in frequency or regularity of arm-hand contact with a keyboard.

3.4 SIGNIFICANCE

Two areas of significance can be identified in this study.

First cerebral palsied children can be disadvantaged in some or all areas of learning through neuromuscular dysfunction. The processes of rhythm used, involving neurological anticipation of beat and physical action to beat, could provide an important vehicle to extend and improve rehearsal of motor control tasks important for learning skills. Also, if consistent or improved motor control does occur, the measurement processes used in this study could form the basis for ongoing or comparative assessment of such children.

Secondly, the independent variables in the study, music therapy with rhythm and melody, are being used in a controlled research situation with accurate and objective computer measurement. This adds a fresh dimension to research in music therapy.

CHAPTER 4. METHODS

OUTLINE

This section describes the sample of children used in the study and the methodology employed to investigate the proposal set out in Chapter 3. Detailed discussion of selection, presenting characteristics and known relevant background and assessment is given. Full description of music therapy processes and data collection procedures is outlined. Instruments of data collection are described. Choice of pre and post tests and data presentation is discussed.

4.1 DEFINITION OF TERMS RELATIVE TO THIS STUDY

Music Therapy is the use of music planned by the music therapist to engage, support and extend a child's performance of a rhythmic task.

Cerebral palsy is a term for a group of conditions characterised by disorders of movement and posture resulting from lesions of the brain which may have occurred before, during or after birth (Bell and Klemz, 1981). The condition may include intellectual handicap.

Motor control is the mental and physical co-ordination of movement. This study looked at upper-body motor control, primarily at motor control of arms, hands and fingers.

Rhythm is the ordering of sound or movement through time. In this study the regular ordering of sound used as a constant stimulus is termed the beat.

Melody is planned pitch change in a sequence of sounds.

4.2 SAMPLE OF CHILDREN

4.2.1 Selection and Grouping of Children

Eight cerebral palsied children between the ages of five and eleven years took part in this study. Five were located by the Manawatu branch of the New Zealand Crippled Children's Society, being the only cerebral palsied children in this age-range on district records. Three others came into the study through personal referral and their cerebral palsy condition was confirmed either by the Crippled Children's Society field officer or the community occupational therapist and physiotherapist team from the Palmerston North Hospital. In effect, therefore, the eight children made up the known cerebral palsy population in an identified geographic area within the determined age-range, and no selection of children was made. A ninth child with cerebral palsy, at a special school for intellectual handicap, assisted in a pilot run to determine functional viability of the study; this child was not included in the actual study.

The children were organised into two groups, four children in Group A and four in Group B. Two research periods were used, three weeks in November 1985 and three weeks in February 1986. Group A children were selected solely on where they lived; more travel time was possible in the November period and the four Group A children lived in two smaller town centres in the region. Three of the Group B children attended city schools and the fourth was a pupil at a large country school close to the city. The children came from six different state schools with comparable rolls and similar general curriculum and activities. Seven of the children were in normal classrooms, some receiving special physical help from teachers, aides and pupils; some used support appliances (wheelchairs, tricycles) and two used typewriters. One was in a special needs unit for intellectually handicapped children attached to a normal school.

4.2.2 Presenting Characteristics of Children in Study

Brief details about each child are given below. They are, age at the start of the study, type and degree of cerebral palsy also any other identified dysfunction (from records of school or Crippled Children's Society), available information on test results or functioning level (from Education Department Psychological Service reports), type of school placement and support, and finally general observations on language ability.

Child One was eight years, male and spastic. In November 1983 he had been assessed on the Portage Guide to Early Education (Boyd, Stauber and Bluma, 1977) as operating at a three to four year age level. He was wheelchair-based, needed much physical help and was in a special unit for intellectually handicapped children attached to a primary school. Language skills were limited, there was some speech, occasional use of short sentences and the language was appropriate.

Child Two was a boy aged eleven years, two months at the start of the study. The cerebral palsy condition was spastic; there was left hemiplegia especially in the left arm, both legs displayed spasticity and there was some visual impairment. February 1986 Wechsler Intelligence Scale (1974) results had been extremely variable and comments noted on the test report included "general IQ range would not represent the true position, e.g. lacks information, picture completion difficult, better results in similarities subtest". He was in an integrated class in a primary school and a teacher aide was assigned for support. He operated an electric wheelchair independently but needed help in many mobility and self-care areas. There was little expressive language, usually single or two-word statements. Words were produced with difficulty and salivation was common. Receptive language appeared to be of a reasonable standard; he could give single-word or non-verbal confirmation of understanding of queries or comments by the therapist.

Child Three, a boy of seven years and one month, was spastic with mild left hemiplegia which presented mainly in the left arm. He walked easily, with a slight limp when tired, and had complete independent mobility and function relative to his age. Stanford-Binet results from September 1983 (just before he began school) were 115 - 125 suggesting above-average intellectual ability. In a normal classrooom situation his expressive and receptive language was adequate; he was responsive, had a quiet voice always and took few conversational initiatives.

Child Four, aged nine years and seven months, male, had some visual impairment. His cerebral palsy condition was spastic diplegia with dysarthria although there were some athetoid characteristics which showed in his movements. He used a large tricycle for independent mobility outdoors and in a normal classroom could walk with balance support from people or furniture. Expressive language was well developed if rather hard to understand. No test data were available.

Child Five, a boy aged eleven years and one month, had athetoid cerebral palsy. He operated his own electric wheelchair in a normal classroom and some teacher aide help was provided; he used an electric typewriter at school. Tests done in December 1981 gave results in the top 15% for age in maths and receptive language, and similar results to children of the same age in reading and spelling. Personal receptive language was very difficult to understand and salivation was regular.

Child Six, seven years and seven months of age, was a boy with mild cerebral palsy which presented as a mild left hemiplegia; he limped a little when tired. No formal tests had been recorded. There was independent functioning in a normal classroom with good levels of achievement. Language skills were above average.

Child Seven, a girl aged nine years and eleven months, was a spastic quadriplegic, wheelchair based, with lower limbs more affected. She received physical help in a normal classroom from teacher and pupils. Results from a May 1984 Peabody Picture Vocabulary Test (Dunn and Dunn, 1981) showed M.A. at five years eight months, and I.Q. 75-83. This was considered a conservative result as the child was "desultory, fatigued". Language expression was in short sentences using repetitive phrases, usually to affirm on-task behaviour, for example "All right?".

Child Eight, a boy aged five years and ten months, was a spastic quadriplegic in a special class at a normal school. He could walk with assistance, but often used a wheelchair. No formal test results were available. Although few words were spoken those used were appropriate.

4.3 PRE AND POST TEST PROCEDURES

A wide search was made for a pre and post test that would be suitable for use with cerebral palsied children and that measured motor control in upper limbs in a way related to the purpose of this study.

Motor development tests such as Denver Developmental Screening Test (1970) and Gesell Developmental Schedule (1949) were for pre-school age children. Other tests were general schedules for motor development with no capacity for measurement where there is physical and possibly intellectual impairment of the subject. Two further tests, the Adaptive Functioning Index (A.F.I.) (1978) and the Luria-Nebraska Neuropsychological Battery (1980) were considered. The A.F.I., used in rehabilitation or special education settings, was for ages 14 years and over, and the Luria-Nebraska Test was used to assess neurological impairment in adults. Neither test was suitable. Sutton (1984) had produced a physiological music therapy test using kinaesthetic terminology; only a research paper has been available.

In considering the Lincoln-Oseretsky Motor Development Scale (1955), for age six to 14 years, it was realised that an adapted version of that scale, the Bruininks-Oseretsky Test of Motor Proficiency (1978) could be appropriate in age-range and in style of test. The Bruininks-Oseretsky battery of 46 tests, in eight subtest groups, measured a broad spectrum of gross and fine motor skills within the age range four years and six months to 14½ years. It provided comprehensive testing and screening for motor development, and two subtests were relevant to the aims of this study.

From the review of literature Thaut's (1985) study, which used auditory rhythm and rhythmic speech to aid temporal muscular control in children with gross motor dysfunction, was of particular interest. Thaut had used the Bruininks-Oseretsky Test of Motor Proficiency with a task similar in content and process to the present study and with a similar experimental time period to this study. Also Donaldson and Maurice (1983) had used Bruininks-Oseretsky tests in their South Auckland perceptual motor dysfunction survey as assessment procedures, with positive comment on their effectiveness. Those factors gave affirmation to the choice of pre and post test as outlined below.

A selection of two subtests was made involving visual-motor co-ordination and upper-limb speed and dexterity (subtests seven and eight from the Bruininks-Oseretsky battery). These sub-test items were selected after consultation with an educational psychologist, an occupational therapist and a physiotherapist. The tests involved motor-control tasks for the upper body that were comparable in movement range with the experimental task and also relevant to real-life tasks desirable for cerebral palsied children. After consulting with an educational psychologist, the size of some of the charts used in the Bruininks-Oseretsky tests was enlarged to enable a better attempt from some children with less muscular control and, in some cases, poor eye-hand co-ordination because of vision defects. These enlarged test-sheets were used consistently for each child in all pre and post tests (see examples in Appendix C).

Both Group A and Group B children were given the selected Bruininks-Oseretsky tests before any experimental work was done. Group A children then had a three-week experimental period. Then Group A and Group B children were given the same selected Bruininks-Oseretsky tests. Twelve weeks later again both Group A and Group B children were given the same pre-test. Group B children had three weeks of experiment then both groups of children were given a final post-test of the same selected tests.

This procedure was considered of potential value to see if any improvement in motor skills (by Group A children) would be sustained after the experimental three weeks period was completed.

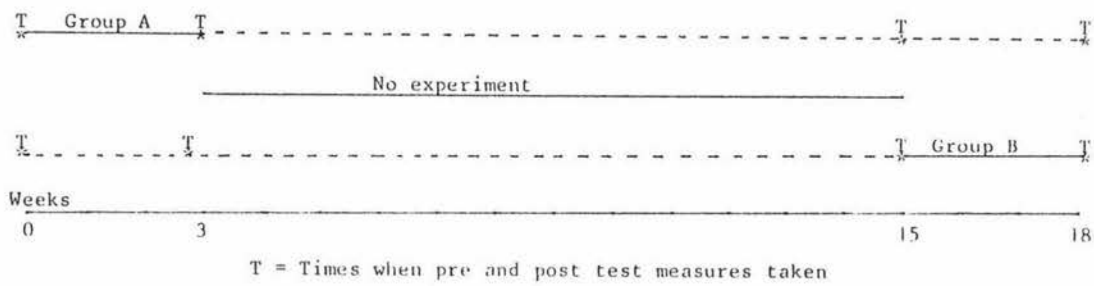


Diagram 3. Time schedule of pre and post test procedures

4.4 ESTABLISHMENT OF PERSONAL TEMPO FOR EACH CHILD

Before the experimental work began each child had a session with the music therapist where an audio recording of personal drum-beat sounds was made. The child was invited to "Play the drum with me" on a two-headed bongo drum. Being careful to allow the child to establish both consistent sound patterns and confidence in the task, the therapist then both matched the child's beat with a very soft tap on the other side of the drum and also sang an improvised pentatonic song with the activity. The song used improvised personal words such as "Betty plays the drum with me, keeps on playing ..." to provide a full musical time-frame around the establishment of personal tempo for each child.

From the audio recordings made, drum beats were timed and averaged and a personal tempo per beat was established for each child (see Table 1). This establishment of personal tempo (Fraisse, 1982) should provide the optimum pace at which a child can perform a rhythm-based task and sustain that task; it appears to be the most natural pace, neither too slow nor too fast.

Table 1 Drum beat measurements to establish personal tempo

Child	Number of beats in secs		Ratio of single beat in secs		
	Left hand	Right hand	Left	Right	Average
1	10 in 15	20 in 30	1.5	1.5	1.5
2	20 in 19	20 in 19	0.95	0.95	0.95
3	20 in 18	20 in 19.5	0.99	0.97	0.98
4	18 in 25	18 in 23	1.39	1.28	1.33
5	31 in 41	62 in 50	1.3	0.81	1.0
6	62 in 46	88 in 46	0.73	0.52	0.62
7	60 in 45	58 in 40	0.75	0.7	0.72
8	64 in 55	68 in 47	0.87	0.69	0.78

Tempo for Group A children was determined prior to their experimental period. For ease of computer calibration the average was brought to the nearest 0.5. Before Group B children's experimental period began, their drum-based measurements were taken - two children presented flexible erratic beating (7, 8) and No 6 presented beats which were regular, even though different speeds had been initiated by the child in an exploratory way. Other children had personal tempo close to one beat per second or one beat per 1.5 seconds. The decision was taken that beats of either 1.0 per sec or 1.0 per 1.5 secs would be desirable for consistent calibration. It was felt that subdivisions of the beat could be expected from Nos 7 and 8, and that No 6 would play evenly over any speed chosen.

Final ratios of personal tempo were established (see Table 2).

Table 2. Personal tempo expressed as a ratio

Child	Ratio (in secs)	Child	Ratio
1	1:1.5	5	1:1
2	1:1	6	1:1.5
3	1:1	7	1:1.5
4	1:1.5	8	1:1.5

4.5 EQUIPMENT USED IN EXPERIMENT

4.5.1 Computer and Keyboard

The task programme was written for an Apple IIE computer with a music interface card. It was designed to control a tone generator and to sense keys being depressed on a large five-note keyboard which had been specially designed.

The computer menu offered the following options:

1. Introduction and duration of lesson. When activated the computer printed a set of commands to be used during a session; then it generated a repeated click sound every one second or 1.5 seconds throughout the lesson according to the disk inserted. Each child had their own programme disk customised to one of those click rates based on their own personal tempo. The researcher controlled a pitch sound generated by contact on the keys by turning it on or off from the computer. Each key when activated sounded a different pitch level; the five pitch range available, one pitch for each key, formed the musical notes C, D, E, G and A. When the pitch sound was turned off there was no sound generated apart from the continuous click-beat sound.

   As a lesson progressed, the computer recorded specific events and the time at which they occurred. It recorded

   (a) Each click-beat generated

(b) Each key depressed by the child, also which key was depressed

(c) Each key release from the child's motor action

(d) The on/off actioning for pitch sound done by the researcher.

2. On completion of the lesson the contents were stored on disk.

The children were seated at chairs and table or in wheelchairs, and a portable adapted keyboard was placed on table, working tray, or wheelchair arm (whichever allowed best natural arm action for playing).

The keyboard consisted of a rectangle of polyurethaned hardboard with an attractive speckled-texture surface into which was inserted five large brown-painted squares of wood (see Diagram 4). Each square, or key as it was termed, was mounted on small springs; when depressed by hand or arm action each square (or key) activated a circuit to the computer. Thus every key contact was computer-registered in a time continuum when the experiment was in progress.

The music interface card in the computer had been programmed to emit a pitched sound from each key when requested. The pitch of the first key on the right-hand side of the keyboard was set at 440 cycles per sec using a New Era alto glockenspiel as pitch monitor. Relating to that pitch of note A, the computer programmer cued in notes C, D, E and G using the xylophone and therapist to check accuracy of pitch relativity. Practicing musicians can identify in-tune intervals between notes with a 95% accuracy (Siegel and Siegel, 1977b, in Deutsch, 1982).

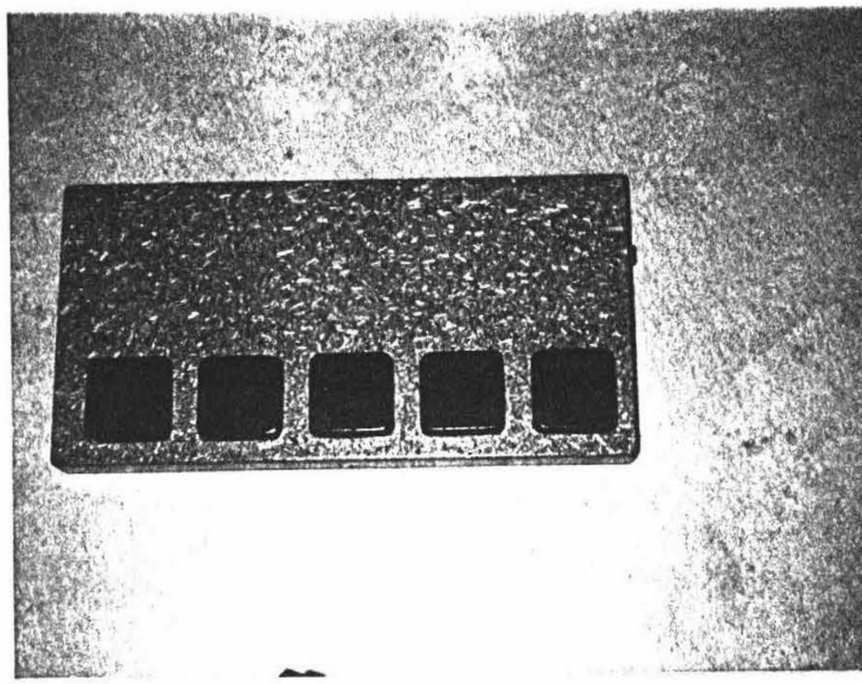


Diagram 4.

The researcher could action beat and pitched sound emission by pressing a computer key and could switch pitched sound out by a further press. Both beat sound and pitched sound was given 20 watt amplification through a speaker system consisting of an adapted cabinet with three eight-inch speakers. Volume was adjustable but was kept constant (see Table 3 below) as no children were hearing impaired.

Later use of computer. It was possible to

(a) load a previous lesson, transferring a saved lesson back into computer memory from a disk;

(b) Replay a lesson which played back all the computer-generated sounds that were recorded during the actual lesson under review;

(c) Analyse a lesson. The lesson could be played back on the computer screen showing when click-beats, key depressions and on/off sound commands occurred.

The computer material was subsequently converted into histograms of six determined categories of response to be studied.

4.5.2 Level of Sound Used

A simple analog decibel meter was used to measure the decibel level of the click generated by the computer. This meter was placed two feet from the speakers, slightly above the centre of the speaker case. It was noticed when measurements began that the intensity of the sound varied by several percent with even a few inches in change of meter placement. Also the sound emitted was not constant for a long enough time to allow the measuring instrument to register a settled value. By requesting the computer to emit continuous sound (rather than manually turning on and off to begin and end click emission) a settled value could be reached, but that intensity was louder than the manually-controlled click sound (see Table 3) and was too loud. The decibel level meter had a response curve setting that modelled the response of the human ear and that setting was used. Background noise (traffic and people in adjacent rooms) was 40 - 50 decibels.

Having established that no child had a hearing deficiency (records plus observation of response) the volume level was kept steady at setting three, that is, at 63 decibels(see Table 3). Constancy of volume was necessary so that volume did not become another variable in the experiment.

Table 3. Sound levels from computer

Vol. setting on amplifier	dB Click measure	dB Continuous sound
1	not audible	not audible
1.5	47	80
2	60	83
2.5	62	87
3	63	92

Error 5-10% Position of amplifier knob 3

4.6 PRACTICAL SETTINGS FOR EXPERIMENT

All experimental sessions were held in schools attended by the children, usually in withdrawal or resource rooms familiar to the child. The nature of the school environment therefore was still preserved, but there was less likelihood of interruption or noise distraction by use of these rooms. A notice requesting people not to come into the room was in place during working sessions.

Following advice from physiotherapy and occupational therapy professional people, care was taken to ensure correct posture for children during the sessions. Seating was adjusted to give full trunk support, so that the body was upright and not flexed forward. Effective placement of the keyboard was more difficult; there had to be both appropriate height and distance placement in front of the child and also enough space to allow left-right horizontal arm movement to different keyboard squares. Keyboard height was matched to working height used in the classroom situation by use of either desk, table or wheel-chair arms or tray at the appropriate level. The keyboard was shifted to a central placement for left or right hand use.

4.7 NATURE OF SOUND USED

In planning a motor task with steady beat sound as a constant variable there was an awareness that an intervention calling itself music therapy should use as much "musical" content as possible. While a constant beat-click signal of definite loudness and tone quality could be termed a music impulse, it does not contain melody, that is, planned pitch change. Melody is a factor that adds a recognised and acceptable musical ingredient to an experimental rhythm task (Moog, 1979). Children are more sensitive to simple, physically defined properties of tone stimuli (Krumhansl and Keil, 1982) so a simple, five-note framework was considered suitable for melodic selection.

Therefore this experiment included a component of melody within the multiple baseline design in sections B and C. This component was a five-note pitch sequence, a pentatonic scale based on notes C, D, E, G and A where A is 440 cycles per second and the other four notes are pitched below that frequency (see Table 4). Both the constructed keyboard in sections B and C and the vocalisation contributed by the music therapist in section C sounded only those five pitched notes. The keyboard squares each emitted a different note.

Table 4. Frequencies for keyboard notes

Note	Frequency in cycles per sec
A	440
G	392
E	329.63
D	293.66
C	261.63

In B and C sections, the child activates pitch by depressing keyboard squares of his/her choice while 'playing with the beat'. This melody release should give that child immediate concrete aural feedback which should sustain application to the task (Johnston, 1981), particularly when key depression in any of the A sections would not result in pitch emission.

The nature of the pentatonic scale is such that any sequence of the five notes sounds melodically compatible; a large number of folk-songs and children's songs in many cultures are based on the penta-tonic scale. Also, any two of the five notes sounded together give an aural blend that is harmonically acceptable. So the therapist's voice in section C could sing either matching or different notes of the five-note scale which are being activated by the child, and the two sounds together are musically compatible, also musically fuller than a single pitch sound. In many lessons the music therapist matched her voice pitch to the notes being played by the child. This was done by observing the hand or arm placement of the child on the keyboard squares and pitching the voice to that precise note in the scale.

4.8 THERAPIST BEHAVIOUR IN EXPERIMENT

It was important throughout the experiment to maintain consistent therapist behaviour. This required personal discipline to avoid a wide range of reinforcements normally used by music therapists. Facial expression, verbal directions, (apart from verbal directions at the beginning of each session), body posture and distance from the children, gestures, modelling techniques for demonstrating use of the sound-making instrument and statements of encouragement and commendation at the completion of the sessions had to be consistent and suitably low-key for each subject. Generally the therapist maintained a facial expression of consistent interest (half-smile), and made eye contact when the child initiated it. Verbal directions were not given during the experiment but Children One, Four and Seven needed occasional verbal reinforcement. Body position relative to the child and body posture was dependent on the position of the keyboard in the rooms used. The therapist sat in a chair opposite the child where possible. With Children One, Two, Five and Seven, who were in wheelchairs, and for Child Three where the workspace was a narrow room, the therapist sat alongside the child. In every session the therapist altered the computer input with the left hand and (if this was not distracting to the child) made brief notes with the right hand. If note-taking was distracting during the session it was done after each session. Physical gestures and physical support were not given, except for two children, One and Four, where physical restraint from changing from one performing arm to the non-required arm during a session was required. It was felt that this form of restraint and reminder of the required arm would be less interruptive and more aligned to the nature of the study than verbal intervention.

Modelling of playing the keyboard was not necessary after the first session. Each child played the instrument readily. Remarks at the end of sessions were kept to general positive comments about participation, consistent effort and seeing them again at the following session. Always the therapist responded to questions (Child Four had many) or to verbal or non-verbal comments related to the session from the subject (Child Two told the therapist how he had worked out the structure of the session). Many of the children asked if the therapist was coming again or stated when the therapist was due next.

An exception to this neutrality of post-session dialogue was made on one occasion with Child Five who had, in the latter sections of a session, begun to bang the keyboard squares with greatly increased weight. The behaviour was different and deliberate and it damaged the keyboard. This was pointed out to the child with the statement that further sessions depended on absence of such behaviour. There was no recurrence of the banging.

Regular audio recordings of sessions were taken and played back between sessions by the therapist to monitor therapist behaviour, confirm observed vocalisations or verbalisations from the child, or recall any interruptions or diversions in the session.

4.9 PILOT SESSION

A pilot session of the experiment was conducted with a pupil at a special school where the therapist and child were observed by the school principal, the computer programmer and technician and the study supervisor. The pilot session checked technical details of the equipment, enabled the research process and content to be commented upon and gave an opportunity for refinement of a new style of research procedure.

The child had spastic diplegia, was ten years old, with some speech and moderate level of mobility. She could walk slowly and move her arms slowly, and she had defective vision. She related to the task readily, could depress the keys and there was good attention throughout the task.

Minor adjustments to the equipment were made, mainly to allow for immediacy of beat sound from the computer. Also the therapist altered verbal instructions to start the session.

4.10 CONTENT OF EXPERIMENTAL SESSIONS

In each of the three week periods of experiment, first a period for Group A and 12 weeks after for Group B, every child had sessions two or three times a week until a total of 20 "lessons" were recorded successfully; ten lessons for right hand and ten lessons for left hand. Not all sessions were free of practical problems. There were unplanned interruptions, occasionally the computer malfunctioned, and twice there was therapist error in disk selection. Faulty lessons were discarded. This omission or deletion of faulty lessons was seen to be randomly dispersed through the programme.

The equipment (computer, computer monitor, keyboard and speaker cabinet) was set up before a child came to a session. After making sure the child and keyboard were positioned correctly the therapist reminded the child that the computer-sound beat to be matched with contact action had been taken from the personal tempo established previously by drum beating, and that there was a four-beat introduction before response was wanted. "Your beat is in the computer and when I turn it on you are going to <u>play with that beat</u>" (indicating keyboard) "Which hand are you going to use first today?" (wait for hand indication) "Are you ready? Wait for four beats before you start playing."

The computer was switched on by the therapist and the programme began. The four-beat introduction gave the child a time-period to hear and recognise the pace of the regular beat so that a physical response could be anticipated (Fraisse, 1982). Matching pace to the introduction the therapist said "Off you go" to cue the child to begin pressing the keys on the keyboard. Any key could be pressed to begin and any change of key was allowable during the lesson. [The first session with the children had given both verbal and modelling instructions about playing the keyboard on any key, about when to start and when to stop playing.]

After 16 beat sounds (completing Section A1) the therapist switched the computer circuitry to allow pre-determined pitch sound from each key if that key was pressed. The following 16 beat period of Section B contained that possibility, and the computer beat still sounded throughout. At the end of Section B the pitch was switched off. Sixteen beats only sounded for Section A2. Then, during the 16 beat sounds for Section C, keyboard pitch was switched on for a second time and, as well, the therapist vocalised using only the five pitches of the pentatonic scale that were also available from the keyboard i.e. notes C, D, E, G and A. Words used in the vocalisation related to the present situation; "Jane is playing the keyboard now. Keep with the beat and play a tune...." The therapist's song sometimes matched the child's pitch-play, sometimes improvised on other notes in the scale. It lasted during the 16 beats of Section C. Then a final switch-out of pitch led to Section A3 and 16 beats only sounded. The signal to stop was given as the computer was disengaged. Then that lesson was put into disk storage and a lesson for the other hand began (see Diagram 5).

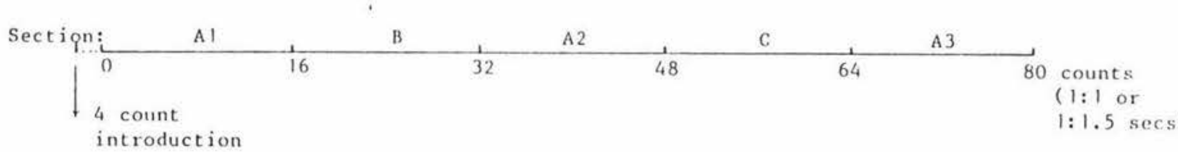


Diagram 5. Time base for one lesson

SUMMARY OF PROCESS: There was continuous and regular beat sound throughout each lesson. This came through use of a separate computer disk for each child which contained the child's particular beat tempo ratio, 1.0 beats per sec or 1.5 beats per sec. Sections A1, A2 and A3 contained beat sound only as the sound stimulus. Section B had beat stimulus plus pentatonic pitch if the child pressed a key or keys. Section C had beat stimulus, the same pitch possibility of up to five pitch sounds actioned by the child and also the therapist's voice using only those five pitches in an improvised song which matched the pace of the beat stimulus.

4.11 ANALYSIS OF PROGRAMME

Data generated by the experiment were presented in a series of histograms. Each histogram showed results for ten lessons with

(a) totals for each of the five sections of a lesson

(b) the accumulated total of the five sections of each lesson.

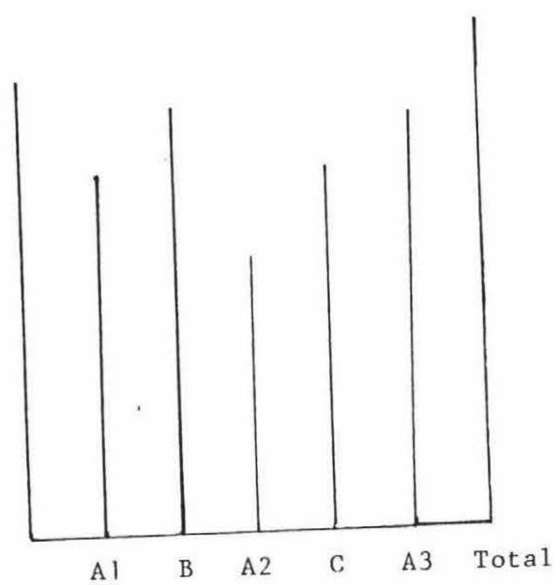


Diagram 6. Detail of histogram of one lesson

Ten lessons for the left hand were plotted on a line continuum and ten lessons for the right hand on a second line continuum.

It was decided to give the same axis for 1:1.5 second beat results as for 1:1 second results to give a straightforward visual comparison.

4.11.1 Definition of Data Categories

Six histograms for each child were graphed. The six categories were:-

1. **Contacts:** The number of contacts in a lesson or session is the number of times the child pressed a key on the keyboard.

2. **Deviation from beat:** Each beat from the computer occurred every 1.0 or 1.5 seconds. The deviation from the beat is the average number of (tenths of) seconds between when a beat occurred and when the child pressed a key.
3. **Average note duration:** This is the average number (of tenths) of seconds that a child held the key down when he/she struck the keyboard.
4. **Note changes:** This is the number of times the child struck a different key on the keyboard. If the same key was pressed each time then the number of note changes would be zero.
5. **Average tempo:** This is the average time between key presses from the child.
6. **Pulse (tempo deviation):** This is the standard deviation of the tempo for each section, lesson and overall, compared with the average tempo for each section, lesson, and overall.

4.11.2 Description of Data Categories

1. **Contacts.** Each lesson consisted of five sections of 16 beats each. The child was asked to strike a key in time with the beat from the computer. Therefore 80 contacts per lesson could be expected and 800 contacts for 10 lessons.

2. **Deviation from beat.** This is a measure of difference in timing, being the average number of (tenths of) seconds between when a beat occurred and when the child made physical contact with the key. Ideally the deviation from beat should be zero, that is the key would be struck always at the same time as the beat sound came from the computer.

3. **Average note duration.** This measurement of the average number (of tenths) of seconds that a child holds the key down when making contact with the keyboard would vary from child to child depending on the neuromuscular co-ordination of the child. Tapping the keys lightly would give a consistently short average note duration. A longer average note duration might relate to degree of spasm or control over hand/arm movement, distraction, or a change from one position on the keyboard to another.
4. **Note changes.** This gives some measure of change of hand/arm position relative to the keyboard. It could reflect an exploratory interest in pitch change.
5. **Average tempo.** This being the average time between key presses from the child gives a different measure than deviation from beat. There could be consistent pressing on the keyboard at a set period of time before or after the beat sound. Ideally the average tempo would be exactly the same as the time between beats from the computer, that is 1.0 or 1.5 seconds. It could reflect regularity of key press with a regular anticipation of, or delay from, beat sound.
6. **Pulse (tempo deviation).** This gives a measure of how consistently the child kept to his/her own tempo. A tempo variation of zero would indicate that the child kept exactly to his/her own tempo. There could be delay in transmission of an activating signal from the central nervous system to the muscles. The brain could receive the aural beat stimulus and register the required anticipation of beat cognitively, but impaired neuromuscular channels could prevent the activation of perceptual motor response within the recognised time-sequence. The fingers, hand or arm may be delayed in making the physical contact on the keyboard. If the experimental measures showed a consistent delay in this transmission of aural stimulus to physical action, then the above premise of a delayed message could be considered. The experiment therefore measured actual time between contacts. This measurement is shown in the pulse histogram.

CHAPTER 5. RESULTS

5.1 INTRODUCTION

The results of this study are presented as histograms, six sets of results for each child, and there are eight children in the study. The content of each experimental session was recorded directly by the computer, and the actual histograms are computer-produced.

There are two graphs presented for each set of results for each child. One graph shows results of 10 lessons for the left hand/arm, the other shows right hand/arm results from 10 lessons. The lessons are not consecutive in number always; technical problems with the computer, major interruptions and distractions and therapist error with disk insertion meant that some lessons could not be completed or had to be discarded. Experimental sessions were continued until ten completed lessons for both left and right sides were computer-recorded satisfactorily. The numbering on the histograms reflects these recording difficulties; baseline numbers refer to the lessons used for recording.

It was decided to restrict presentation of results to histograms, rather than include bar-line graphs. Sufficient data were obtainable in this form. The overall results could be determined accurately and readily by computer for both actual totals (number of contacts made) and comparative totals (note changes made) also for average response results (deviation from beat, note duration, average tempo and pulse). These totals and results form a basis from which to assess whether or not:-

1. The child stayed on task for the complete time-span of each lesson, A1 B A2 C A3, thereby "playing with the beat" for 80 secs (if that child's beat-sound was 1:1 sec) or 120 secs (if the beat-sound was 1:1.5 secs). It should be possible to observe any decrease in number of contacts near the end of a lesson; this could relate to neuromuscular fatigue or to loss of task focus.

2. The child made the same amount of response in each of the five sections of the lesson relating thus to the dependent music variable, beat, or whether there was differential response

relating to the presence or absence of the independent pitch stimuli. Also it could be important to note the follow-on effect in some histogram measurements, to see if there is a systematic effect when the experimental variables are introduced. Where some neuromuscular delay could be expected (dependent on the nature and degree of cerebral palsy present) the effect of one section may still be present during the subsequent section giving a carry-over effect. (This aspect could be particularly applicable to the number of contacts made in each section.) Or neuromuscular function may be such that the child relates to his/her own tempo, apart from the beat stimulus.

3. It is possible to identify the nature of response for each child from results and relate that to observation of actual behaviours during lessons. From that it may be possible in some categories of response to make general comments on observed trends for all eight children. Certainly it will be possible to note any difference in response between left hand/arm and right hand/arm action and relate that to hand preference established (see Table 5) and to cerebral palsy condition.

5.2 PRESENTATION OF DATA

First, Table 5 was established by noting hand preference at the start of each set of lessons in a session. The therapist asked "Which hand would you like to start with today?" Children in Group A had more sessions to enable a full set of 20 lessons to be recorded. There was more computer fault and experimental error in the first stages of the study.

Table 5. Hand Preference

Child	No. of sessions	L.H. start	R.H. start	Preference
One	8	1	7	R.H.
Two	7	1	6	R.H.
Three	7	2	5	R.H.
Four	7	3	4	R.H.
Five	5	0	5	R.H.
Six	5	1	4	R.H.
Seven	5	5	0	L.H.
Eight	5	5	0	L.H.

Table 5 identifies five children with marked preference for right arm/hand starts to sessions; four children had spastic left hemiplegia varying from a marked to slight degree and one child was athetoid. Two children with spastic quadriplegia, which was more prominent in lower limbs, preferred left hand starts exclusively. Child Four who had a marginal preference for right hand starts had been identified as having diplegic cerebral palsy with some athetoid characteristics.

Because of the quantity of data for presentation with six sets of result categories (each set containing two histograms, one for left-side response and one for right-side response) for eight single case studies, it was decided to report from a broad base in this chapter. Each child's histograms and other particular details relevant to results are placed in the Appendix section.

Each category will be discussed thematically pointing out responses in general terms. Following that, any particular observations relevant to individual children studied will be presented.

The six thematic headings for histogram-based results are

1. Contacts
2. Average note duration
3. Note changes

4. Deviations from beat
5. Average tempo
6. Pulse (tempo deviation).

5.2.1 Contacts

The number of contacts in a section, lesson or total is the number of key depressions made by separate hand/arm actions on the keyboard. These depressions could be made on the same key or on different keys. The measurement is of rate of physical activity in response to the two aural music stimuli, beat, present in all five sections of each lesson but heard alone in A1, A2 and A3, and pitch. Pitch is computer-emitted in section B (with five different pitches possible) and section C, where there is an added, similar pitch input from the therapist's voice.

The first table sets out total contacts made by each child for the total of ten lessons.

Table 6. Total contacts made in 10 lessons.

Child	L.H.	R.H.	Preferred Hand
1	291	495	R.H.
2	688	867	R.H.
3	686	835	R.H.
4	913	1016	R.H.
5	762	929	R.H.
6	841	881	R.H.
7	805	780	L.H.
8	1334	1281	L.H.

At least 80 contacts per lesson were expected, one for each beat sounded, therefore 800 per ten lessons could be expected. The total number of contacts made is higher for the preferred hand for all eight children.

Table 7 shows a comparative differential from the expected 800 contacts from ten lessons for left hand and ten lessons for right hand.

Table 7. Comparative differential from 800 contacts

No. of contacts	Diff. from 800	Child	Hand used
805	+ 5	7	L.H.
780	- 20	7	R.H.
835	+ 35	3	R.H.
762	- 38	5	L.H.
841	+ 41	6	L.H.
867	+ 67	2	R.H.
881	+ 81	6	R.H.
688	- 112	2	L.H.
913	+ 113	4	L.H.
686	- 114	3	L.H.
929	+ 129	5	R.H.
1016	+ 216	4	R.H.
495	- 405	1	R.H.
1281	+ 481	8	R.H.
1334	+ 534	8	L.H.
291	- 609	1	L.H.

While this table has nothing to do with regularity of contact measures, it does show a range of contact behaviours. Child Seven has comparable right and left hand actions. Other children have varied results relating mainly to hand-arm preference and non-preference and also to task focus. The scores furthest from the expected 800 contacts over 10 lessons would indicate very fast, or very slow, or erratic contact. This was the case with Child Eight, who had a very fast contact action, and with Child One who gave erratic response and slow actions. These two children were the youngest in the study. Another reason for contact scores higher than 800 is that some children in Section C related their contacts to matching of pattern rather than beat. Often the therapist's improvised pitch and words contained words of more than one syllable; instead of singing "Play the beat" where the expected response would be three even contact actions, sometimes children's names would catalyse five or six contact actions within a comparable time span. More word syllables encouraged pattern-based responses rather than responses to beat.

The following four tables, Table 8 (a), (b), (c) and (d), based on the eight contact histograms registered, set out order ranking for number of contacts made within each section over a total of ten lessons. The detail of each child's order ranking is contained in Appendix A1. The highest histogram bar in each five-section lesson is identified as the section in which most contacts are made.

Table 8. Contacts made within sections

(a) Totals for left hand:

	Sections	A1	B	A2	C	A3
Child	One	2	5	2	0	1
	Two	5	2	1	1	1
	Three	0	0	1	5	4
	Four	4	3	0	3	1
	Five	1	5	0	3	2
	Six	2	3	1	3	4
	Seven	5	1	0	6	0
	Eight	6	3	1	0	0
	Totals:	25	22	6	21	13

Order ranking of sections A1 B C A3 A2

Extra effort to get the non-preferred hand (for six of the eight children) started could be reflected in the number of contacts made in A1 sections. The next two ranked sections contain both pitch and beat, sections B and C.

(b) Totals for right hand:

	Sections	A1	B	A2	C	A3
Child	One	1	6	2	1	0
	Two	1	4	3	4	1
	Three	0	1	0	9	0
	Four	4	4	2	1	0
	Five	4	2	2	2	0
	Six	3	1	6	5	1
	Seven	4	1	1	5	0
	Eight	3	2	4	2	0
Totals:		20	21	20	29	2

Order ranking of sections C B A1 A2 A3

The C section, with a baseline beat and two pitch variables added, scored highest in number of contacts registered, closely followed by B (beat and one pitch variable), then the A1 initiating section. For six of the eight children the right hand was the preferred one.

(c) Totals for preferred hand:

	Sections	A1	B	A2	C	A3
Child	One	1	6	2	1	0
	Two	1	4	3	4	1
	Three	0	1	0	9	0
	Four	4	4	2	1	0
	Five	4	2	2	2	0
	Six	2	3	1	3	4
	Seven	5	1	0	6	0
	Eight	6	3	1	0	0
Totals:		23	24	11	26	5

Order ranking of sections C B A1 A2 A3

Comment: This result parallels the previous table and the same comments apply.

(d) Totals for non-preferred hand:

	Sections	A1	B	A2	C	A3
Child	One	2	5	2	0	1
	Two	5	2	1	1	1
	Three	0	0	1	5	4
	Four	4	3	0	3	1
	Five	1	5	0	3	2
	Six	3	1	6	5	1
	Seven	4	1	1	5	0
	Eight	3	2	4	2	0
	Totals:	22	19	15	24	10

Order ranking of sections C A1 B A2 A3

Comment: The three-layered C section contained most contacts.

For all four tables the first three ranked sections include A1, B and C. A1 is the initiating section, Section B is pitch and beat based with keyboard-computer sound triggered by keyboard contact, Section C has the double sound source of keyboard-computer beat and pitch as well as the therapist's voice. The concurrence in ranking of right hand and preferred hand totals is noted. The non-preferred hand ranking is slightly different with the C section still highest ranked but initiating Section A1 ranking higher than Section B. Three of the four tables show lowest ranking for the final A3 section where beat-only stimulus is given. Tables for right hand and preferred hand show a marked drop in contact ranking for Section A3. There is a lesser drop for Section A3 registered for left hand and non-preferred hand but it is still distinct.

A2 sections rank lowest for left hand results and second lowest for the other three tables. A1 ranks highest for left hand results, and the A2 lowest ranking has to be considered in the sequential order of sections in a lesson. It is also of note that Section C, which comes after Section A2, always registered more contacts, as does Section B showing that there is a resurgence of contact effort made in sections where extra stimuli occur.

5.2.2 Average Note Duration

This measurement gave the average duration, in tenths of seconds, that the key was held down when pressed by the child. The physical action of the left or right upper limb involved a downward movement on to the keyboard, actual pressure on a key followed by a release of that key. The use of antagonistic muscle groups in this down-up action was purposeful, and the average note duration could

(a) reflect the cerebral palsy condition as it affected upper limbs in respect to control over extensor and flexor muscle groups

(b) become a comparative measure of improvement in desired muscle tone and activity towards fine motor control in upper limbs.

Two result areas were considered therefore relating to (a) and (b) above.

1. First, a co-relation between hand preference and longer average note duration was observed in six of the eight children's results (see Table 9).

Table 9. Average note duration in seconds

Child	L.H.	R.H.	Hand preference
1	1.15	0.76	R.H.
2	0.57	0.49	R.H.
3	0.59	0.42	R.H.
4	0.84	0.74	R.H.
5	0.45	0.37	R.H.
6	0.78	0.79	R.H.
7	0.55	0.48	L.H.
8	0.29	0.24	L.H.

The measurements for Child Six were very close, 0.78 L.H. and 0.79 R.H.; Child Six had no identifiable dysfunction of neuromuscular control in either upper limb so that comparable note duration could be expected. Other children showed variability between left and right side duration times.

2. From a close visual comparison of all histograms for average note duration there was (a) no discernable pattern of increase or decrease of average note duration during the five sections of each lesson except for Child Six (see note below); (b) a trend towards increase in average note duration over the course of ten lessons for Child One, Child Three and Child Seven. Whether or not this can be correlated to improvement in muscle tone is debatable.

Note on Child Six

Ratings for left hand showed a preference order of A1>A3>A2>B>C and for right hand A3>A1>C>A2>B. Beat-only sections appeared to coincide predominantly with increase of note duration (see Table A2 in Appendix A).

5.2.3 Note Change

If a child pressed the same key throughout a lesson then no note change would be registered. The computer could identify each different key pressed according to pitch. However the note change histogram registers the number of times the child pressed a different key without identifying how many of the five different keys were pressed. Observations made during lessons however were able to identify children who explored a few keys beside one another or, who explored all keys.

Results in this note change section show that all eight children made more note changes with their preferred hand (see Table 10).

Table 10. Note changes in 10 lessons

	Total note changes		
Child	L.H.	R.H.	Preferred hand
1	132	191	R.H.
2	469	774	R.H.
3	160	231	R.H.
4	739	776	R.H.
5	447	688	R.H.
6	218	324	R.H.
7	641	617	L.H.
8	203	138	L.H.

More note changes were made with the preferred hand by all eight children (see Table 10). There did not appear to be a section-based interest in note change from histogram observation.

From observation, both Child Two and Child Seven established a regular cyclic pattern of movement across the keys, downwards with the right hand and upwards with the left. Child Four stated regularly "Used all the keys" at the end of lessons, and usually had done just that. This degree of conscious directional activity on the keyboard to explore different keys and notes was reflected in the note change histograms for these three children.

Child Three particularly, and Child Eight to a lesser extent, used more note changes in later lessons, playing on single keys only in early lessons. This was noted in personal observation and confirmed by the histograms. Later lessons were approached more confidently and more key exploration occurred.

5.2.4 Deviation from Beat

The deviation from the beat, emitted from the computer every one or 1.5 seconds, is the average number of tenths of seconds between a beat occurrence and a child pressing a key while trying to "play with the beat". A low deviation from beat, where the child "plays with the beat" more consistently means also that the child is close to his/her own personal tempo of 1:1 second or 1:1.5 seconds. A high deviation from beat shows that the keys on the keyboard were being pressed at erratic intervals of time. It could not be assumed that the key depression, (in erratic playing), would always be before, or always after, the beat. It was therefore measured in relation to the closest beat sound (see Diagram 7).

		X^1		X^2		X^3		X^4		
Beat 1:1 secs	0		1		2	3		4		5

X = when contact with key made

X^1 relates to beat 1
X^2 " " " 2
X^3 " " " 3
X^4 " " " 4

Diagram 7. Relationship of contact to nearest beat

This basis of measurement resulted in the following measurements being computer-recorded and produced in histograms (see Table 11).

Table 11. Deviation from beat

Child	L.H.	R.H.	Preferred hand
1	0.34	0.35	R.H.
2	0.39	0.30	R.H.
3	0.35	0.38	R.H.
4	0.34	0.34	R.H.
5	0.25	0.24	R.H.
6	0.18	0.15	R.H.
7	0.35	0.35	L.H.
8	0.34	0.35	L.H.

Specific comments on individual children:

1. Most children, six of the eight, had measurements from 0.30 to 0.39. Child Five had scores of 0.25 and 0.24, and Child Six achieved the closest scores, 0.18 and 0.15. It could be considered that Child Six anticipated the beat with greater accuracy as that score was indicative of contacting the key almost at the same time as the beat sound is heard. This was confirmed by personal observation.

2. Sectional comparison in each lesson on the histograms did not reveal any particular trends (see Appendix A, Table A3).

5.2.5 Average Tempo

This measurement is the average time in seconds between keypresses from the child. Whereas deviation from the beat reflected the relationship between press contact and beat sound, this measurement is independent of beat sound. It could reflect a child's consistent anticipation of beat sound by pressing before the beat or a consistent delay of action after beat sound is heard. This may be of some significance for cerebral palsy children with neuromuscular dysfunction. Ideally the average tempo would be the same as the time between beat sounds, that is, 1.0 or 1.5 seconds, this having been established for each child as a suitable personal tempo.

Table 12. Average tempo (in secsonds)

Child	L.H.	R.H.	Hand preference	Personal tempo
One	2.85	1.91	R.H.	1:1.5
Two	1.06	0.91	R.H.	1:1
Three	1.15	0.94	R.H.	1:1
Four	1.11	1.06	R.H.	1:1.5
Five	0.91	0.81	R.H.	1:1
Six	1.34	1.28	R.H.	1:1.5
Seven	1.22	1.21	L.H.	1:1.5
Eight	0.79	0.77	L.H.	1:1.5

These results in Table 12 have some correlation with personal tempo for some children, such as Child Two, Child Three and Child Five, and could therefore indicate anticipation or delay of action. Notes on each child's playing relative to average tempo results will be in Appendix A4. It should be remembered that some children pressed more often in Section C, relating to pattern of song rather than beat; this would affect average tempo. Also, Child Eight played at a fast pace, averaging around two key contacts per beat stimulus.

Results in this average tempo section are not consistent between each child. Although for all children rankings for Sections A1, B and C were in the first three results there was also a number of A2 and A3 section rankings scattered among the first three. It must be remembered that this measurement is an average measure only, and results therefore would not show extremes of registration which could have been present.

General Comments on Average Tempo Results

1. Personal tempo for each child was established prior to the research component of this study by means of a simple drum task which was not related specifically to either hand; probably it reflected the tempo suited to the child as displayed through the preferred hand. It is interesting that these results do not give a clear-cut distinction between preferred and non-preferred hand. Apart from Child One, all children displayed a close relationship between the average tempo and personal tempo, for both hands.

2. Section rankings were established for each child from the histograms (see Appendix A4). No correspondence is apparent between deviation from beat rankings and average tempo rankings. A strong correspondence however exists between average tempo and contact ratings.

Specific Comments Relating to Children

1. Child One's results reflect a random approach to "playing with the beat", though Section B appears to provide stimulus for some action.

2. Results for Child Two give no shared trend; left hand average tempo appears to be more constant in the initiating A1 sections, whereas Section B is first ranked for right hand action.

3. Child Three has a strong Section C ranking for both hands. This preference for Section C is consistent with other results, such as contacts, for this child.

4. Right and left hand results are paralleled for Child Four. Section A has highest ranking, then Section B (beat and pitch from computer), then Section C (beat and pitch from both computer and therapist's voice).

5. Child Five's results are almost paralleled between hands, except for an interchange of order between Section B and Section A1 in the left hand becoming ordered as Section A1, then Section B, in the right hand. Section C ranks lowest. This child often sang in Section C and this personal music-making appeared to be the prime focus rather than beat matching. In no lesson was A3 marked as a preference.

6. Results for Child Six indicate homogeneity of effort; in several lessons two sections were equal in height on the histogram.

7. Child Seven's results, with highest rankings for Sections A1 and C, correlated with observed patterns of behaviour. A definite start was made to each lesson, and Section C refocused action on the keyboard.

8. Child Eight's actions, with a definite and regular start to each lesson, are reflected in Section A1 ranking, particularly for the preferred left hand. In other sections more uneven physical responses occurred.

5.2.6 Pulse (Tempo Deviation)

This measurement ignores the beat sound from the computer as a referrent and gives a measure, in seconds, of how consistently the child keeps to his/her own tempo. The histograms show the standard deviation of the tempo compared with the average tempo, for each section, lesson and overall. A pulse (tempo deviation) of zero would mean that the child kept exactly to his/her own tempo. It shows consistency on task.

Table 13. Pulse (tempo deviation) in seconds

Child	L.H.	R.H.	Hand preference
One	2.815	1.891	R.H.
Two	0.786	0.403	R.H.
Three	0.538	0.343	R.H.
Four	0.807	0.732	R.H.
Five	0.91	0.81	R.H.
Six	0.460	0.504	R.H.
Seven	1.369	1.109	L.H.
Eight	0.92	0.787	L.H.

A high pulse (tempo deviation) value signals that the child is not consistent in task behaviour. If a child with a high pulse value seems to have a more on-task result in average tempo histograms, it is important to realise that the average tempo <u>is</u> just an average, and has ignored the high and low readings. No child kept exactly to his/her own tempo. The closest to zero measurements came from least cerebral palsied limbs.

Results for Child One and Child Seven in Table 13 reflect the erratic nature of response for Child One and the marked tendency for Child Seven to cease playing unless encouraged.

Closest measurements came for preferred hand action of Child Three and Child Two. Child Six's 0.460 secs for left hand and 0.504 seconds for right hand show that this child has almost matched muscular co-ordination in each arm. Full tables are given in Appendix A5 to show section rankings.

In Appendix A6 a comparative table is given showing ranking of sections for average tempo and for pulse (tempo deviation). Comments relating to some children follow, showing some particular characteristics of rhythmic anticipation for individuals. Some definitely relate better to beat-only stimulus, others appear to be affected positively by pitch and beat stimulus in their attempts to "play with the beat".

Notes on individuals related to Table A6.

Child One Although average tempo results for right hand, 1.91, could be considered near the personal tempo ratio of 1 beat every 1.5 seconds, the high tempo deviation from zero in the pulse results confirm Child One's erratic application to task. Both average tempo and pulse rankings show B as highest achievement section. This was confirmed by observation; Child One took some time to focus on task, then played, then usually was distracted by the singing of the therapist. Results have little significance in rhythmic terms, only erratic attention has been monitored in all results. Child One was younger, and was in a unit for intellectually handicapped children.

Child Two Results here reflect observed consistent effort with both hands, with preferred right hand results showing better beat matching than left in pulse measurements. Each lateral sweep of right or left arm-hand done by Child Two in the consistent downward or upward sequencing of key-playing took more time than other between-key actions, especially for the left hand-arm sweep. This, plus the following "settling-down" contact would affect both sets of results. This child would benefit from more rhythm-based motor control work. Rankings reflect his interest in counting beats; he conveyed to the therapist by non-verbal gestures and vocalisations that he knew there were 16 counts to each section.

Child Three With little motor dysfunction, Child Three's results are consistent, and close to both the desired one beat per second for average tempo and zero for pulse. Child Three also has consistent interest in Section C, with a strong A3 section indicating a carry-over effect from Section C.

Child Four This child had more spasm and muscle tone dysfunction than others in the study. Each lesson would be undertaken with maximum concentration and effort and this is reflected in the rating preference for A1 sections for both hands in both average tempo and pulse measurements. Often C sections in later lessons were sung by Child Four as well as the therapist, so this extra input would cause uneven beat playing at times. Also a marked tendency to ask questions would interrupt the constancy of action and thus pulse results are some distance from zero. Child Four also became tired several times.

Child Five This child, with athetoid cerebral palsy, also had a marked degree of spasm and muscle tone dysfunction. Lessons were started with some consistency of beat, then abnormal reflex patterns would emerge and the action would often be continued with extra difficulty and less beat consistency. Sections A1 and B therefore received best effort, as is shown in the ranking table.

Child Six While Child Six's average tempo and pulse times were relatively close to the desired targets, ranking of sections did not seem to reflect any particular special influence on beat behaviour. From observations it was apparent that Child Six consciously tried to play evenly throughout each lesson, counting often as he did so. Whereas contact results seemed to show a preference for beat-only sections, results here for average tempo and pulse do not reflect beat behaviour related to any particular section.

Child Seven Average tempo results for Child Seven appear to be close to the desired timing. However pulse results more accurately reflect the variable nature of beat response from this child. There were frequent stops, reinforcement to continue was often needed. However C sections were responsible for more consistent playing, and this was confirmed in a later session when Child Seven told the therapist "Like you singing." The ranking table reflects this positive beat response to C sections, and early sections, in lessons.

Child Eight This child had a rapid beat action; the establishment of personal tempo originally was made on the premise that two actions per beat would be made by Child Eight. Aged five years ten months, Child Eight did appear to enjoy the task, to focus well to start and when pitch stimulus was included, but patches of non-action did occur from time to time. There was no consistent beat-based or other regular rhythmic behaviour.

5.3 PRE AND POST TEST RESULTS USING SELECTED SUBTESTS OF BRUININKS-OSERETSKY TEST OF MOTOR PROFICIENCY

Subtests seven and eight were selected for use. Their content, outlined in Appendix C1, reflected tasks similar to real-life situations related to learning, to the experimental music therapy task and to suggestions made by specialist occupational therapists and physiotherapists and educational psychologists. Specific alterations made to these subtests are also contained in Appendix C2, and these alterations were used consistently in all pre and post test situations.

Table 14. Results of pre and post tests

Time measured:		Start of study			3 wks			15 wks			18 wks		
Score in sub-test		7	8	Total	7	8	Total	7	8	Total	7	8	Total
Child	One	1	5	6	0	8	8	1	7	8	1	9	10
	Two	8	22	30	6	36	42	5	34	39	3	37	40
	Three	13	33	46	10	33	43	12	39	51	14	38	52
	Four	0	11	11	0	10	10	0	9	9	0	12	12
	Five	1	11	12	0	8	8	0	11	11	0	10	10
	Six	14	30	44	20	28	48	19	27	46	19	29	48
	Seven	4	18	22	1	16	17	5	24	29	2	22	24
	Eight	2	7	9	0	7	7	2	5	7	1	6	7

Table 14 sets out comparative results for subtests seven and eight for all children, whether Group A or Group B, over the eighteen-week period. Subtest seven, relating to visual-motor control, gave initial low scores with no score gain for six children, Child Three had higher scores but showed no consistent improvement, and Child Six improved his original score. Both Child Three and Child Six have mild cerebral palsy and are fully independent in living and learning situations. The other six children have varying degrees of physical dysfunction, and some had defective vision. Lack of experience in real-life situations would be responsible for the variation in score level between the two groups of children. The period of time over which measurements were taken was relatively short, and any improvement noted could be attributed as readily to maturation as to the effects of this study.

Upper limb speed and dexterity, measured in subtest eight, was also relative to type and degree of physical dysfunction in scoring levels achieved. The two youngest and two athetoid-tendency children formed a group of four children whose low scoring was definite and consistent, although Child One did appear to make some score gain over the total 18 week period. Child Two, Child Three and Child seven made some score gain and Child Six stayed at much the same level. Again the stability or improvement of score could be the results of maturation as well as study content.

CHAPTER 6. DISCUSSION

OUTLINE

This chapter reviews and discusses the results presented in Chapter Five and relates the findings to literature reviewed in Chapter Two. The distinctive features of this study are described with reference to the wide range of influence which led to content, method and measurement processes. Relationships between rhythm primarily, and melody, and neuromuscular function and dysfunction are explored with focus on difficulties that arise because of the nature of cerebral palsy. The role of music as an interactive therapeutic agent is included throughout the discussion, as are suggestions for theoretical and practical projections for possible future research.

6.1 DESCRIPTIVE DATA

This study, the first of its kind in New Zealand in either music therapy or music education, provides encouragement for the continued exploration of the use of music stimuli and therapy support for interventions and research involving motor control with cerebral palsied children.

A brief summary of major result findings confirms this statement:

All eight children took part readily in the required motor control task showing consistent, participatory effort and interest in each lesson. There was some evidence of differential response within lessons, with increased contacts registered in opening sections and in the two sections which contained pitch stimuli. There was strong correspondence between preferred hand/arm and better motor control in all measurements. Although comparing pulse and average tempo measurements of rhythm rate gave some evidence that a few children related more to their own personal tempo than to synchronisation with beat sound based on personal tempo, the experiment may have been too short to allow a definite trend to emerge. Least palsied limbs displayed most motor control, as could be predicted; this related directly to preferred hand/arm. Importantly though, results for average tempo showed comparable amount of effort between preferred and non-preferred limb demonstrating the value of this music therapy activity for rehearsal of a motor task.

Few research studies involving cerebral palsied children or adults and motor control have been undertaken using music as a dependent variable. Early descriptive studies referred to in Chapter Two reinforced the general value of music in cerebral palsy programmes to support physical mobility. Later studies used music as contingent reward for cerebral palsy subjects as support towards relaxation training or visual-motor sequencing. One study consciously superimposed well-known marches as rhythmic stimulation to support rehabilitation of gait disorders (Staum, 1983) and some of the subjects were cerebral palsied children.

With little suitable reference therefore from cerebral palsy study sources, it was necessary to base this study on information from wider music and motor control research. To improve any form of motor control a regular time-based rehearsal framework is supportive. Music traditionally has provided this framework of regular sound stimulus for a wide range of physical activities such as skipping games, marching and all forms of dance. In each case the physical action required becomes coincident with the regular rhythmic beat of the music. To achieve this match of effort with sound the person has to anticipate that regular musical beat (Fraisse, 1982) and does so by around 30 milliseconds (Fraisse, 1984). Conscious use and reinforcement of this anticipatory quality of music is the basis of this study to encourage children with cerebral palsy to rehearse an upper-body motor control task by "playing with the beat". Active music-making is more conducive to alteration of behaviour than passive listening (Holloway, 1980).

The element of music used to provide orderly reinforcement of effort is rhythm, and within rhythm the consistent, motivating auditory impulse was regular beat. To encourage extension of task rehearsal and physical effort it was important to use beat at a pace compatible with a motor action that the children could sustain, and that action should be functionally useful too. The children must be encouraged to use actions that avoid spasm (Bobath, 1971) by inhibiting patterns of abnormal reflex activity, yet they should not get over-tired. The use of previously determined personal tempo was important in achieving a balance of sustained effort. In the study all children sustained effort over the required time span, some more consistently than others. Three children showed signs of tiredness near the end of some lessons by making less physical effort. Two younger children, less able to keep focus on task and less able to keep to a beat, sometimes ceased regular effort towards lesson completion. This relates to Gilbert's (1981) findings which linked age-based maturation in physical development with improvement in motoric music skills.

The results for all the children with observable cerebral palsy dysfunction reflected their lack of regular experience of usual patterns of body movement in space. Because of this possibility the music task had been kept to a simple form (Moog, 1979). The three-week long experimental period was not long enough however to establish whether or not there would be permanent improvement in motor control shown by sustained or improved scores of contacts made or of matching beat-based behaviour. The three-week period was long enough to show much consistency of effort in both contact scores and beat-based behaviour.

Using a time-based framework based on the child's own tempo therefore did result in improvement in motor effort. The registration of that effort on a constructed keyboard, linked to a computer, provided both complete accuracy of measurement at the moment of physical contact on the keys and, as the experiment confirmed, a direct comparative evaluative process for each single case study. This use of a specially designed music-programmed computer was effective and a major development in objective measurement for suitable music therapy processes.

It was considered advisable however (James, 1986) to use also a pre and post test to provide a more generalised assessment setting. Two sub-tests of the Bruininks-Oseretsky Test of Motor Proficiency were used, both of which had some resemblance to the physical nature of the rhythm task planned. The selection of just two sub-tests from a full battery of motor proficiency tests was done after much consultation regarding the validity of such a procedure. A wide and fruitless search for a test suitable for cerebral palsied children had been undertaken; the decision to use the two sub-tests was made to provide a measurement process with some relevance to the motor abilities of cerebral palsied children. Pre and post test results did not provide clear-cut evidence of improvement in motor control so could not support a case for immediate referral of skills learned through a music rhythm task being transferred readily to a perceptual-motor task. The short time of the experimental period again needs to be recalled in this connection. Three weeks was not long enough. High variability of performance gave erratic results; the variable nature of the cerebral palsy condition, which is also different in degree and presentation for each individual, would explain these results over a short period of motor activity. A replication of this study should take a longer experimental time-span.

The person conducting the pre and post tests drew attention to proportionate improvement in motor control that did take place with some children. The Bruininks-Oseretsky Test battery was developed primarily around normal muscle development, not relating to neuromuscular dysfunction. In the examiner's manual for the tests it is stated that they provide a screening device for students with serious motor dysfunction and developmental handicaps so that remedial intervention can be offered. The interpretation of scores on individual subtests, while not recommended routinely, was suggested as an analysis process to help evaluate particular student performance. There is no suggestion that comparative evaluation was possible for persons with serious motor dysfunction. Though Bruininks, writing in the manual on the validity of the Test for Motor Profiency, says

> The evidence presented here must be viewed as necessarily incomplete, since additional studies are needed to delineate further the usefulness of the test with children having different types of handicaps. (p. 28.)

It does seem that further development of pre and post test measures, based on the Bruininks-Oseretsky sub-tests, would be useful for children with cerebral palsy. A separate study could be made of the protocol details needed to satisfy standardisation of assessment procedures. In turn, this would add validity to experiments in music therapy tasks such as the one presently under discussion.

Research on muscle function for people with cerebral palsy shows that they have specific problems in suppression of involuntary muscle activity and regulation of tonic stretch reflexes. Reduction of spasm and muscle tone is an important component in therapy for cerebral palsy (Neilson and McCaughey, 1982; Scartelli, 1982; Safranek, Koshland and Raymond, 1982). In the latter study, even rhythm changed the electromyogram patterns of two antagonist muscles. This could be the appropriate physiological explanation for the effort observed in the present study of regular rhythm on muscle tone. With neurological function impaired to a lesser or greater degree among the eight children studied, the organisation of motor response needed extra stimulus and support provided by auditory rhythm in the form of beat sound based temporally on a self-determined personal tempo. Scartelli's (1982) advocacy of relaxation training, with sedative music, to educate or re-educate cerebral palsy muscle tissue also supports the use of personal tempo and, as well, constant musical and non-musical behaviour from the therapist.

6.2 RHYTHM, MEASUREMENT, AND SENSORY INTEGRATION

In charting a new experiment through developing areas of musical knowledge it is important to base directions on well-founded and affirmed theories and practice. Three areas of music-related theory and research have special relevance to this study: the work done on rhythm in the last twenty years, developing interest in processes of objective measurement of behaviours influenced by music and music application of theories of sensory integration.

Rhythm perception has been studied most intensively by Fraisse (1982) who drew research attention to the principle of rhythmic anticipation of motor behaviour. In 1966 he established that the anticipation of a tap or beat to sound occurs very quickly, from the third beat or pattern onwards when synchronisation then occurs. This rapid assimilation of beat impulse was apparent in the present results; all children were physically active in the first section of the first lesson and most were able to produce a contact action that tried to synchronise with the first beat after a four-beat introduction. Younger children need more time to process temporal information (Morongiello, Kulig and Clifton, 1984) and two younger children reflected lesser ability to follow the required instructions with appropriate motor action. That they did play the keyboard at all, and that the other children contributed as well as they did, reflects their affective interest in the task. Nelson (1983) reminds us that affective readiness, as well as cognitive readiness, is important for effective learning processes involving music. Also something of what Berlyne (in Spender and Shuter-Dyson, 1981) calls 'arousal potential' has been activated by a beat task such as this. Several children's verbal and non-verbal communications with the therapist confirmed that this 'arousal potential' was present; they questioned or commented about the beat, the singing component, the computer (both as a sound source and a measurement device) and they talked about their own keyboard performance and 'their beat' in the computer. This ready interest could be the basis for more music-based diagnostic assessment of motor function. Maranto, Decuir and Humphrey (1984) suggested that musical rather than verbal stimuli could be used to assess auditory memory by use of rhythm span scores. In a comparable way the assessment of improved motor function is possible (over a longer period than three weeks), by use of a music-based task measured accurately and immediately by computer. This would go some way towards supporting Sutton's (1984) statement:

> A reliable, valid, easily administered method of recording gross and fine movements used in instrumental performance could be helpful to music therapists using musical instruments to facilitate physical rehabilitation in a variety of settings. (p. 162.)

Time-based behaviour then has a continuum of awareness built in when there is constant auditory stimulus, which provides immediate feedback to the person creating or interacting with the constant sound source.

Measurement processes for music and motor control are not plentiful. Sutton's (1984) Music Therapy Physiological Measures Test used elemental motion, recording it in kinaesthetic terminology. It aimed to objectify rhythmic accuracy, which has been traditionally a subjective judgement. This aim could be supported, as here, by computer-based registration of rhythmic contact. Gilbert's (1981) Motoric Music Skills Test for young children aged three to six years, contained 44 tests similar to the Bruininks-Oseretsky subtests used here as pre and post tests. Such detailed definition of test content, in itself, provides an objective look at music therapy procedures. This emphasis is critical to the acceptance of music therapy as a behavioural science.

Madsen (1981) set out four principles of behaviour modification for music therapy use which can be related to this attempt to influence motor control behaviour in cerebral palsied children. First, Madsen suggested that the behaviour to be eliminated is pinpointed and skills and behaviours arranged hierarchically, based on specific behavioural objectives. Then specific behaviours are listed as they happen. Thirdly, contingencies are set up, (such as personal responses from the therapist), and reinforcers; Madsen used the term consequating for this behaviour. Finally, provide continuous evaluation. Madsen pointed out that ultimate effects may be different from immediate effects; evaluation must be allowed to operate for some time before final data analysis can be done.

This study shows some relationship with Madsen's four principles. First, the pinpointed behaviour to be eliminated was unwanted upper-arm motor reflexes so that regular contact could be made with the keyboard. Arrangement of skills was organised carefully; pace was self-determined by using personal tempo and the beat-matching task required a functional down and up arm-hand action. Computer recording was immediate and accurate, of contacts made, note duration, notes used and beat-matching skills. Consequating behaviour from the therapist however was restricted. None of Madsen's suggested contingencies could be used during the recording of the session. Afterwards the therapist could interact in very general terms only. A few reinforcers were available during the session; these included the therapist's consistent directive behaviour to the child and the vocal music component in Section C, and the use of attractive involvement objects, the keyboard and the computer. Continuous evaluation was provided by means of information first stored on computer disk then produced on print-out information and graphs. It was most evident that the time-span used for the experiment was too short for what Madsen calls 'ultimate effect'. Considering the neuromuscular difficulties associated with cerebral palsy it would be more effective to use a much longer period than three weeks. This would be more appropriate and realistic for many children to register consistent improvement in motor control.

The value decision to use music as an intervention process therefore is not challenged in the above framework. What can emerge however is the possibility of a negative value choice to exclude certain usually expected therapy behaviours. On the other hand, strict control of therapy behaviour does allow the music content itself to be seen as the major modifying influence on behaviour.

The present study, requiring a particular response of 'playing with the beat', does not use conventional behaviour modification techniques where it might have been expected that addition or removal of music elements would be used, solely as positive or negative reinforcements. There is more to music therapy than simply the presence or absence of music content, even though that presence or absence has been shown to have an effect on learning (Miller, 1976; Madsen, 1981). First, music is a complex entity, and certain interactive therapy environments demand a focus on individual elements of music either singly or in planned groupings. The effect of music therapy depends partly on the emphasis given to rhythm, melody, harmony, texture or dynamics, also on the particular musical structure into which these elements are placed. Secondly, all music causes some effect on the listener or participant, which then is reflected in the response or initiative taken by that listener or participant. This affective power of music alters the original environment and creates a new one, and so the process goes on. Nelson (1983) wrote about the cognitive-affective dualism of music. Other writers have discussed the emotional experience of music, for untrained listeners, as a means by which emotional experiences can be transferred; this is part of the function of musical structure (Nielzén and Cesarec, 1982). The balance of perceptual cognitive, affective and structural content must be recognised in music therapy; this goes a great deal further than reference to one behavioural style. Music therapy has to be eclectic, using what is appropriate for the situation.

The music focus of the present study was rhythm, with less emphasis on melody and texture. The sound of the beat was always there. Pitch was possible in the music continuum in two lesson sections dependent upon its activation by the child. In one sense the tactile keyboard contact made in Sections B and C was rewarded by an aural pitch sensation but the responsibility for that pitch inclusion resided with the child's own decision to make contact.

This self-controlled aural stimulus of pitch added to the sensory dimension of the contact task; it could be said to enhance the effort to suppress unwanted spasm and muscle tone and allow arm-hand movements through space to touch and release keys to fulfil the 'playing with the beat' task. James (1984) advocated a sensory integration approach for much music therapy, arguing that an approach that aims solely for the exact skill missing from the client's repertoire operates often at the cortical level of neurological function. The client may not be ready for this; motor and cognitive abilities follow a developmental sequence and certain prerequisite abilities may not have been fully integrated. Shift in focus from the specific skill required to a more general mix of vestibular, tactile, proprioceptive, visual and aural stimuli leads the therapeutic intervention to neurological function at the subcortical level where appropriate learning can be catalysed.

Whether one accepts James' (1984) identification of brain area for particular function or not, certainly his sensory integration theory matches promising music therapy work and cognitive writing in the Piagetian mould from Rider (1981), Serafine (1983) and Zimmerman (1984). Fraisse (1984) believes that the emergence of the cognitive approach in psychological research of the last two decades has encouraged the re-examination of many aspects of human experience, including that of perception of time. He now states that perception of both duration and succession of sounds is present very early in life, but that their joint functioning is not acquired until seven or eight years, "when the child first becomes capable of logical thinking" (p. 3). Although concern for duration and succession of sound is a much more refined perceptual area than dealt with here, the principle of developmental readiness for time-based perception is clear.

A new study by James (1986) incorporating sensory integration theory and proprioceptive neuromuscular facilitation is based on a cerebral palsy young adult and affirms the useful parameters of sensory integration, using as full a range of sensory stimuli as is both possible and suitable. This multi-faceted approach to cerebral palsy treatment reaffirms Bobath's (1971) approach which advocates facilitation of innate normal basic motor patterns in a planned team approach so that the same goals can be targeted through several treatment modalities. Bobath stressed the need to treat developmental and neurological deficit together.

6.3 RELATIONSHIPS BETWEEN RESULTS AND CURRENT THEORIES AND PRACTICE

In Chapter Five, three questions were asked to provide an evaluative base for data about contacts made, note duration, note change, deviation from beat, average tempo and pulse, these being the six thematic result groups.

The first question sought to establish the capacity of each child to stay on task for total lesson time, or to identify marked decrease in physical action in latter sections of the lesson. Secondly, was there equal response in each of the five lesson sections? Or any follow-up effect in follow-on sections? The third question asked for identification of response from results and from observations made at the same time as results were being recorded. Also, although each of the eight children provided a single case study,were there any general observations that could be made for all children?

That the children stayed on task, shown by contact histograms, makes this type of music task a positive one for rehearsal of motor control for upper limbs for cerebral palsied children. It could be used for lower limbs as well. While most lower limb motor control rehearsal involves walking, as in Staum's (1983) work on gait rehabilitation, there may be need for more non-locomotor exercises for palsied legs. The keyboard and computer equipment could be used for foot contact action 'playing with the beat'.

Most of the children in the study did perform the arm-hand actions of 'playing with the beat' with some consistency. Also in contact results, it is of note that C sections always ranked higher than A2 sections which preceded them; in other words there was resurgence of interest in making contacts with the keyboard near the end of the lesson when melody from the therapist's voice plus self-activated pitch from the keyboard computer source came into action. The children were thus motivated to increase physical action in the later Section C. Each of the five sections of a lesson did not elicit the same contact activity. Results for preferred, non-preferred and right hand showed highest number of contacts in C sections. The other pitch-based section, Section B, was ranked second twice, and third once, in the same three groupings of preferred, non-preferred and right hand contact results.

This pitch emphasis in results is interesting in the light of studies done on the effect of melody on rhythmic processing. Sink (1984) found difference in effect; for some children rhythmic processing was not affected when patterns were presented in single-tone or melodic-rhythmic context; for others pitch inclusion did affect their perception of rhythm. Sink quotes a 1966 study of Petzold (in Sink, 1984) who found children could perform patterns when melody and rhythm were presented together. But Gabrielsson (in Sink, 1984) found it was difficult to concentrate on rhythmic information amidst melodic information. Moog (1979) provided the best basis for relevant discussion to this question. Working with three groups of children and rhythmic processing tasks, he found that children of low intelligence welcomed pitch with rhythm in perception of rhythm tasks as did, to a lesser degree, non-handicapped children. But a large part of the rhythm perception tasks was less successfully accomplished if these were constructed with melody, and physically handicapped children showed the least increase of effectiveness in rhythmic perception in such circumstances. Moog pointed out that physically handicapped children, also some non-handicapped children, made the melodic input the prime focus of experience and disregarded the rhythm perception tasks. Also limitations in movement since early childhood reduced perception of rhythmic forms and physically handicapped children lacked this movement experience.

Moog's tasks were based on listening to aural stimuli where "same" and "different" judgements on paired exercises were executed by non-verbal raising of different cards. This rhythmic processing requirement was a totally different task from that required from each cerebral palsied child in this study. Instead of processing rhythm in a same/different immediate recognition parameter, each child was given a participatory perceptual-motor task which continued over a period of time. Different stimuli content were introduced during this time span demanding new cognitive understandings of the required task. First, in matching contracting and relaxing muscle action to beat stimulus to play with the beat, one learning pattern was established. When key contact occurred in Section B, pitch sound was released to join beat sound and a new learning pattern had to be developed. A return to the first learning pattern preceded Section C where, with extra voice stimulus added, a third learning task was undertaken. With melody attracting attention (Moog, 1979) and a reinforcing on-task message being conveyed by means of sung words, it is to be expected that more response activity could take place. This response activity is motoric in action, but cognitive in style, therefore relating to a certain developmental level.

Moog (1984), looking at music learning, put elements of music in a hierarchy first assessed through a single sound which is non-relational and has timbre, duration, volume and dynamics. Then comes rhythm, which is relational because of its temporal quality; there cannot be rhythm until several sounds relate to one another in succession through time. Melody is the next learned element, relational to rhythm and being a succession of single sounds. All relational elements of music can only be learned cognitively. Another important learning quality of music is the fact that relational sound is always present, giving a form of learning that does not demand abstraction. Other forms of learning for children start with concrete experiences with objects, then the concept to be learned is abstracted apart from the physical objects. Music however is always <u>there</u>. One can talk about music in an abstract way and remember music in one's mind, but sounds exist and relate to one another in their own right through time. As each musical element relates to one another the musical event becomes more complex.

In summary, regarding the first group of results relating to contact performance, the initiating Section A1 was always in the first three rankings. The initial impact of beat sound was an effective stimulus for each child to start rehearsing a motor action. Impetus to continue with that motor action was strengthened by pitch stimulus inclusion in Sections B and C. Beat and pitch together were definite reinforcers for physical and intellectual development of cerebral palsied children in a motor control task that had several learning components. Interest, or affective readiness, was also essential for continuance of the learning task.

Other thematic results, besides contact, can be divided into two areas of discussion. Average note duration and note change could be considered together and the three histogram groups of deviation from beat, average tempo and pulse (tempo deviation) can be discussed in a complementary way.

Average note duration is a second measure that could be used in comparative evaluation of muscle control in cerebral palsy. Work on micro-structure of tapping movements in children (Schellekens, Kalverboer and Scholten, 1984) shows two control processes in goal-directed movements. First, there is a rapid movement through distance that is not as accurate as the second homing sequence of fine motor adjustments under visual control. The present study task therefore would be valuable for cerebral palsied children, especially those with visual handicap, to rehearse such movements in a structure that gives aural feedback for continued effort; pitch sound identifies a target 'hit' and pitch change available encourages target 'release'. The average note duration could be used to monitor the efficiency of contact-release by flexor and extensor muscle activity. It was noted that six of the eight children studied registered longer average note duration with their preferred hand which had more control over contact-release action. Self-regulation of spasm and muscle tone in cerebral palsy can be achieved for young adult cerebral palsied subjects by experimental reflex training (Neilson and McCaughey, 1982) where favourite music is activated on achievement of the set goal. Younger children respond better to less verbally-directed procedures; they may not have had enough music listening experience upon which to base favourite choice, and they could be motivated more effectively by a tactile, involvement process such as offered in the present experiment. Staging of learning tasks referred to previously, immediate feedback of self-activated pitch, and melodic song reinforcement are strong arguments for suggesting that the motor and music task is developmentally and neurologically suitable. Note duration therefore would provide a comparative measure that can be extracted immediately and accurately by computer over a period of time.

As with average note duration, note change was effected more with preferred hand than non-preferred hand for all eight children. Some children began a regular up-and-down movement sequence along the keyboard in their motor response, with both hands. The lateral left-to-right and right-to-left movements provided good self-directed exercise which may have been stimulated by the note change effect. Five different pitches which, by the nature of the pentatonic scale, together in sequence became a close-interval melody, thus provided a simple melodic stimulus for such physical effort. As Moog (1979) pointed out, pitch commands attention. The implications of this for controlled exercise programmes for cerebral palsied subjects are considerable. This study, based on music precepts, presented a large-scale keyboard left-to-right parameter for movement. Safranek, Koshland and Raymond (1982) used a triangle of targets which, when touched, registered electromyogram measurements. The use of different shape arrangements of contact keys which could emit beat and pitch sound and have computer-registration of touch, would provide a useful resource for all therapists concerned with improvement in motor control for cerebral palsied subjects. For children, something of a 'game' concept can be reinforced too. It was noticeable that several children were aware and interested in the therapist's use of the same pitch in song as was being produced by their choice of key contact in Section C of lessons. This conscious use of play is a component of importance in interaction between therapists and children.

The three measures relating particularly to regular time-based motor actions, deviation from beat, average tempo and pulse (tempo deviation), were all necessary in an exploratory study into the effect of rhythm on motor control of cerebral palsied children.

Deviation from beat was not a measure of much comparative use in this short study; it may well be of value over a much longer period of experimental time. The results showed that only one child, one with least dysfunction, had results that were close to the zero score, thus 'playing with the beat' to near personal tempo. The others, to a lesser or greater degree relating to limb dysfunction, could not anticipate the beat regularly and their contact action was not consistent. This measure would be a useful one to use with non-handicapped children and this is an important area of study to be suggested. Not only would such a study provide a needed base for comparison between normal function and dysfunction in motor control, but also it could establish whether or not there was a change in regularity of contact between beat stimulus alone and beat plus melody stimulus together. Such a study would explore the effectiveness of motoric and music ingredients in a well-controlled experimental environment.

As explained in the result section, average tempo measurements were taken to see whether or not cerebral palsied children had consistent anticipation or delay between receiving a neurological stimulus signal and actually making the physical contact. If average tempo time came close to personal tempo time then the child was making a consistent press contact on the keys independent of the beat sound stimulus therefore playing ahead or behind that beat stimulus in a regular way. Fraisse (1984) pointed out that foot tapping to a simple repetitive auditory rhythm takes 20 milliseconds longer than hand-tapping which anticipates the sound by 30 milliseconds. If neuro-muscular messages take longer to reach the feet than the hands and normal hand action is ahead of beat stimulus, it would seem possible that impaired neuromuscular function would result in delay of transmission of movement messages from brain to upper limb and that the delay would not be consistent where abnormal reflex muscle tone interfered with the message. For some children the insertion of song pattern caused extra key presses in some C sections. This was not a common occurrence and the therapist became aware of its effect early in the experiment and tried to avoid patterned song. It could affect average tempo results and future replicated studies looking solely at regularity measures would be advised to use single-syllable song words, one syllable per beat. Although the song patterns positively supported extra regular contact on the keyboard, they could influence, negatively, beat-based measurements. Also, from the results, it did seem that some children kept to a beat-based task more readily when beat stimulus was the only stimulus.

The final thematic category, pulse (tempo deviation), when compared with the previous average tempo results, revealed those children who were on task consistently from those who were not. Some took long pauses, became tired and played sporadically near the end of a lesson, or played with erratic pace, particularly with the non-preferred hand. Unlike average tempo, which averaged out extreme high or low measurements, pulse or tempo deviation measures were based on the child's own tempo. This gave the most useful measure of time-based behaviour for those children whose general consistency was interrupted by some patches of erratic muscle reflex action or by lack of focus on the beat-based task. Children with less dysfunction gave results in pulse measurements that were relatively consistent with results in the average tempo measures. These children therefore could well be measured by either average tempo or deviation from beat measures as their neurological anticipation of beat and physical contact on keyboard with beat would be more regular.

6.4 FINAL SUMMARY AND IMPLICATIONS

A case-study approach acknowledges individual difference. The eight cerebral palsied children in this study differed in sensori-motor organisational ability, conceptualisation of spatial and sequential factors, ability to integrate sensory messages and perceptual-motor response and hence capacity to learn cognitively. The rhythm-based task accommodated to many of these differences because of the way it was planned and structured. Basing pace on personal tempo removed many potential problems of tension resulting in spasm and abnormal muscle tone. Keeping lessons short, and sections within lessons to a 16-count length, both gave a supportive, consistent time-frame and also short enough time to prevent habituation to the beat stimulus. The novelty effect of pitch inclusion along the interrupted time series framework also supported continuation of effort. Each lesson was long enough to allow inhibition of unwanted muscle tone in a relaxed environment, and therefore support rehearsal of a functional upper limb motor control action. Certainly the melodic component encouraged more physical action, although it was, for most children, an attention focus which detracted from rhythm-based measures. That is not to say that, as more rehearsals took place, the melody component would not become a familiar and reinforcing component, because it was definitely a component of interest to the children. Once the novelty effect of melody receded, the insertion of a second music stimulus could be a strong motivator towards sustaining of motor effort.

The time-frame of this experiment was too short to establish a realistic comparative measurement base for children with motor dysfunction. Cerebral palsied children lack early motoric and proprioceptive experience, and consequently require rehearsal of motor control over a longer period of time than for children with no neuromuscular dysfunction. Enough positive results were recorded however to encourage replication of this study, over a longer period, with the refinements suggested. The use of a music-programmed computer was also a significant factor in obtaining objective and accurate measurements. Computer measurement reinforces the acceptance of music therapy processes which take place in as interactive an environment as is possible within the restrictions necessarily imposed by scientific research on behaviour change.

The music content in this study encouraged learning by providing as full an aural stimulus as possible having regard to the developmental level of the children. Rhythm had a vital and stimulating role in ordering the perception of real time through motor action. Melody, which is a higher relational sound element, enhanced the sound spectrum as a second music stimulus, and encouraged continued motor effort. Using music in as full a manner as possible, in the particular environment of cerebral palsied children, reinforced the holistic concept of addressing perceived need through a wide range of sensory experiences.

The study supported the development of functional motor skills through time-based rehearsal with music stimuli, using music therapy processes to implement and encourage the activity.

APPENDIX A. SUPPLEMENTARY TABLES

A1. Contact rankings

The following tables were assembled from contact histograms showing sectional ranking of contacts made within each lesson. Where several sections had the same histogram level (i.e., the same number of contacts) each section was included in the contact ranking. Totals over 10 lessons then, could register a contact ranking total greater than 10 where this occurred.

Table A1. Sections with greatest number of contacts and personal ranking for each child.

Lesson:		1	2	3	4	5	6	7	8	9	10
Child One	L.H.	B	A3	A1	A1	B	B	B	A2	A2	B
	R.H.	A3	A2	A1	B	C	B	B	B	B	B

Contact ranking:

L.H. B=5, A2=2, A1=2, A3=1

R.H. B=6, A2=2, A1=1, C=1

Lesson:		1	2	3	4	5	6	7	8	9	10
Child Two	L.H.	A1	A1	C	B	A1	A1	B	A1	A3	A2
	R.H.	A3	BA2C	C	A2	BC	B	C	B	A1	A2

Contact ranking:

L.H. A1=5, B=2, A2=1, C=1, A3=1

R.H. B=4, C=4, A2=3, A3=1, A1=1

Lesson:		1	2	3	4	5	6	7	8	9	10
Child Three	L.H.	C	A3	A2	C	A3	A3	C	C	C	A3
	R.H.	C	C	C	C	C	C	B	C	C	C

Contact ranking:

L.H. C=5, A3=4, A2=1

R.H. C=9, B=1

Lesson:	1	2	3	4	5	6	7	8	9	10
Child Four L.H.	B	A1B	A3	A1	C	C	A1	C	A1	B
R.H.	A1	B	B	A1	A3	A1B	A3	A1	C	B

Contact ranking:

L.H. A1=4, C=3, B=3, A3=1

R.H. A1=4, B=4, A3=2, C=1

Lesson:	1	2	3	4	5	6	7	8	9	10
Child Five L.H.	A1	A3	B	C	A3	B	B	BC	B	C
R.H.	C	A1	A2	A1	A1	A2	A1	C	B	B

Contact ranking:

L.H. B=5, C=3, A3=2, A1=1

R.H. A1=4, B=2, A2=2, C=2

Lesson:	1	2	3	4	5	6	7	8	9	10
Child Six L.H.	C	B	B	A3	B	CA3	A1A2A3	A1	A3	C
R.H.	C	C	B	A2	A1C	A2	A1A2CA3	A2	A1A2C	A2

Contact ranking:

L.H. A3=4, C=3, B=3, A1=2, A2=1

R.H. A2=6, C=5, A1=3, B=1, A3=1

Lesson:	1	2	3	4	5	6	7	8	9	10
Child Seven L.H.	C	A1C	A1	A1	C	A1C	C	B	A1	C
R.H.	A1C	A1	A1	C	A2	C	C	A1	C	B

Contact ranking:

L.H. C=6, A1=5, B=1

R.H. C=5, A1=4, A2=1, B=1

Lesson:		1	2	3	4	5	6	7	8	9	10
Child Eight	L.H.	B	A1	A1	B	B	A2	A1	A1	A1	A1
	R.H.	A2	A1	A1	B	C	A1	BA2	A2	C	A2

Contact ranking:

L.H. A1=6, B=3, A2=1

R.H. A2=4, A1=3, C=2, B=2

Table A2. Average note duration preference within lesson sections for Child Six

Left hand:

Lesson	Order of note duration/section	Rating scale
1	B A1 A2 A3 C	
2	A3 A1 B C A2	A1 = 4+4+5+3+4+4+4+3+5+4 = 40
3	A1 A3 A2 B C	B = 5+3+2+3+2+3+2+1+3+2 = 26
4	C A2 A1B A3	A2 = 3+1+3+4+3+4+5+4+4+5 = 35
5	A3 A1 A2 B C	C = 1+2+1+5+1+2+1+2+3+1 = 19
6	A3 A1A2 B C	A3 = 2+5+4+2+5+5+3+5+2+3 = 36
7	A2 A1 A3 B C	
8	A3 A2 A1 C B	A1 > A3 > A2 > B > C
9	A1 A2 BC A3	
10	A2 A1 A3 B C	

Right hand:

Lesson	Order of note duration/section	Rating scale
1	A3 A1 C A2 B	
2	A1 BA3 C A2	A1 = 4+5+3+2+2+4+4+4+5+3 = 36
3	A3 A2 A1 C B	B = 1+4+1+3+1+1+1+1+3+2 = 18
4	C A3 B A1 A2	A2 = 2+1+3+1+5+2+5+2+2+1 = 24
5	A2 A3 C A1 B	C = 3+3+2+5+3+3+2+3+1+4 = 29
6	A3 A1 C A2 B	A3 = 5+4+5+4+4+5+3+5+4+5 = 44
7	A2 A1 A3 C B	
8	A3 A1 C A2 B	A3 > A1 > C > A2 > B
9	A1 A3 B A2 C	
10	A3 C A1 B A2	

Table A3. Deviation from beat section rankings

Note: Where no bar is present on the histogram, a check was made on contact histogram. If no contact was registered, on this measurement the lowest bar present was used.

Child One. Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	B	A2	A2	C	B	A1	A1	B	C	A2
R.H.	B	A3	A2	C	A3	A1	C	B	C	A2

Ranking:

L.H. B=3, A2=3, A1=2, C=2

R.H. C=3, B=2, A2=2, A3=2, A1=1

Child Two. Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	A2	A2	A1	C	B	A1	A3	A2	A2	A2A3
R.H.	A2	A2	A1	A3	C	C	A3	A1	A1	A2

Ranking:

L.H. A2=5, A1=2, A3=2, B=1, C=1

R.H. A1=3, A2=3, C=2, A3=2

Child Three Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	C	C	A2	B	A1	B	A2	A1	B	A1
R.H.	C	B	A3	A2	B	A3	C	B	A2	C

Ranking:

L.H. A1=3, B=3, A2=2, C=2

R.H. B=3, C=3, A2=2, A3=2

Child Four. Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	B	A3	A3	A3	A2	CA3	A3	A3	A3	A3
R.H.	A1	A2	C	A3	B	C	A2	A1	A1A2	A1

Ranking:

L.H. A3=8, B=1, A2=1, C=1

R.H. A1=4, A2=3, C=2, B=1, A3=1

Child Five. Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	A1	A2C	C	A3	A3	A1	A1	A2	C	A2
R.H.	A1	B	A1	A3	C	A1	B	A2	B	A1

Ranking:

L.H. A1=3, A2=3, C=3, A3=2

R.H. A1=4, B=3, A2=1, C=1, A3=1

Child Six. Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	A1A3	A1	A1	A1	A1	A1	A1A3	A1A2	A1	A1A2
R.H.	A1	A1	A1	A1	A3	C	A3	A3	A1A3	A1

Ranking:

L.H. A1=10, A2=2, A3=2

R.H. A1=6, A3=4, C=1

Child Seven Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	A2	C	A1A2	C	A3	A1	C	A2	B	A1
R.H.	A1	A1	S1	A1	C	A1A2	A2	B	A2	A3

Ranking:

L.H. A1=3, A2=3, C=3, B=1, A3=1

R.H. A1=5, A2=3, B=1, C=1, A3=1

Child Eight Lesson:	1	2	3	4	5	6	7	8	9	10
L.H.	C	C	A3	C	C	C	C	A2	A2	A1A2C
R.H.	B	A2	A3	A1	A2	A1	A2	A1C	A3	A2C

Ranking:

L.H. C=6, A2=3, A1=1, A3=1

R.H. A2=4, A1=3, C=2, A3=2, B=1

Table A4. Average tempo - section rankings (taking lowest bar on histogram as comparative measure) over 10 lessons

Child One

L.H.	A1	A3	A1	B	B	A2	B	A2	A2	B
R.H.	A2A3	A2	A1	B	C	B	B	B	B	B

Rankings:

L.H. B=4, A2=3, A1=2, A3=1

R.H. B=6, A2=2, A1=1, A3=1, C=1

Child Two

L.H.	A1	A1	C	A1	A1	A1	A3	A1	A1	A3
R.H.	A3	B	C	C	B	B	A2	B	A1	A2

Rankings:

L.H. A1=7, A3=2, C=1

R.H. B=4, A2=2, C=2, A1=1, A3=1

Child Three

L.H.	C	A3	A2	C	A3	A3	C	A1	C	C
R.H.	C	C	C	C	C	C	B	C	C	C

Rankings:

L.H. C=5, A3=3, A1=1, A2=1

R.H. C=9, B=1

Child Four

L.H.	B	A1	A3	A1	C	A2	A1	C	A1	B
R.H.	A1	B	B	C	A2	A1B	A3	A1	C	A1B

Rankings:

L.H. A1=4, B=2, C=2, A2=1, A3=1

R.H. A1=4, B=4, C=2, A2=1, A3=1

Child Five

L.H.	A1	A2	A1	A1	C	B	B	B	BA2	C
R.H.	BC	A1	BA2	A1	A1	A2	A1	C	B	B

Rankings:

L.H. B=4, A1=3, A2=2, C=2

R.H. A1=4, B=4, A2=2, C=2

Child Six

L.H.	C	B	B	A1A3	BC	BA3	A2	A1	A3	C
R.H.	A1C	A2C	B	A2	A1	A2	A1A3	A2	C	A2

Rankings:

L.H. B=4, C=3, A3=3, A1=2, A2=1

R.H. A2=5, A1=3, C=3, B=1, A3=1

Child Seven

L.H.	C	A1	A1	A1C	A2	C	A1	A2	C	C
R.H.	A3	A1	A1	C	A2	C	A1	A1	C	B

Rankings:

L.H. C=5, A1=4, A2=2

R.H. A1=4, C=3, B=1, A2=1, A3=1

Child Eight

L.H.	B	A1	A1	B	B	A2	A1	A1	A1	A1
R.H.	A2	A1	A1	B	C	A1	B	A3	A3	A3

Rankings:

L.H. A1=6, B=3, A2=1

R.H. A1=3, A3=3, B=2, A2=1, C=1

Table A5. Pulse (tempo deviation) section rankings

<u>Child One</u>

L.H.	A1	A3	C	B	B	A2	B	A2	A3	B
R.H.	A3	A2	A1	B	A1	B	B	B	C	

Rankings:

L.H. B=4, A2=2, A3=2, A1=1, C=1

R.H. B=4, A1=2, C=2, A2=1, A3=1

<u>Child Two</u>

L.H.	A1	A1	C	A1A2	B	C	B	A2	A1	A3
R.H.	A2	A1	C	A3	A2	C	A3	A2	C	A1

Rankings:

L.H. A1=4, B=2, A2=2, C=2, A3=1

R.H. A2=3, C=3, A1=2, A3=2

<u>Child Three</u>:

L.H.	A2C	C	A2	A3	A3	A3	C	A1	A2C	B
R.H.	A3	A3	A1	A2	A3	A1	A3	A3	A2	C

Rankings:

L.H. C=4, A3=3, A2=3, A1=1, B=1

R.H. A3=5, A1=2, A2=1, C=1

<u>Child Four</u>

L.H.	C	C	A1	A1	B	A1	C	B	A1	A1
R.H.	A1	A3	B	A1	A2	A2	A1	B	A3	B

Rankings:

L.H. A1=5, C=3, B=2

R.H. A1=3, B=3, A2=2, A3=2

Child Five

L.H.	A1	A2	A1	A3	A1	A1	B	B	B	C
R.H.	B	A1	B	B	A2	A1	A1	A3	B	A1

Rankings:

L.H. A1=4, B=3, A2=1, C=1, A3=1

R.H. A1=4, B=4, A2=1, A3=1

Child Six

L.H.	A1	C	A1	B	A3	A2	A1	A2	B	BA2
R.H.	A1	A1	A3	A1	A3	A1	A1	A3	A3	A3

Rankings:

L.H. A1=3, B=3, A2=3, C=1, A3=1

R.H. A1=5, A3=5

Child Seven

L.H.	C	A1	A1	C	A2	B	C	B	A1	C
R.H.	A3	A1	C	C	B	C	A1	B	B	A2

Rankings:

L.H. C=4, A1=3, B=2, A2=1

R.H. B=3, C=3, A1=2, A2=1, A3=1

Child Eight

L.H.	A3	A1	A1	B	B	A2	A1C	A3	C	A1
R.H.	C	A1	A1	B	C	A2	B	A3	C	C

Rankings:

L.H. A1=4, B=2, C=2, A3=2, A2=1

R.H. C=4, A1=2, B=2, A2=1

Table A6. Average tempo and pulse (tempo deviation) - comparison of section rankings

Child		Average tempo	Pulse
One	L.H.	B A2 A1 A3	B A2 A3 A1 C
	R.H.	B A2 A1 A3 C	B A1 C A2 A3
Two	L.H.	A1 A3 C	A1 B A2 C A3
	R.H.	B A2 C A1 A3	A2 C A1 A3
Three	L.H.	C A3 A1 A2	C A3 A2 A1 B
	R.H.	C B	A3 A1 A2 C
Four	L.H.	A1 B C A2 A3	A1 C B
	R.H.	A1 B C A2 A3	A1 B A2 A3
Five	L.H.	B A1 A2 C	A1 B A2 C A3
	R.H.	A1 B A2 C	A1 B A2 A3
Six	L.H.	B C A3 A1 A2	A1 B A2 C A3
	R.H.	A2 A1 C B A3	A1 A3
Seven	L.H.	C A1 A2	C A1 B A2
	R.H.	A1 C B A2 A3	B C A1 A2 A3
Eight	L.H.	A1 B A2	A1 B C A3 A2
	R.H.	A1 A3 B A2 C	C A1 B A2

Table comparing average tempo and pulse (in seconds)

Child	Average tempo L.H.	R.H.	Personal tempo	Pulse L.H.	R.H.	Hand preference
One	2.85	1.91	1:1.5	2.815	1.891	R.H.
Two	1.06	0.91	1:1	0.786	0.403	R.H.
Three	1.15	0.94	1:1	0.538	0.343	R.H.
Four	1.11	1.06	1:1.5	0.807	0.732	R.H.
Five	0.91	0.81	1:1	0.91	0.81	R.H.
Six	1.34	1.28	1:1.5	0.460	0.504	R.H.
Seven	1.22	1.21	1:1.5	1.369	1.109	L.H.
Eight	0.79	0.77	1:1.5	0.92	0.787	L.H.

In the above tables, average tempo ideally could be the same as the time between beat sounds, that is the same as personal tempo. A pulse (tempo deviation) of zero would show that the child kept exactly to his/her own tempo.

APPENDIX B. NOTES ON INDIVIDUAL CHILDREN

B1. Contact response.

Child One — This child's motor response did not appear to be influenced by the beat and was inconsistent and erratic. The results showed more contact in Section B of lessons; there the child's actions on the keyboard resulted in pitch sound being emitted from the computer which could have prompted more task focus. This child gazed open-mouthed at the therapist when singing was added in Section C, and this reaction is reflected in the results. Child One was eight years.

Child Two — This child stayed on task throughout each lesson and from the end of the first lesson developed a particular style of hand-arm movement sweeping down the keys on the keyboard with right hand action and upward with left hand action. More contacts were made by the preferred right arm. The non-preferred left arm was inclined to spasm as each lesson progressed and there was uneven contact control after the opening Section A1. The preferred right hand made most contacts in Sections B and C, and the histogram shows more even contacts with that right side action.

Child Three — The vocal pitch input in Section C was of great interest to this child; this is reflected in the results. If the therapist sang two-syllable words, relating to name and action occurring, then the child would sometimes match contacts with this pattern rather than with the beat. This contributed to the high ranking for Section C.

Child Four — At school this child is instructed to use both hands for typewriting; this could explain the difficulty displayed in keeping to the lesson requirement of one hand only per lesson. Novel exploration of the keyboard occurred, with a finger 'over and over' action, stepping along the keys. Especially in later lessons the child sang consistently with the therapist in Section C and there seemed to be vocal matching of pattern rather than contacts made to beat or pattern.

Child Five THis child had difficulty in bringing the left hand/arm up to and on to the keyboard and the starting action was usually with clenched fist and some arm spasm. There was much more effective starting action with the preferred right hand. While physical control was erratic, concentration on task was consistent.

Child Six For this child there was very little difference in motor control between left and right hand action and the right hand preference was marginal. The child counted beats during each lesson appearing to concentrate on this self-determined task. A deliberate physical contact action was sustained and often gazing around the room would accompany that action. Sections B and C sometimes appeared to interrupt this concentration.

Child Seven This child (like Child Two) developed a cyclic motor action, going left to right up the keyboard with the left hand and right to left down the keyboard with the right hand. Task focus needed to be reinforced by nods and gestural actions towards the keyboard. Often action ceased during Section A3. There was definite interest in Section C with a return to playing with the beat, a smile or look at the therapist and some pitched vocalisation from the child.

Child Eight Snatches of erratic, very fast playing were normal for this child. Often the C sections were played mainly on the wooden surface of the keyboard and not the keys, so few contacts would be registered by the computer.

APPENDIX C. PRE AND POST TEST INFORMATION

1. Description of selected sub-tests.

Sub-test 7 contains eight items relating to visual motor control. The sub-test measures the ability to co-ordinate precise hand and visual movements through: cutting out a circle with preferred hand, drawing a line through a crooked, straight and curved path; copying a circle, triangle, horizontal diamond and overlapping pencils with preferred hand.

Sub-test 8 has eight items relating to upper-limb speed and dexterity. This sub-test measures hand and finger dexterity, hand speed and arm speed. Items are: placing pennies in a box with preferred hand; placing pennies in two boxes with both hands; sorting cards with preferred hand; stringing beads with preferred hand; displacing pegs with preferred hand; drawing vertical lines; and making dots with preferred hand.

2. Alterations made to sub-tests.

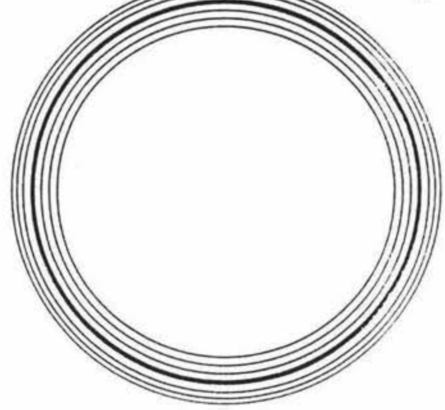
Several sections of the two sub-tests were altered for some of the children in the study to provide tasks that were possible within their range of motor function. Items one to four in Sub-test Seven were magnified and some items in Sub-test Eight had their time span increased from 15 to 30 seconds. also, in Section Eight some materials provided in the test kit, such as pegs and cards, were unsuitable for some of the children. These materials were replaced with larger or thicker similar items so that an attempt could be made at the tasks which measured dexterity.

In all cases alterations were kept constant in every pre and post test. Thus, in a single case study design, providing comparable criteria.

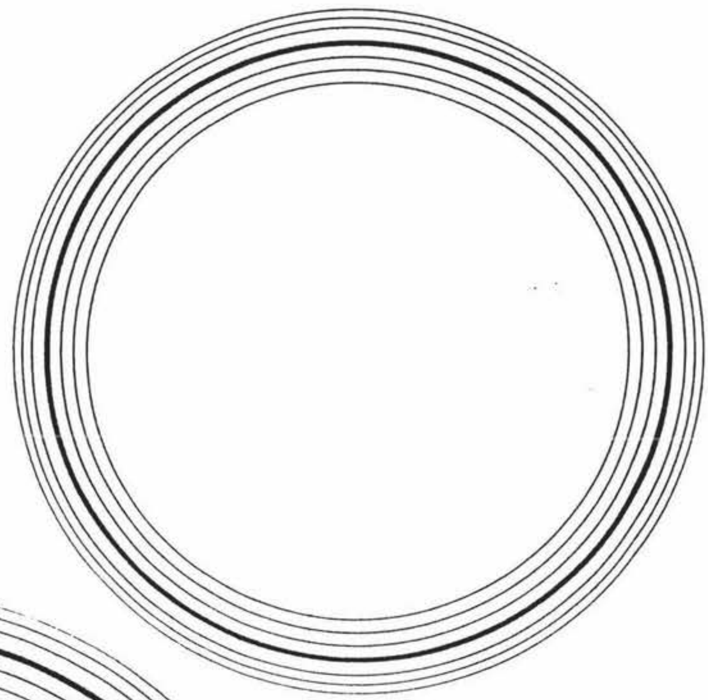
C(i)

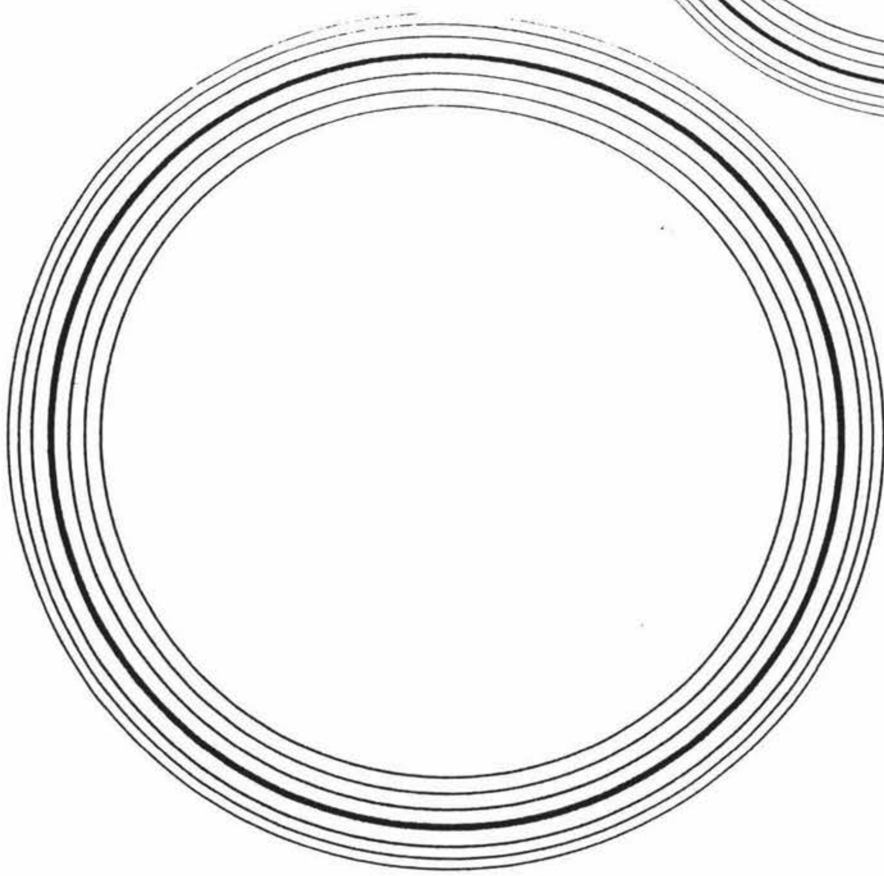
SUBTEST 7: Visual-Motor Control

Item 1 / Cutting Out a Circle with Preferred Hand

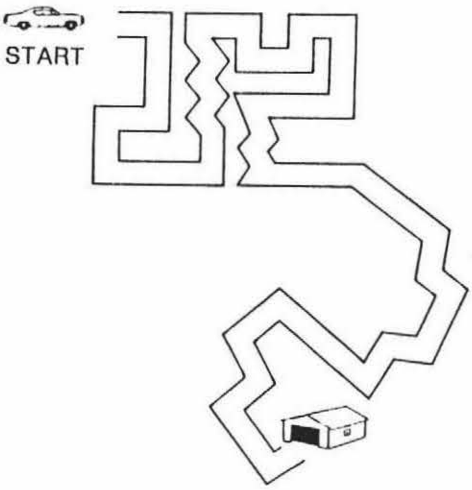


Number of Errors



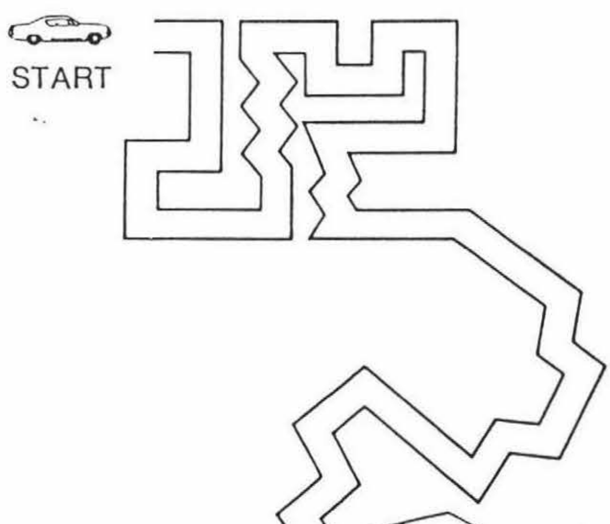


Item 2 / Drawing a Line Through a Crooked Path
with Preferred Hand



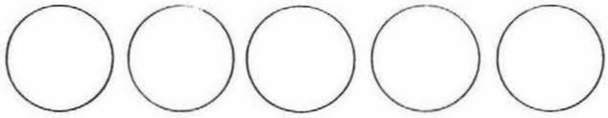
Number of
Errors

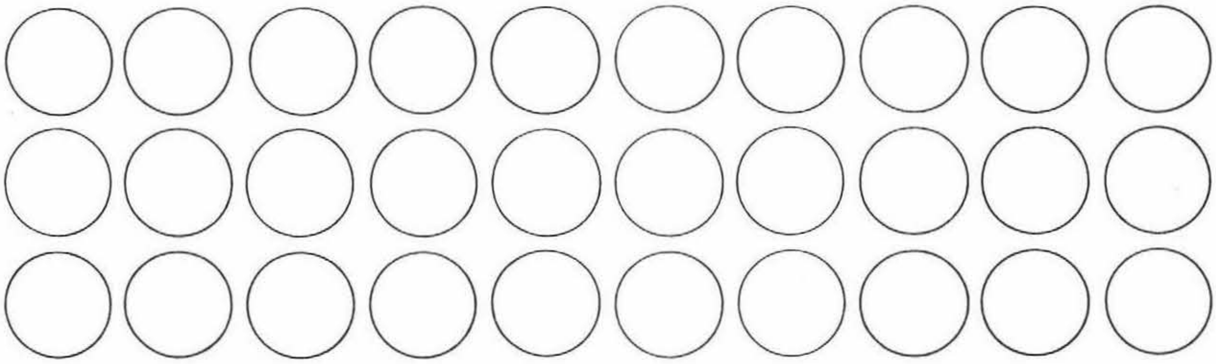
Item 2 / Drawing a Line Through a Crooked Path
with Preferred Hand



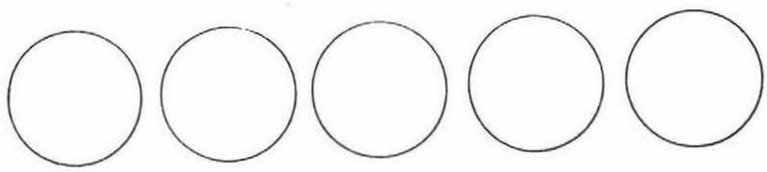
Number of

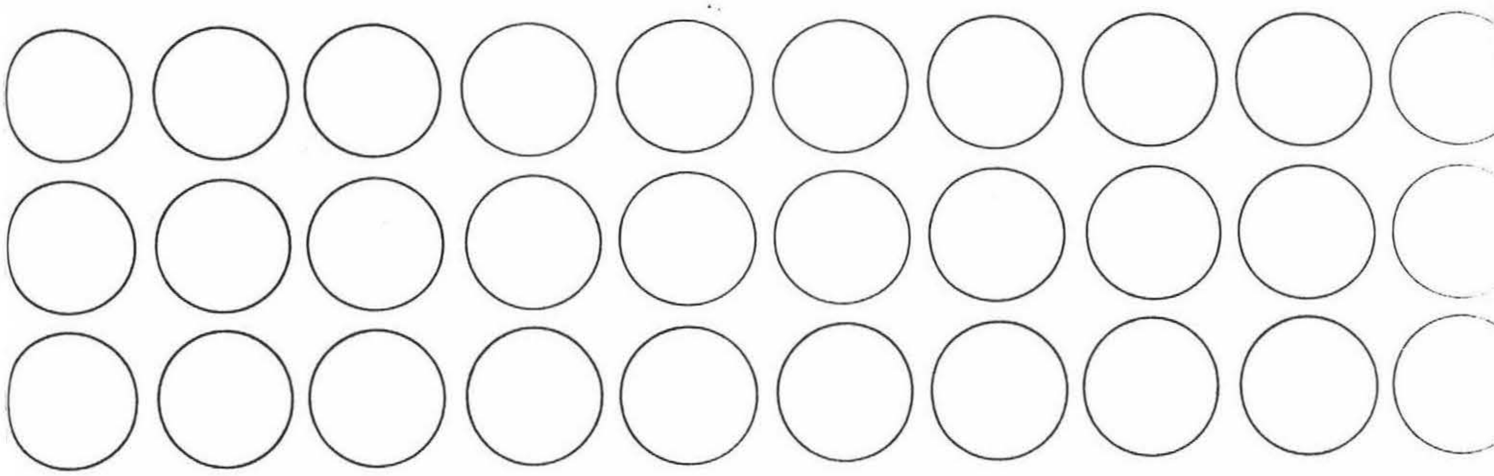
Item 7SF / Making Dots in Circles with Preferred Hand

Practice: 

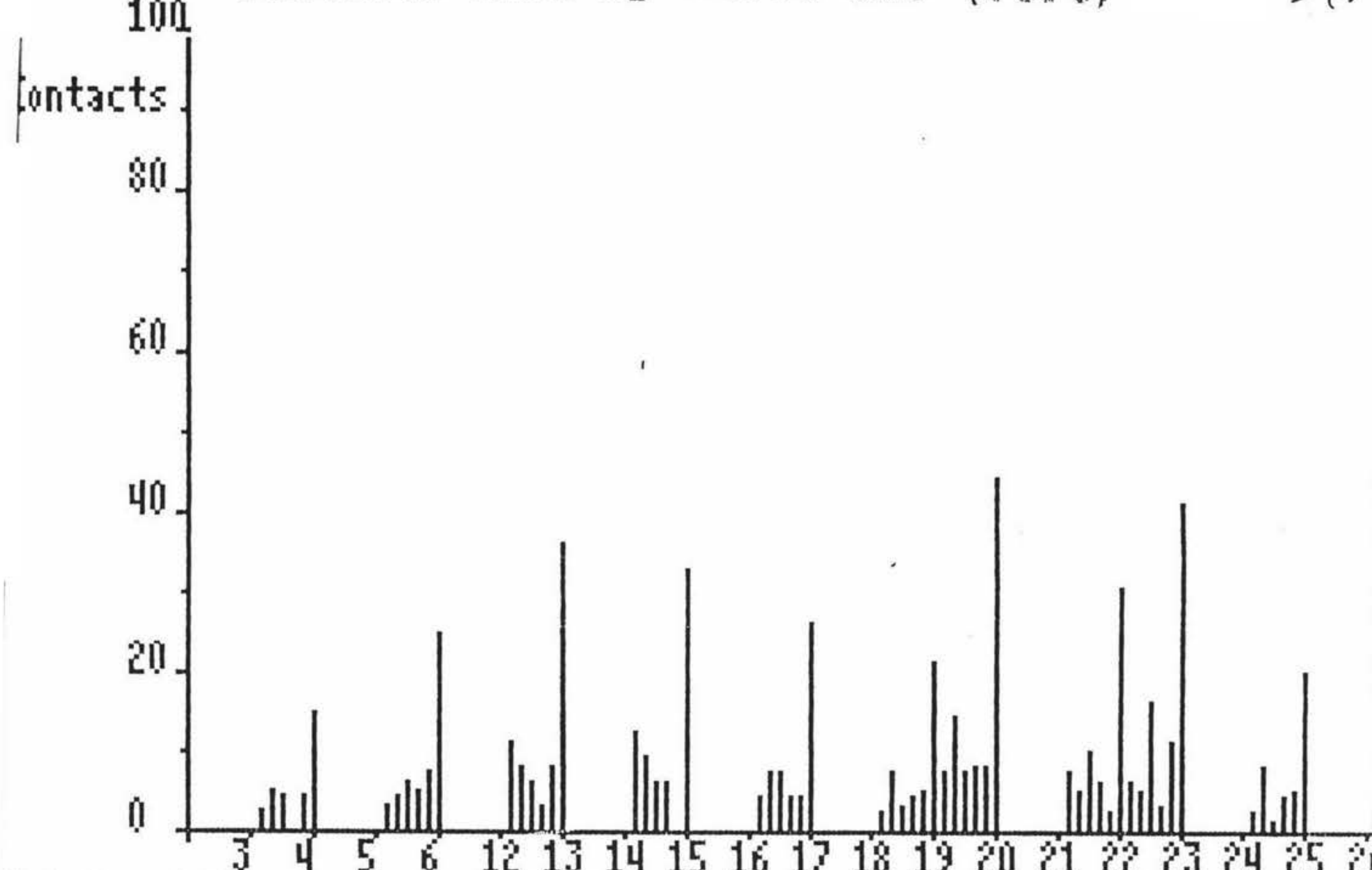


Item 7SF / Making Dots in Circles with Preferred Hand

Practice: 

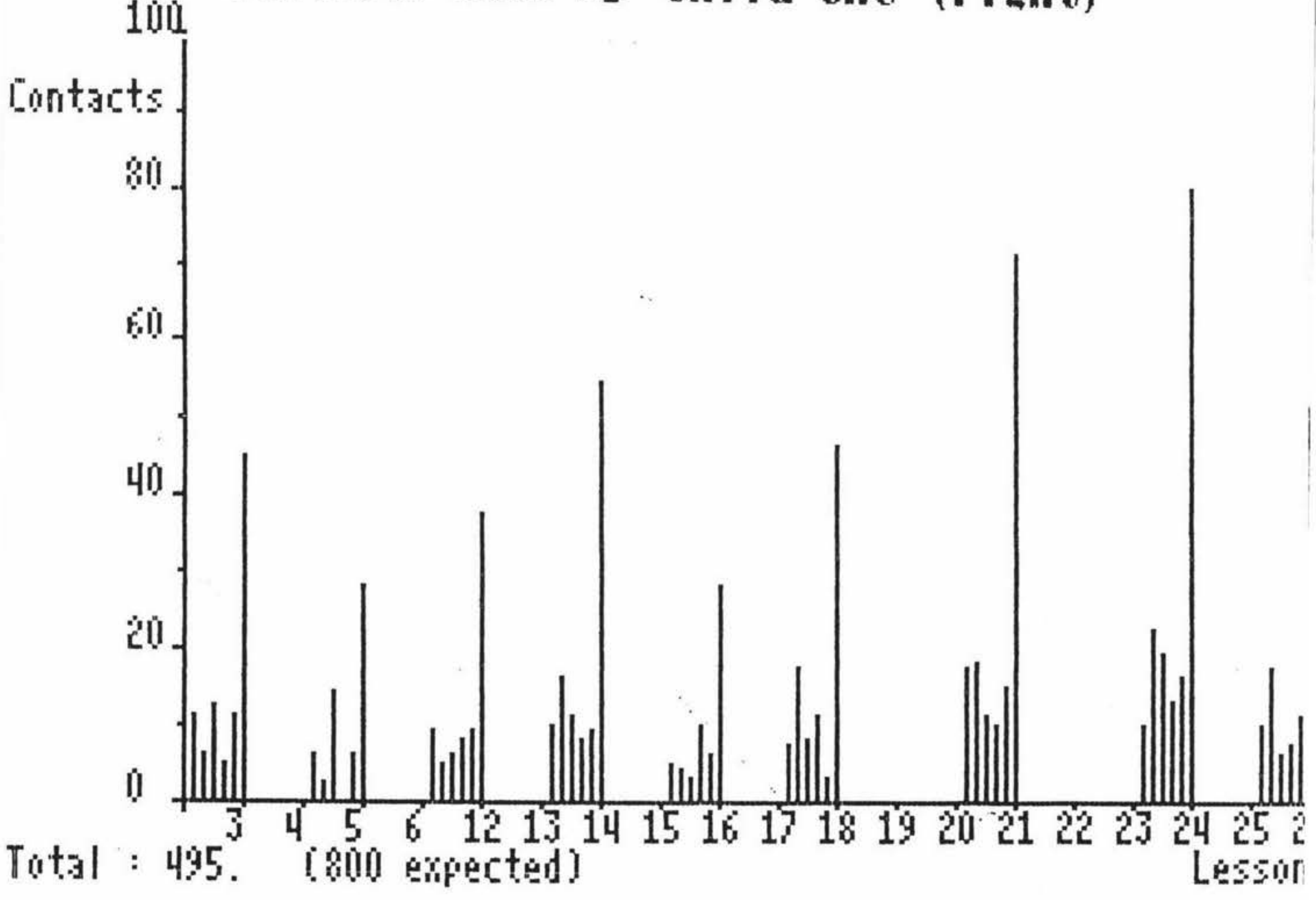


Contacts made by **Child One (left)** D(i)



Total : 291. (800 expected)

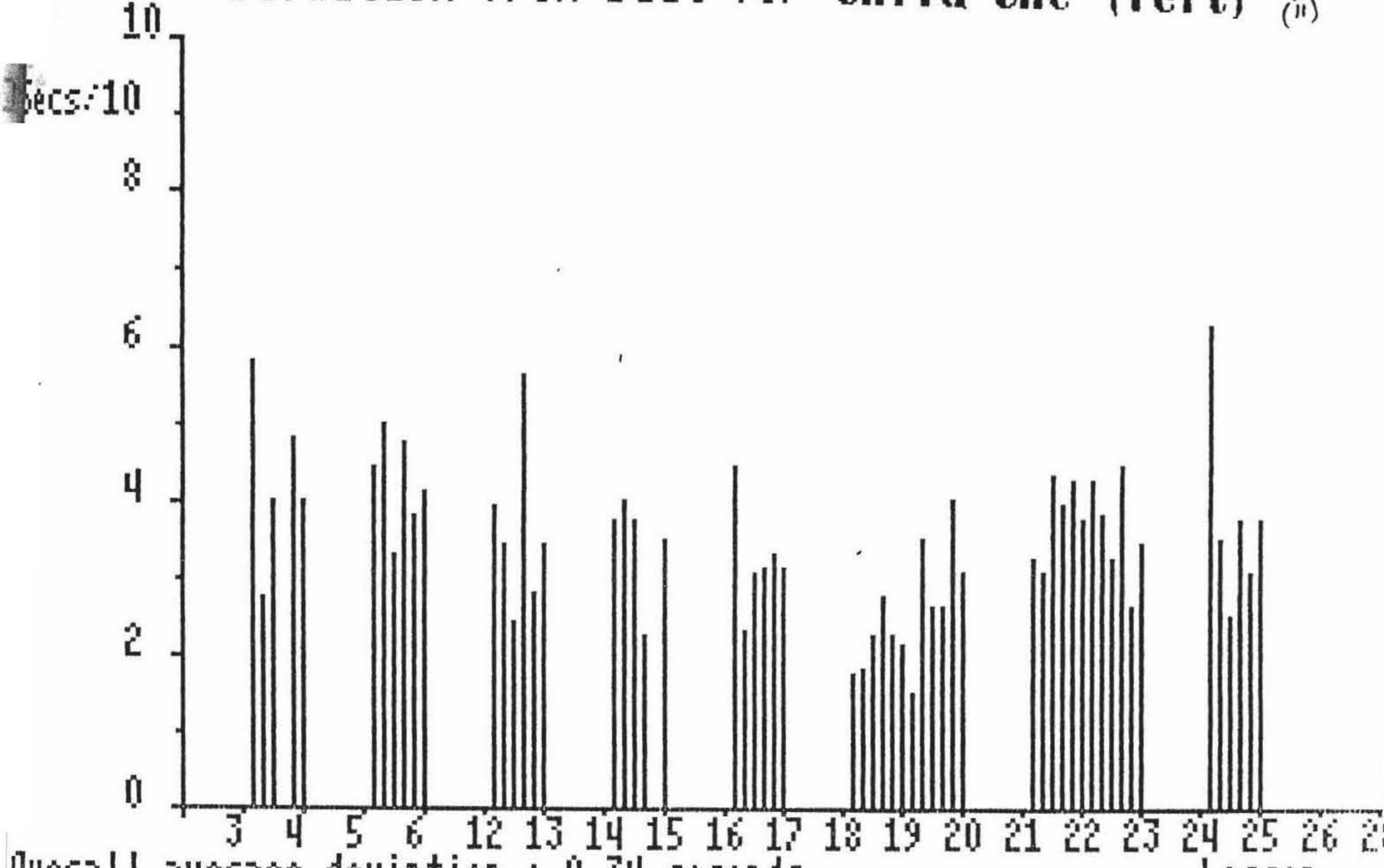
Contacts made by **Child One (right)**



Total : 495. (800 expected)

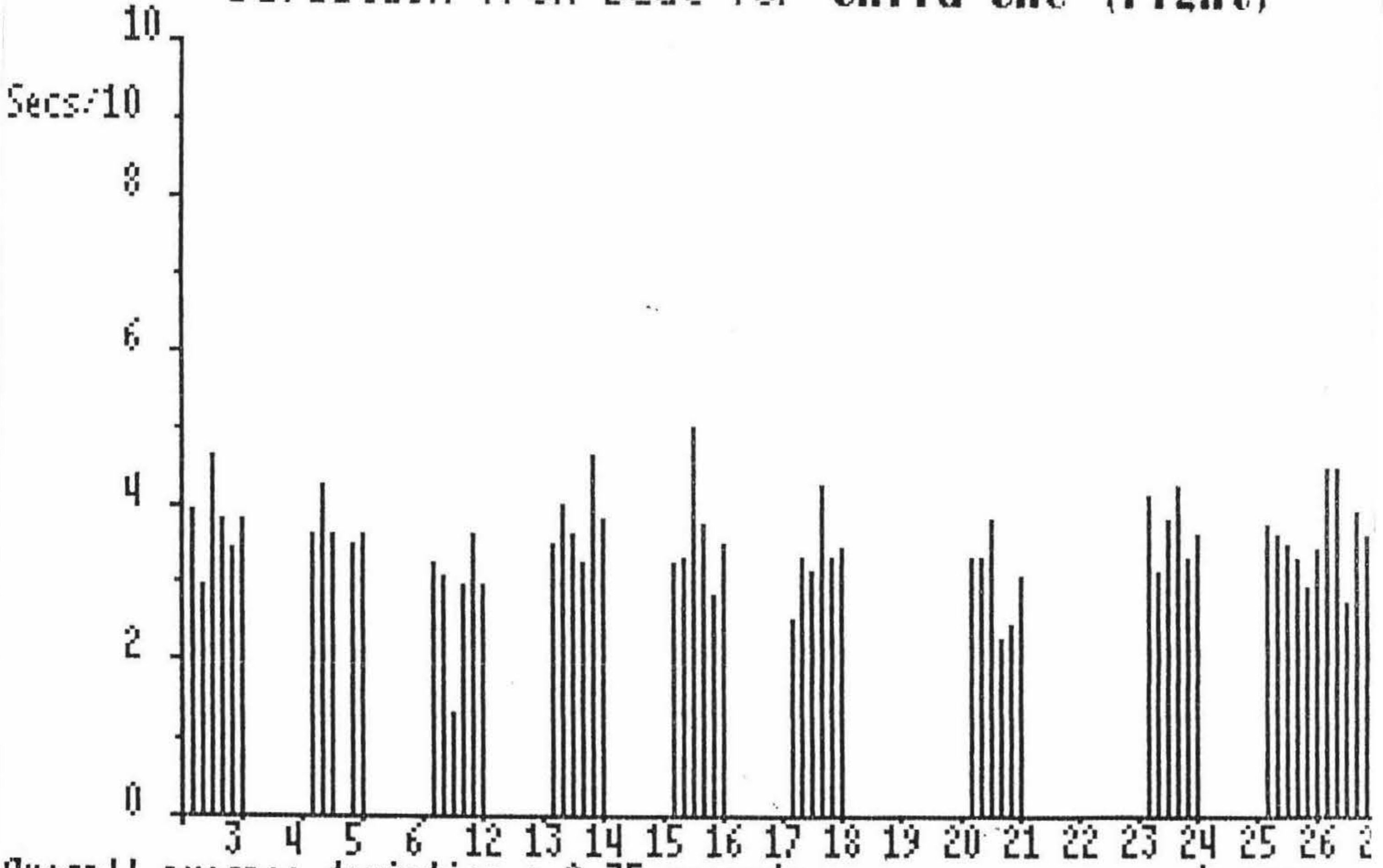
(ii)

Deviation from beat for **Child One (left)**

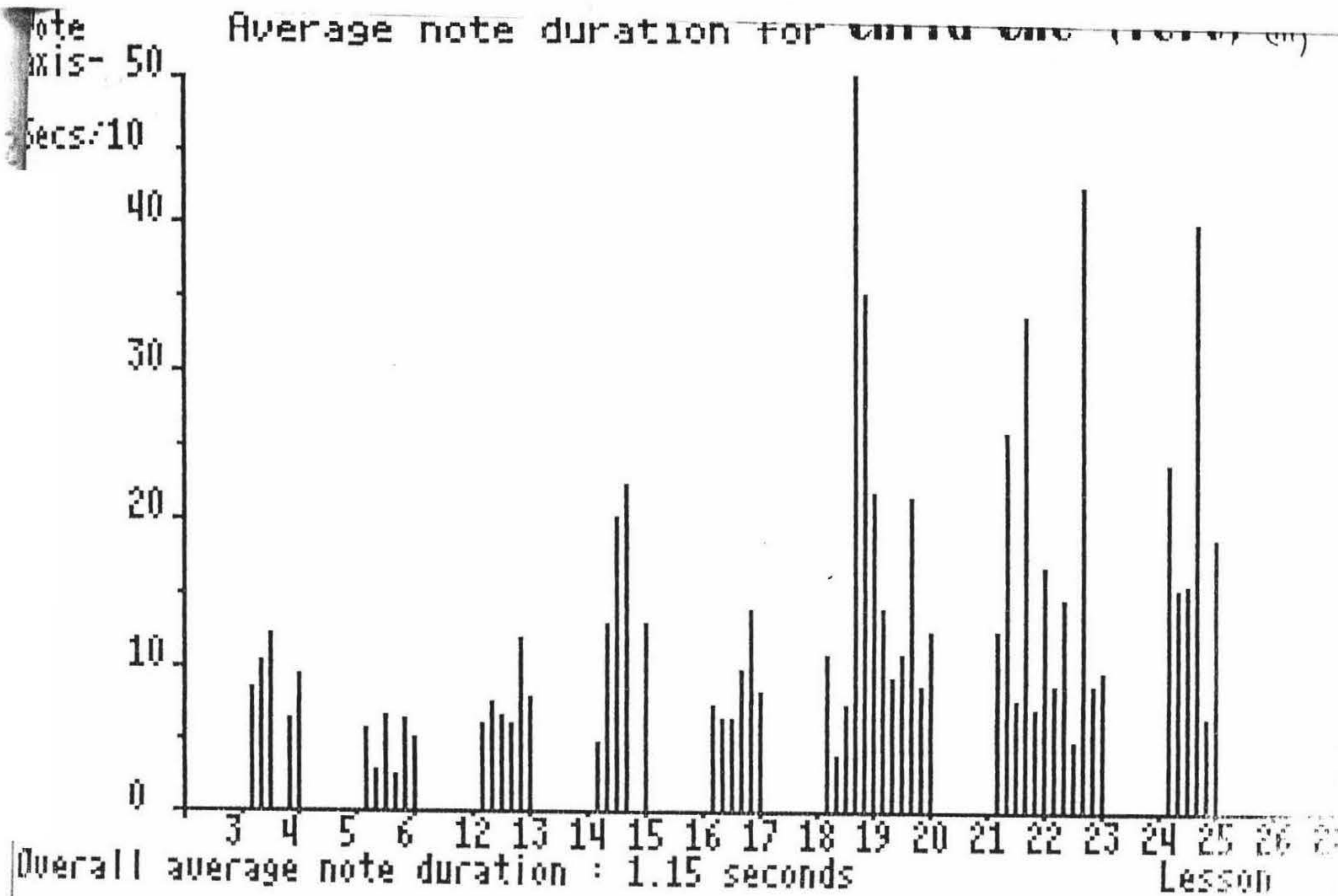


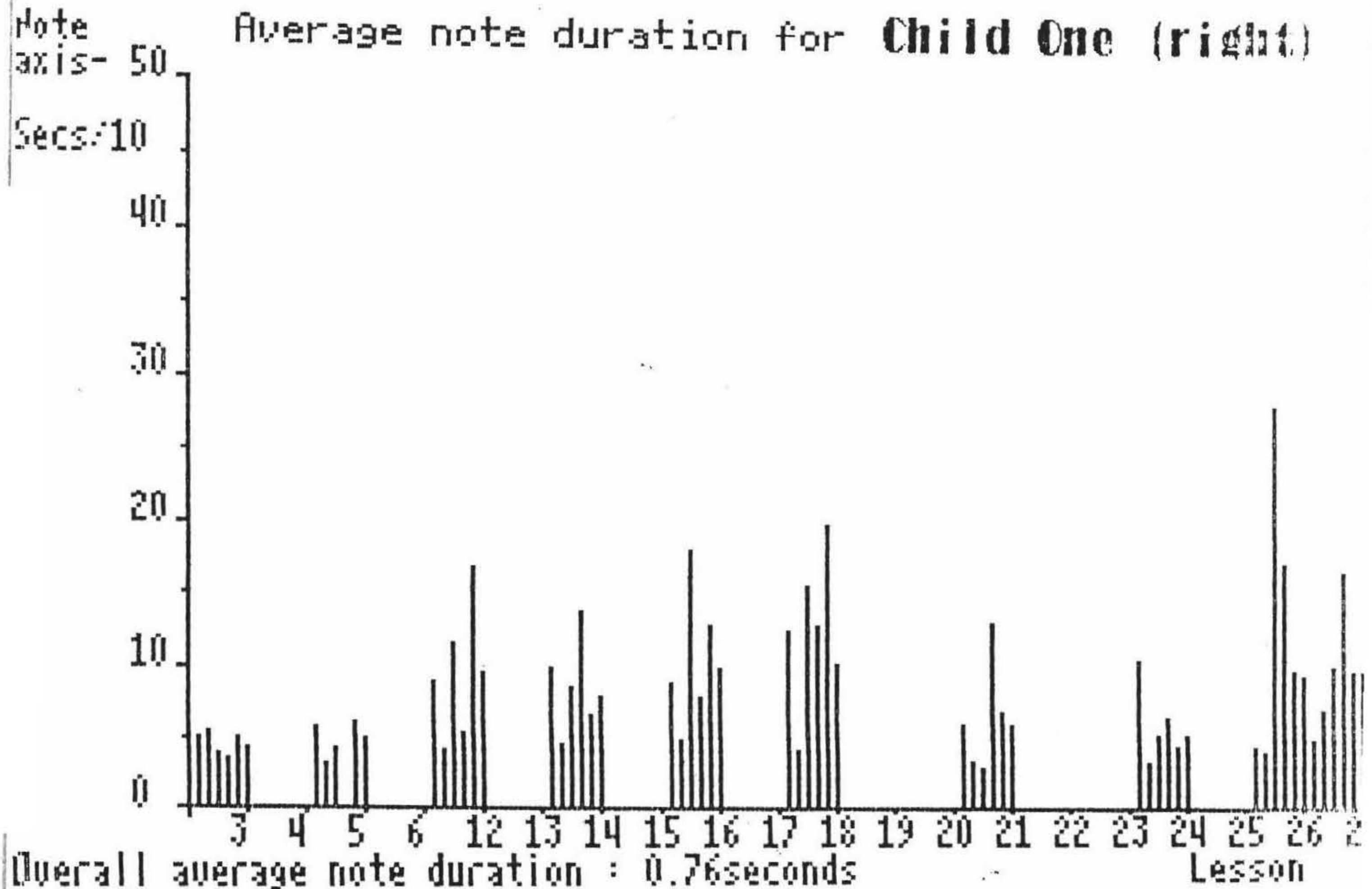
Overall average deviation : 0.34 seconds

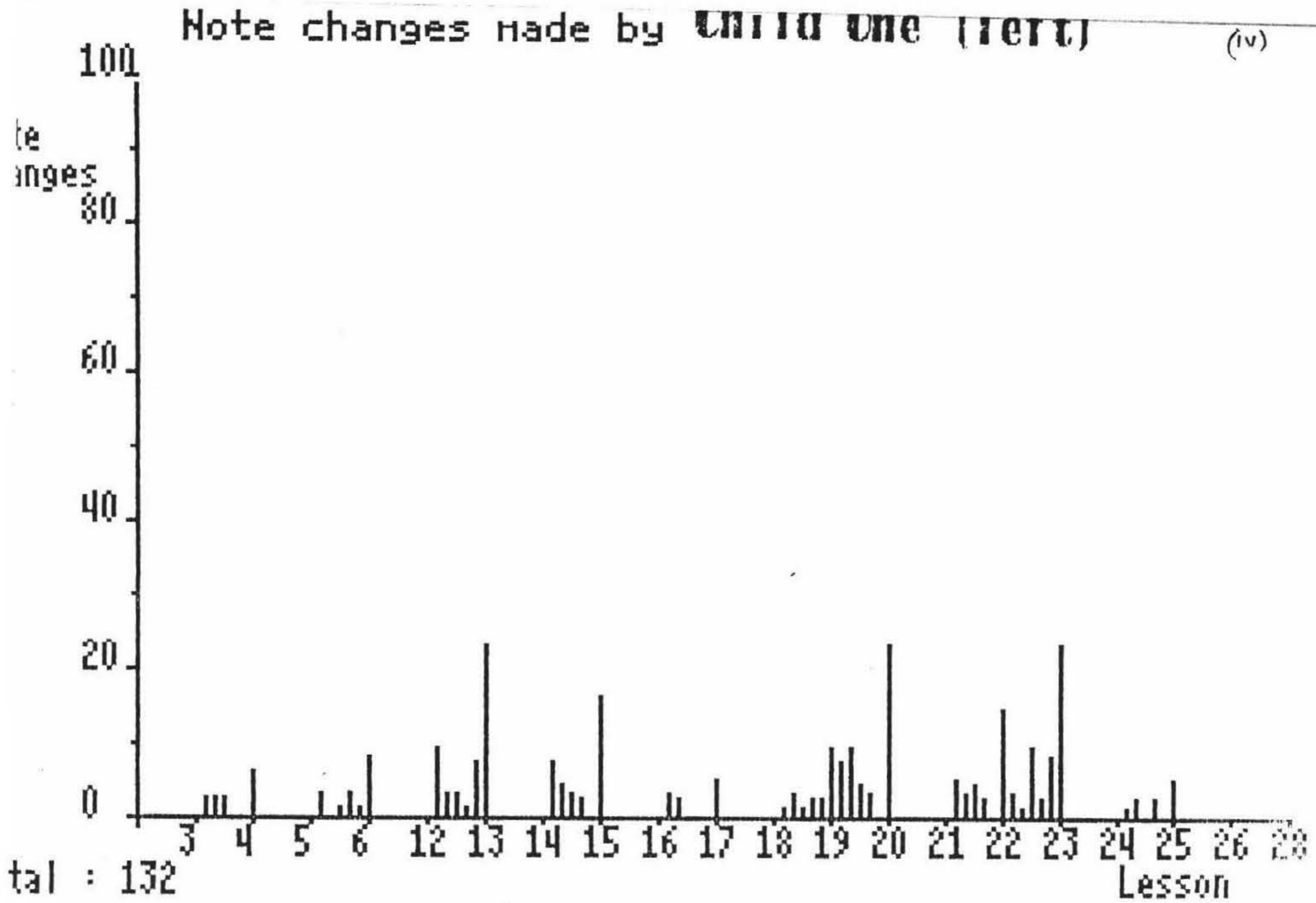
Deviation from beat for **Child One (right)**

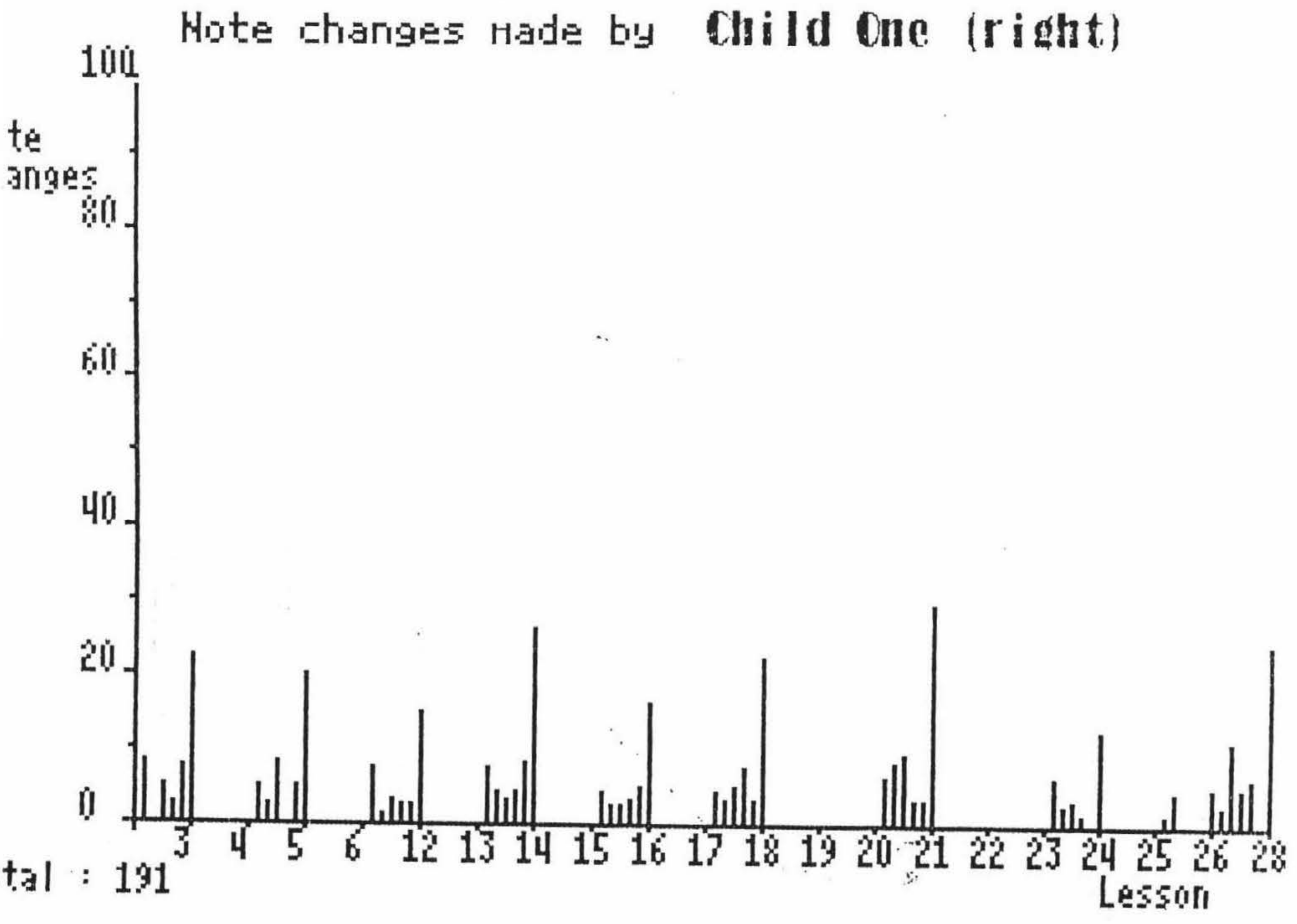


Overall average deviation : 0.35 seconds

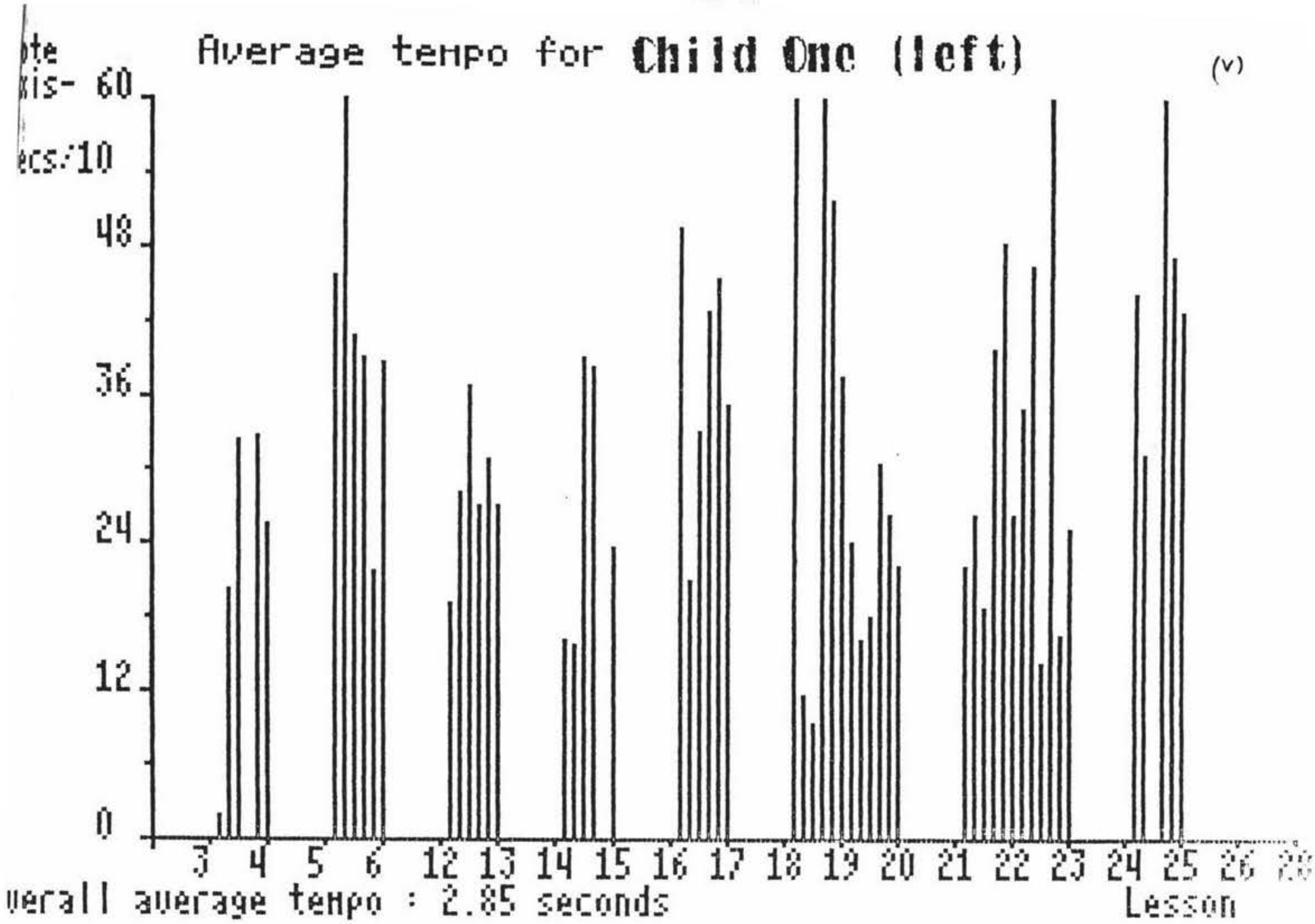

Average note duration for
Note axis- Secs/10
50
40
30
20
10
0
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Overall average note duration : 1.15 seconds
Lesson


Average note duration for Child One (right)
Note axis- Secs/10
50
40
30
20
10
0
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Overall average note duration : 0.76seconds
Lesson

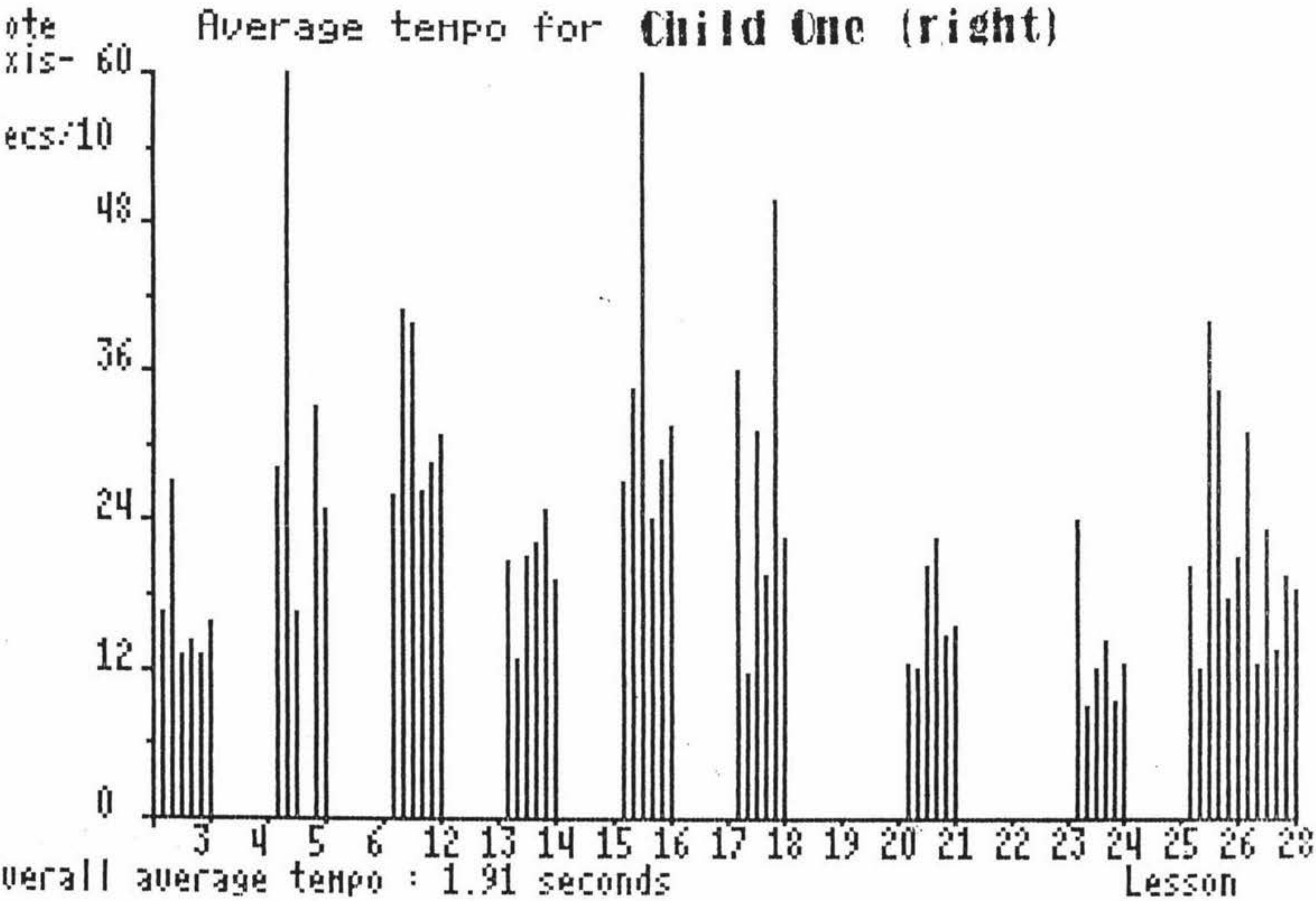

Note changes made by Child One (left)
(iv)
100
te
anges
80
60
40
20
0
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28
tal : 132
Lesson


Note changes made by Child One (right)
100
te
anges
80
60
40
20
0
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28
tal : 191
Lesson

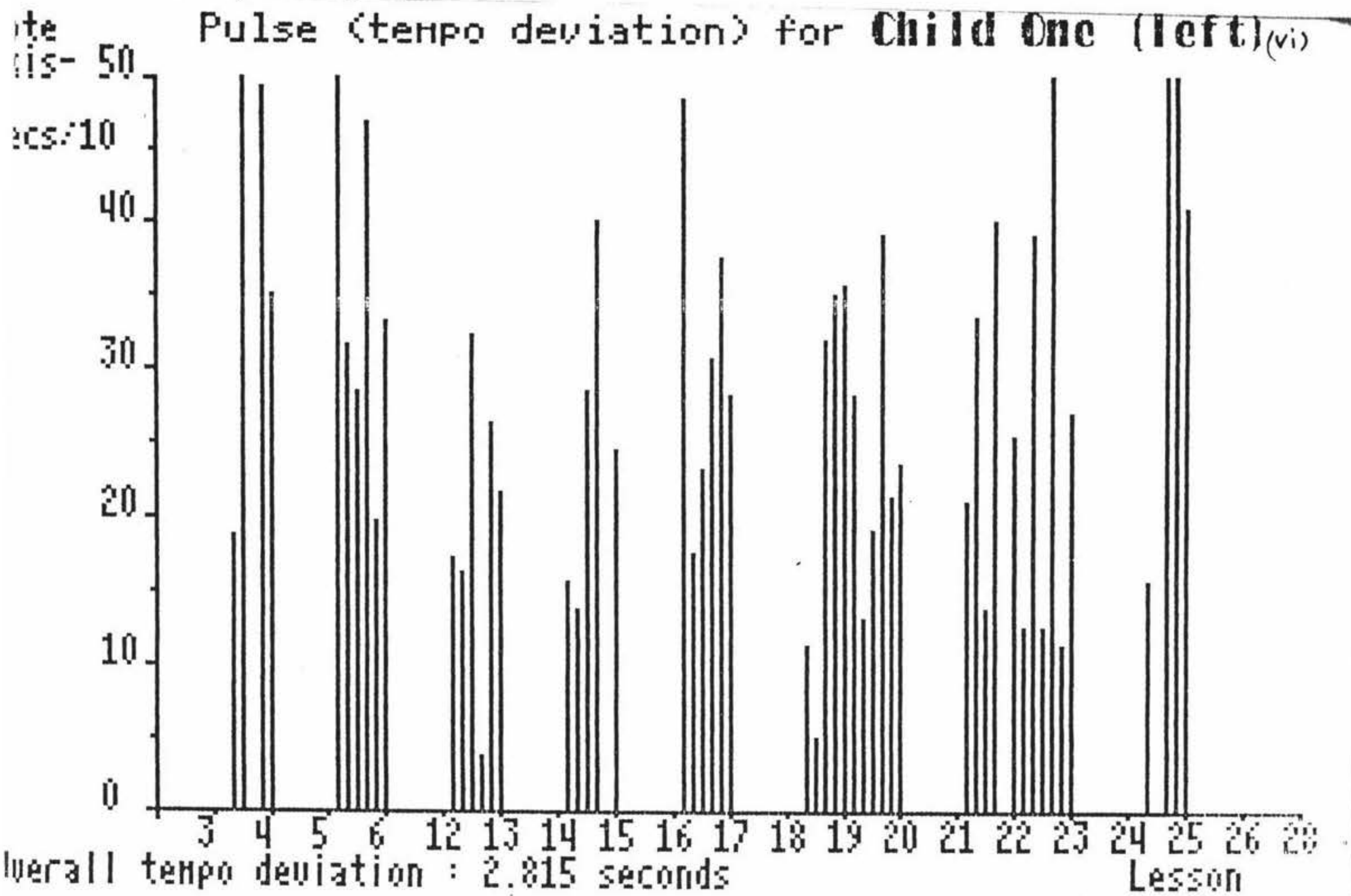
(v)

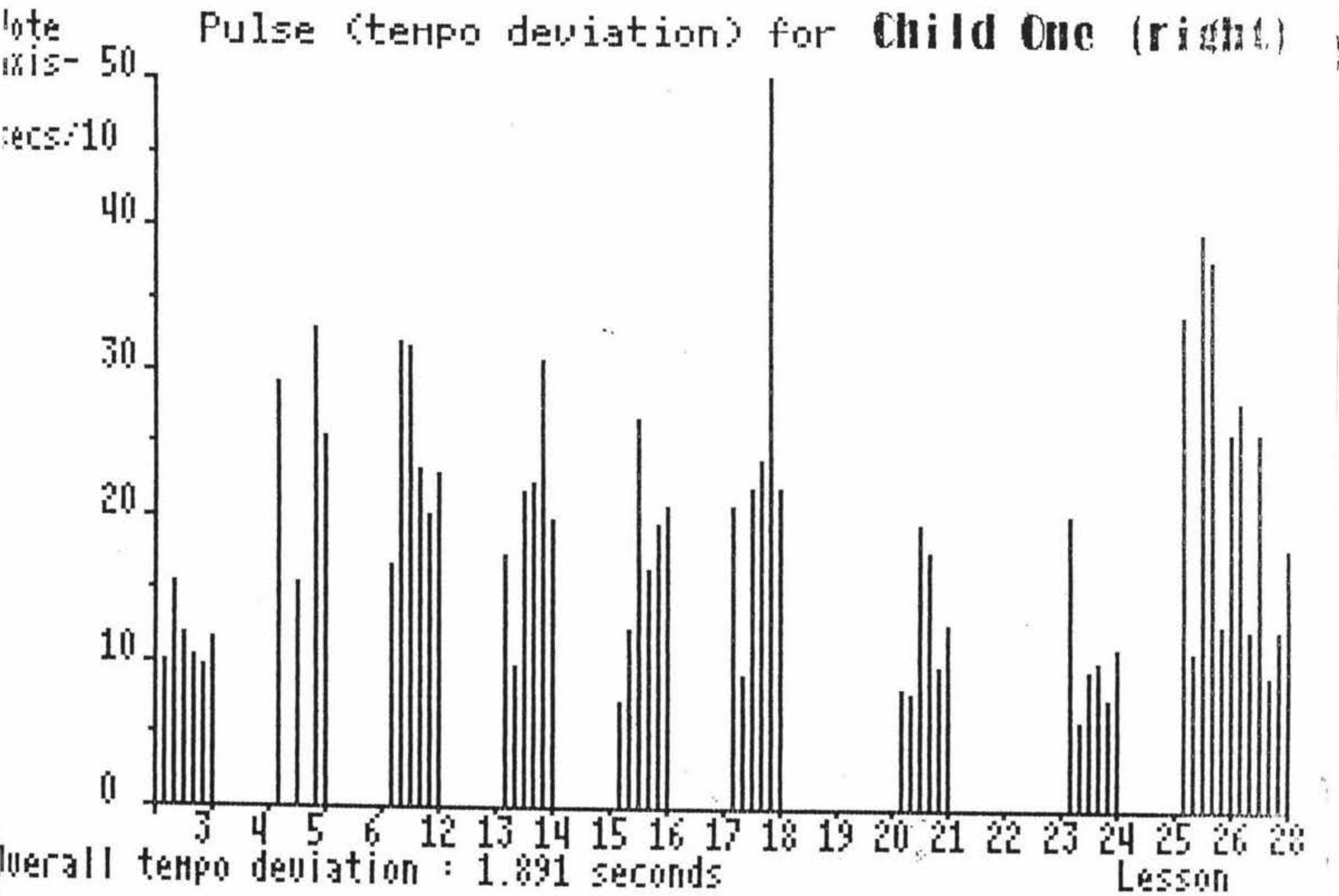


ote
xis- 60
ecs/10
48
36
24
12
0
Average tempo for Child One (left)
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28
verall average tempo : 2.85 seconds
Lesson



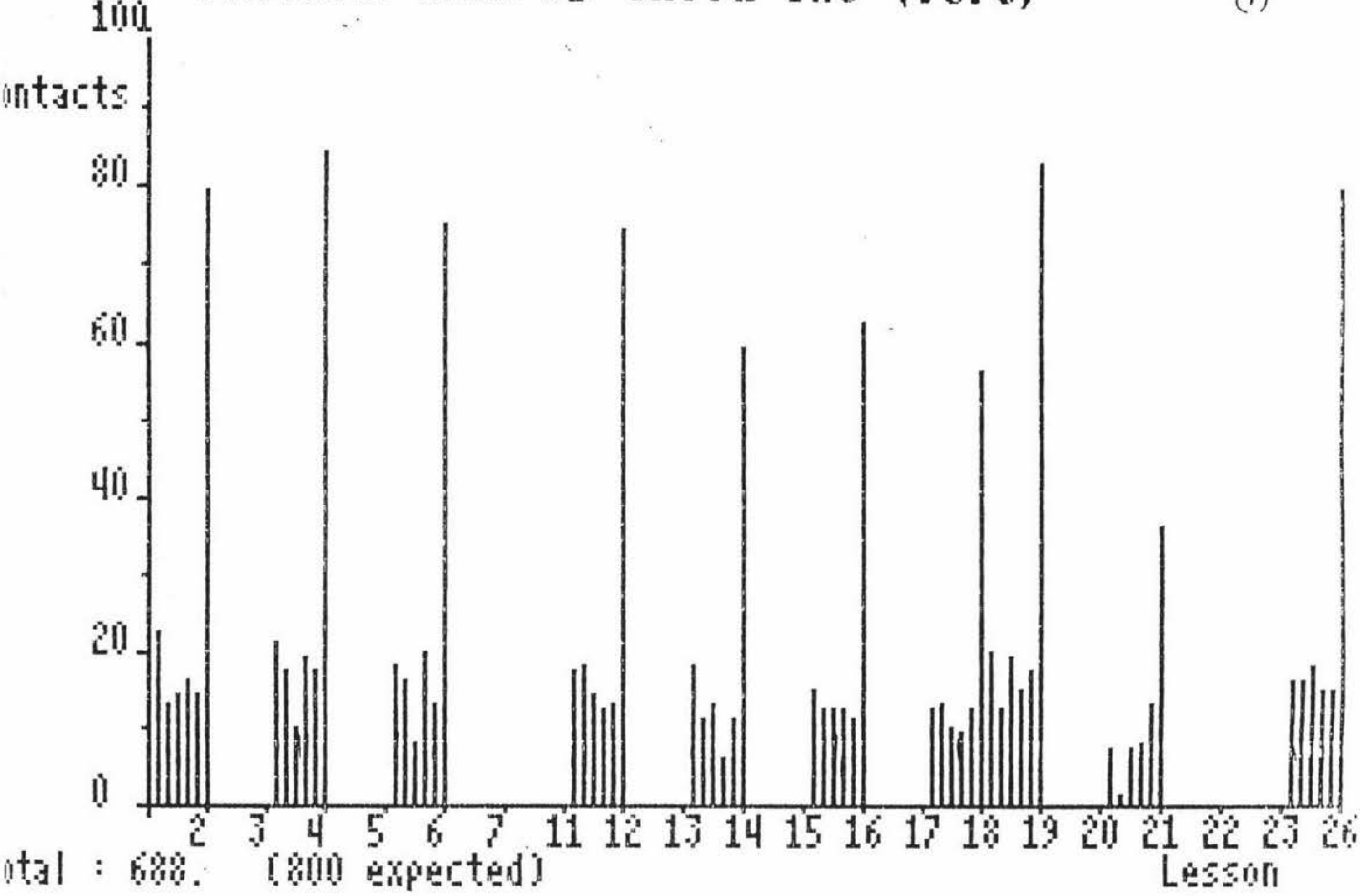
ote
xis- 60
ecs/10
48
36
24
12
0
Average tempo for Child One (right)
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28
verall average tempo : 1.91 seconds
Lesson


Pulse (tempo deviation) for Child One (left)
(vi)
50
secs/10
40
30
20
10
0
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28
Overall tempo deviation : 2.815 seconds
Lesson

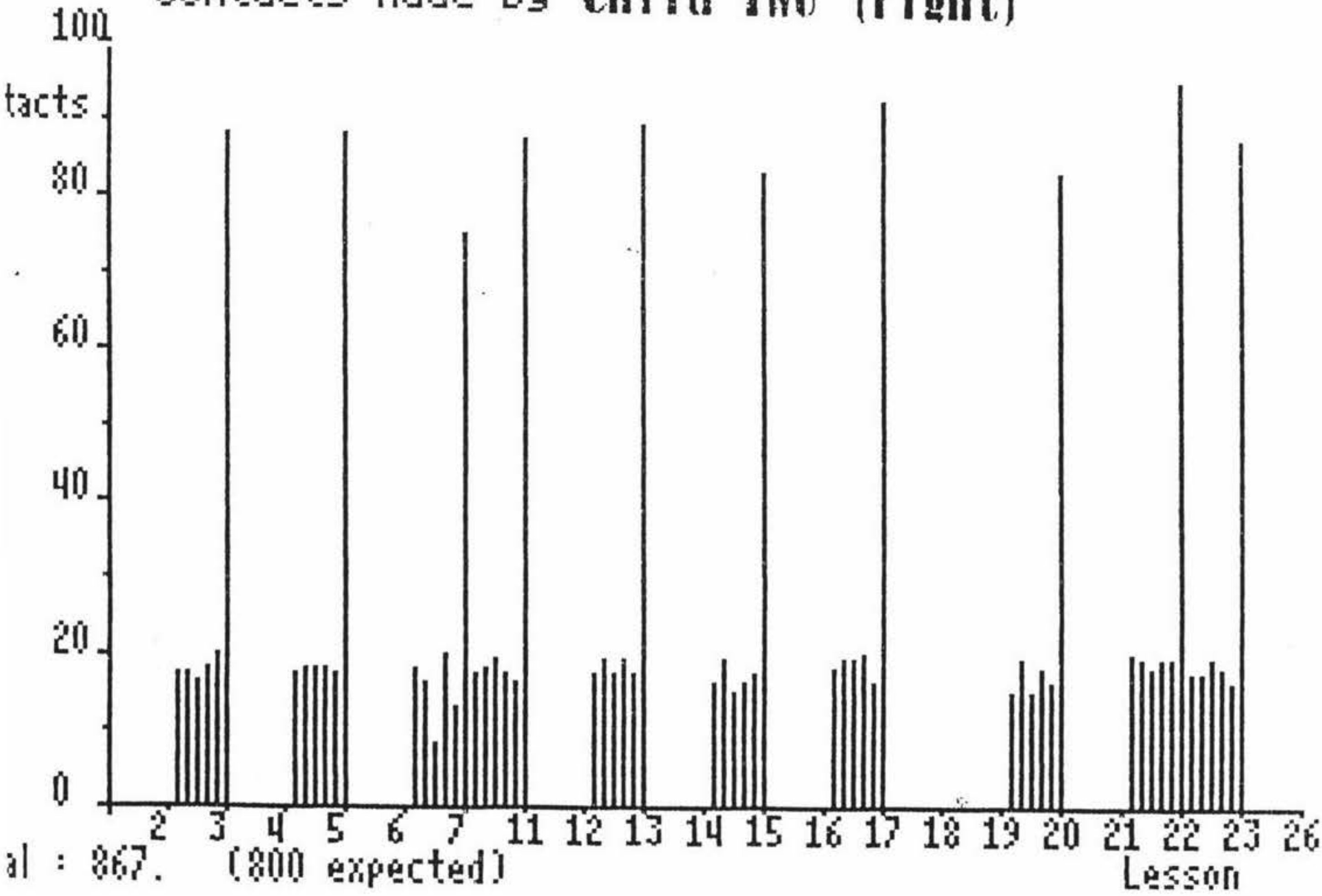

Pulse (tempo deviation) for Child One (right)
50
secs/10
40
30
20
10
0
3 4 5 6 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28
Overall tempo deviation : 1.891 seconds
Lesson

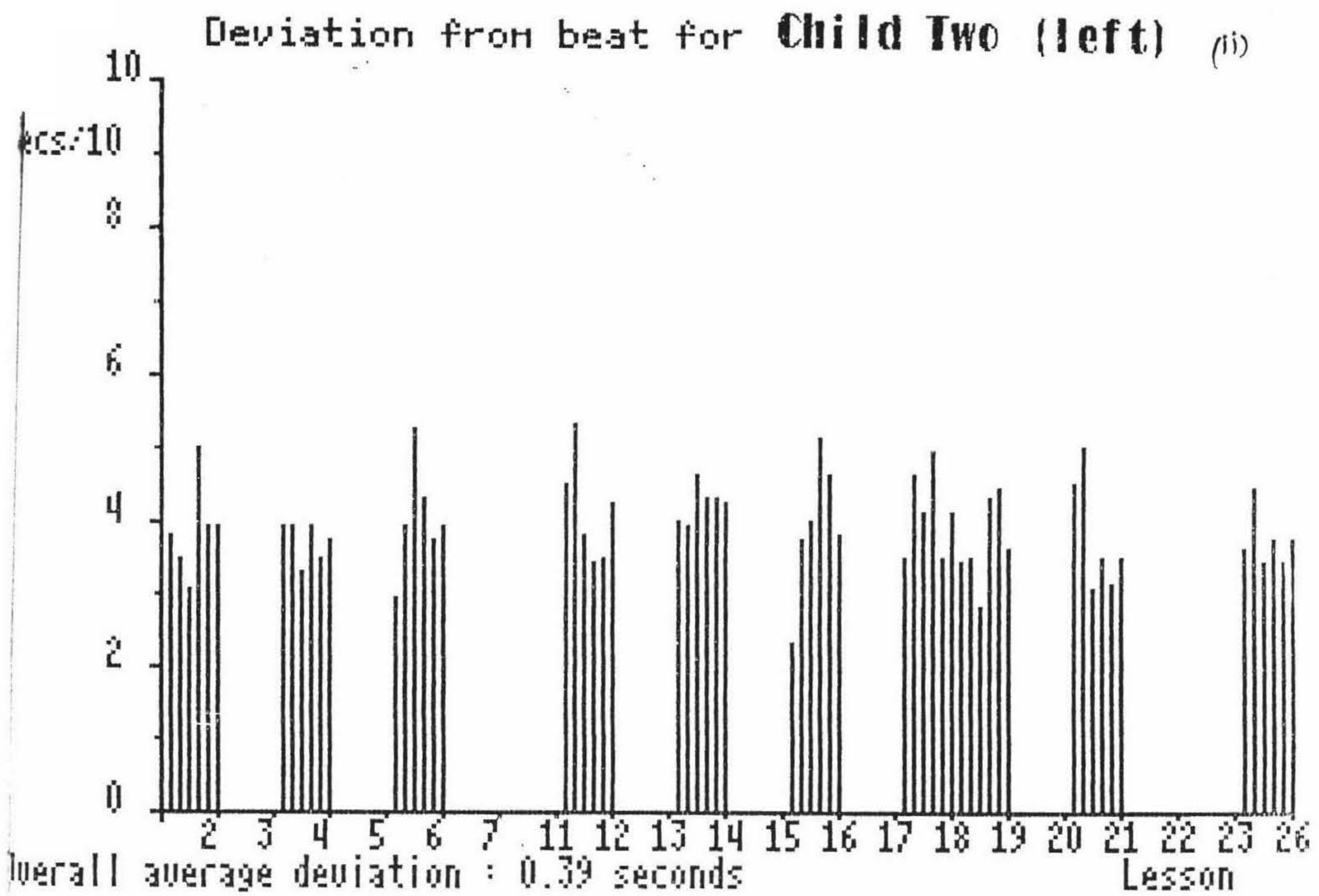
(i)

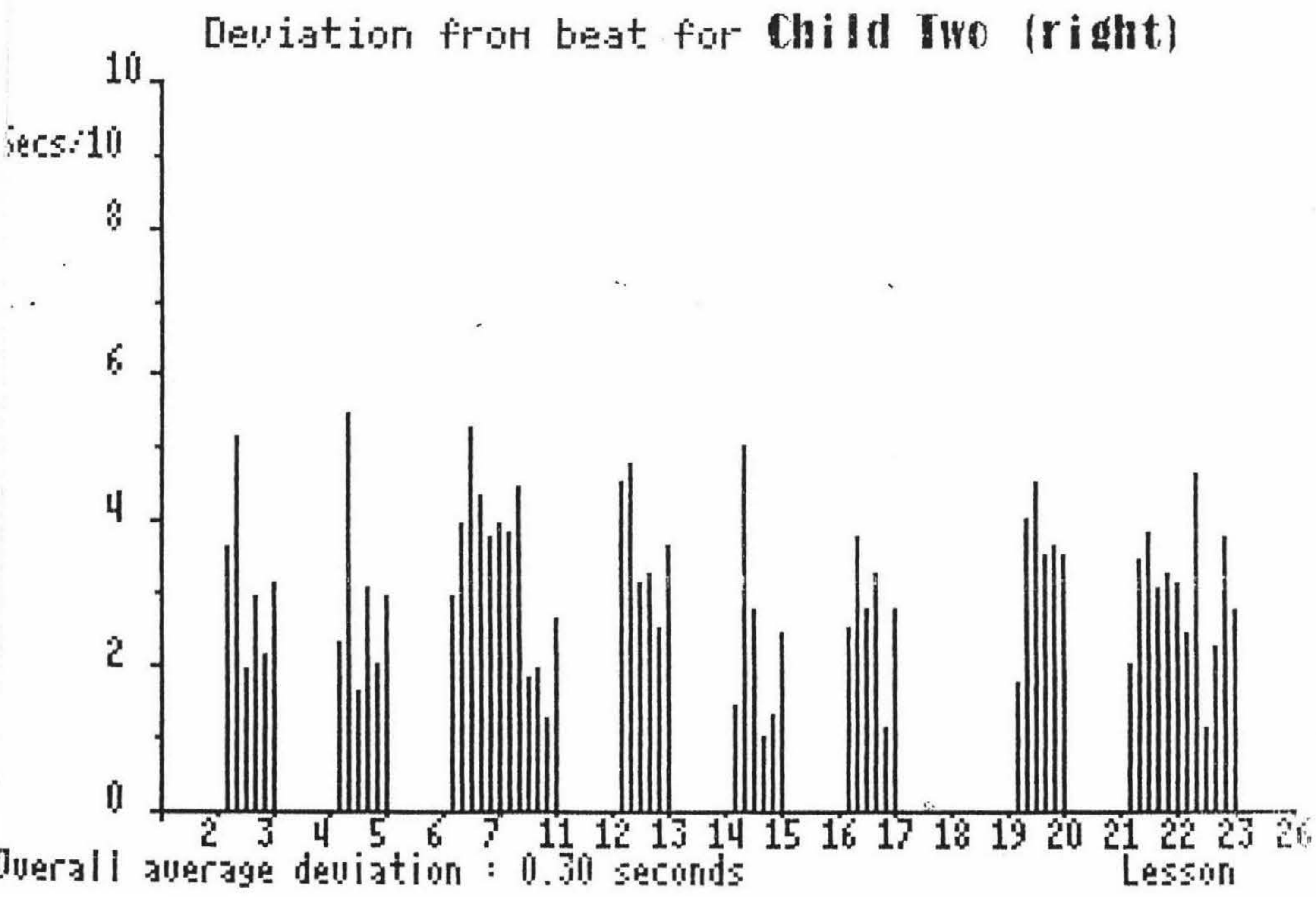
Contacts made by **Child Two (left)**

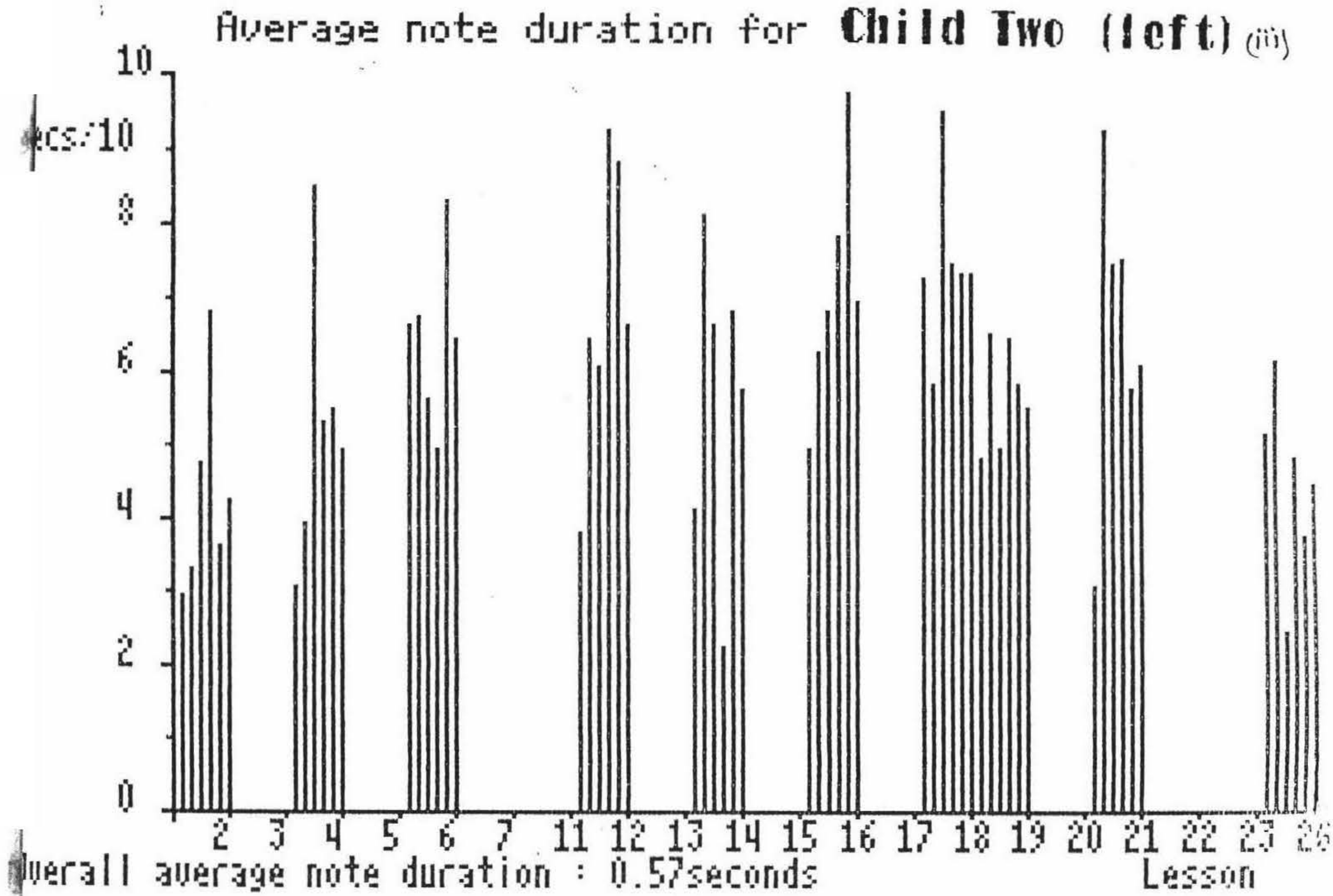


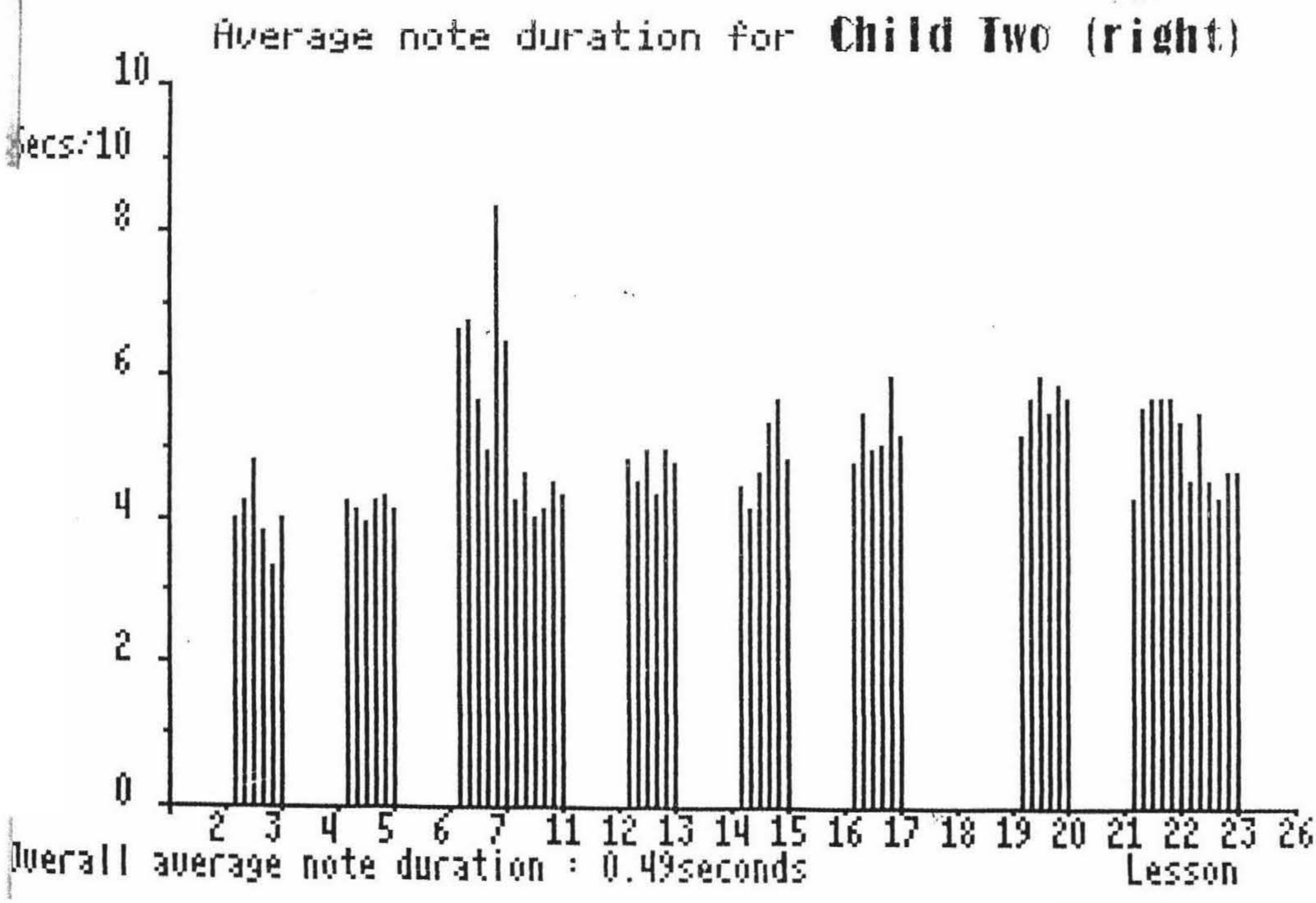
Contacts made by **Child Two (right)**

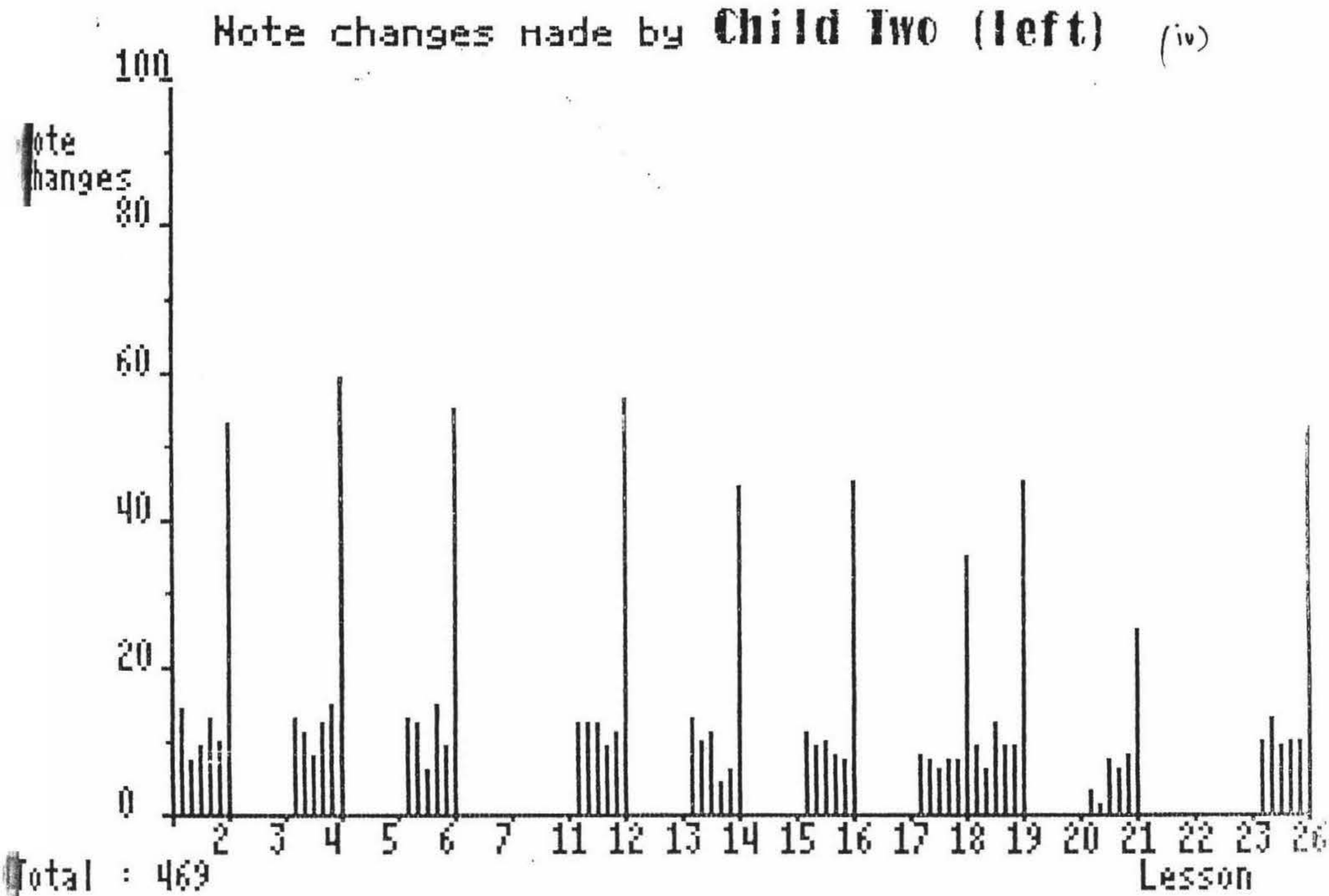



Deviation from beat for Child Two (left)
(ii)
10
Secs/10
8
6
4
2
0
2 3 4 5 6 7 11 12 13 14 15 16 17 18 19 20 21 22 23 26
Overall average deviation : 0.39 seconds
Lesson

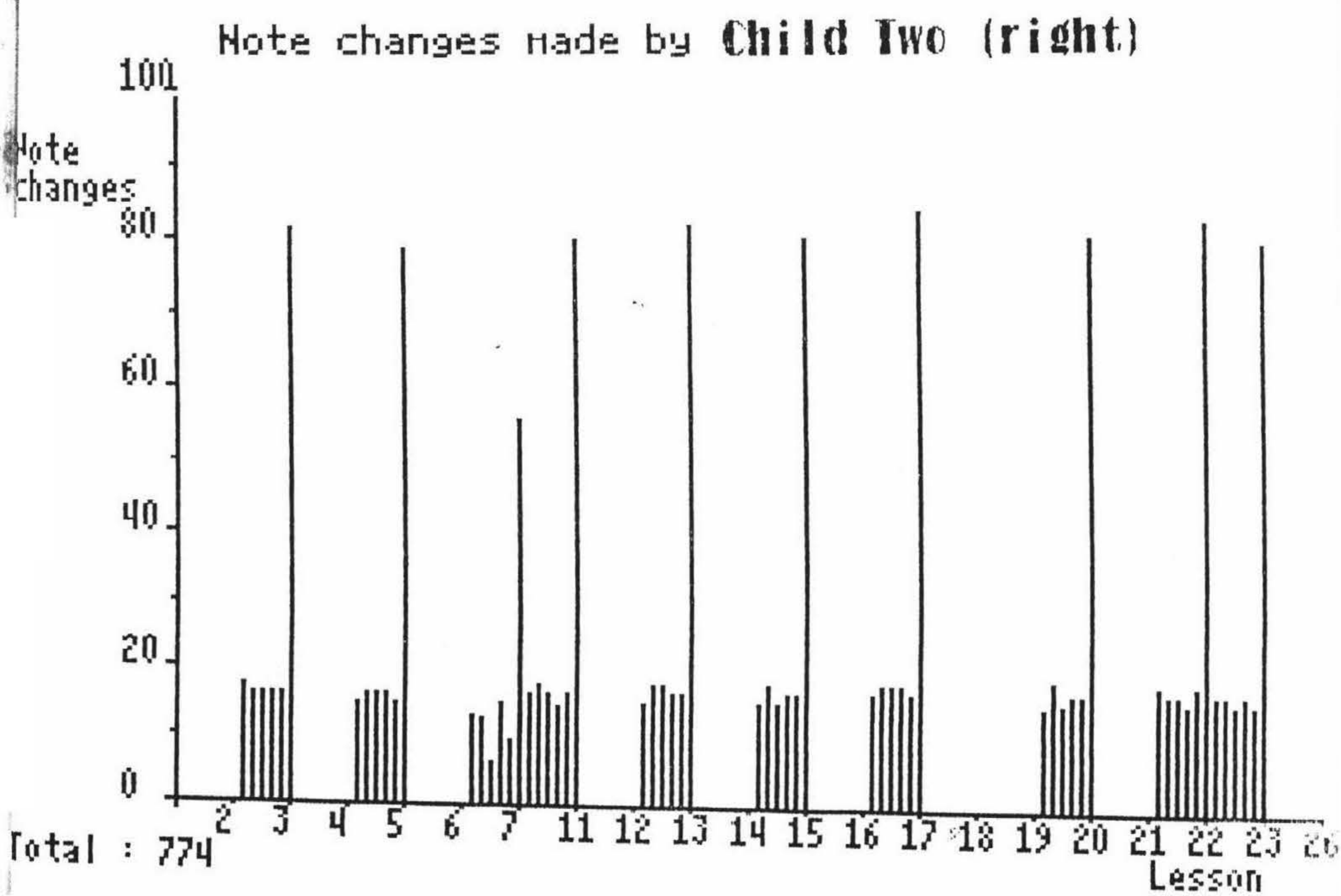

Deviation from beat for Child Two (right)
10
Secs/10
8
6
4
2
0
2 3 4 5 6 7 11 12 13 14 15 16 17 18 19 20 21 22 23 26
Overall average deviation : 0.30 seconds
Lesson


Average note duration for Child Two (left) (iii)
Secs/10
10
8
6
4
2
0
2 3 4 5 6 7 11 12 13 14 15 16 17 18 19 20 21 22 23 26
Overall average note duration : 0.57seconds
Lesson


Average note duration for Child Two (right)
Secs/10
10
8
6
4
2
0
2 3 4 5 6 7 11 12 13 14 15 16 17 18 19 20 21 22 23 26
Overall average note duration : 0.49seconds
Lesson



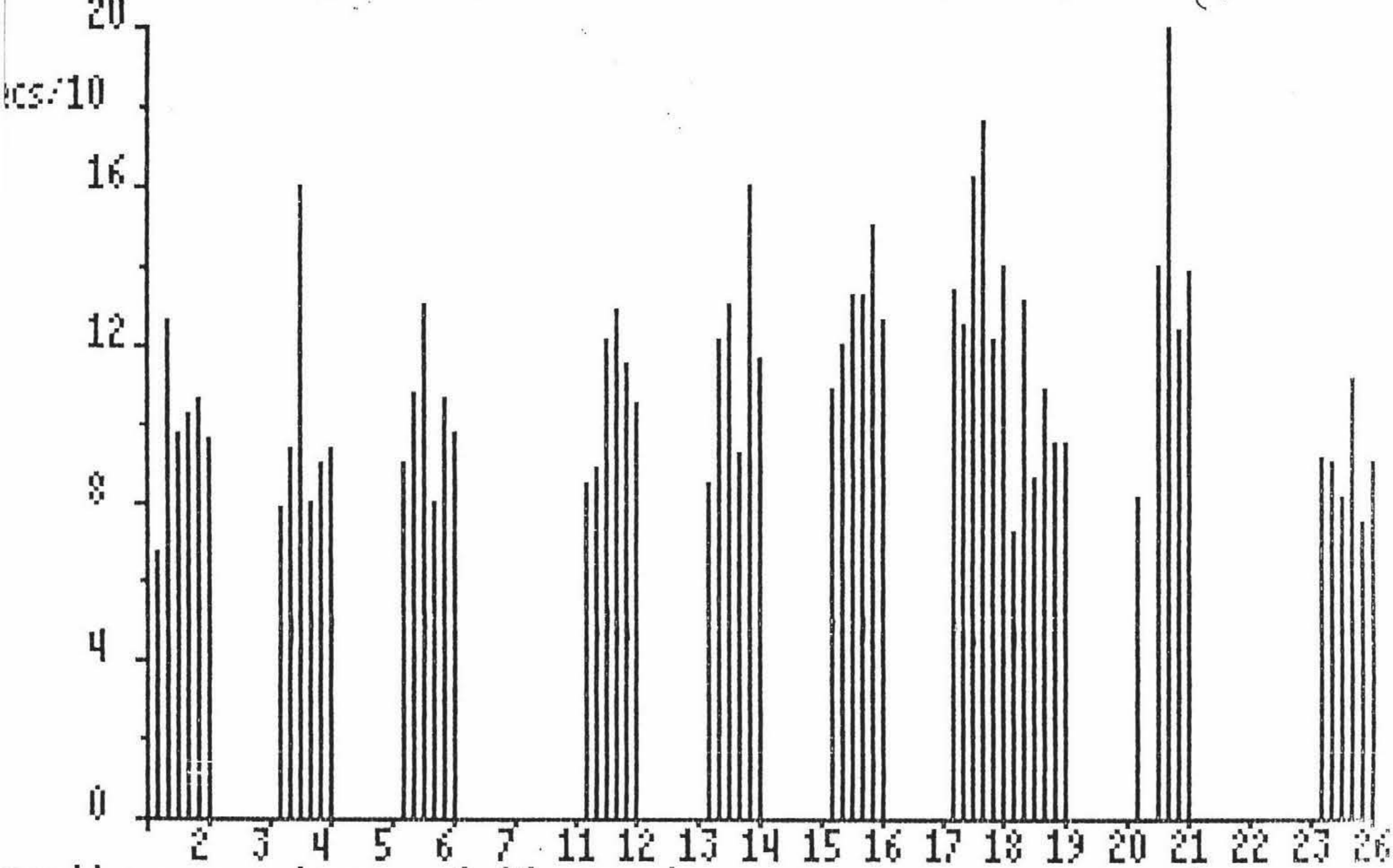
Note changes made by Child Two (left)
(iv)
100
Note changes
80
60
40
20
0
2
3
4
5
6
7
11
12
13
14
15
16
17
18
19
20
21
22
23
26
Total : 469
Lesson



Note changes made by Child Two (right)
100
Note changes
80
60
40
20
0
2
3
4
5
6
7
11
12
13
14
15
16
17
18
19
20
21
22
23
26
Total : 774
Lesson

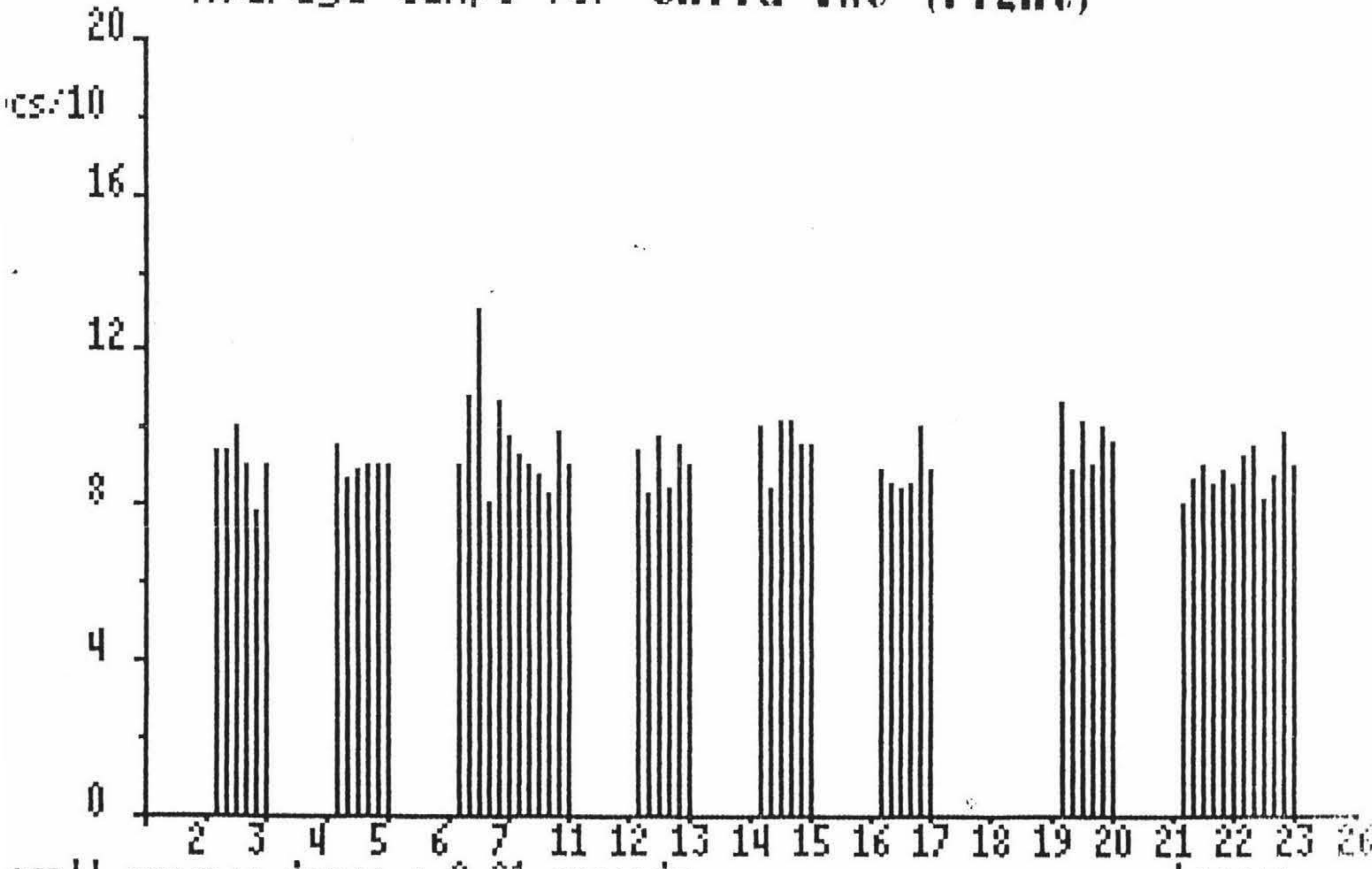
(v)

Average tempo for **Child Two (left)**

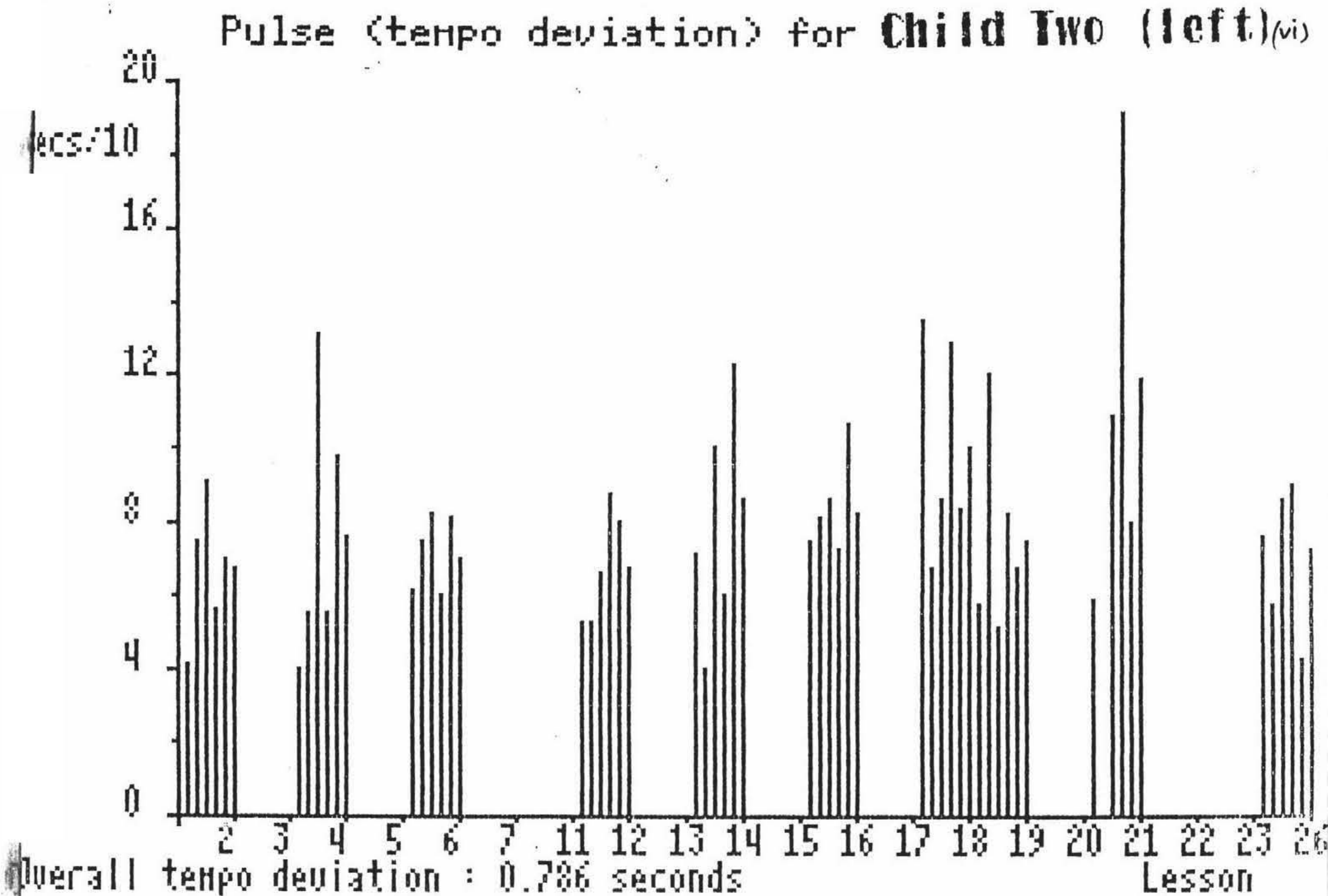


verall average tempo : 1.06 seconds

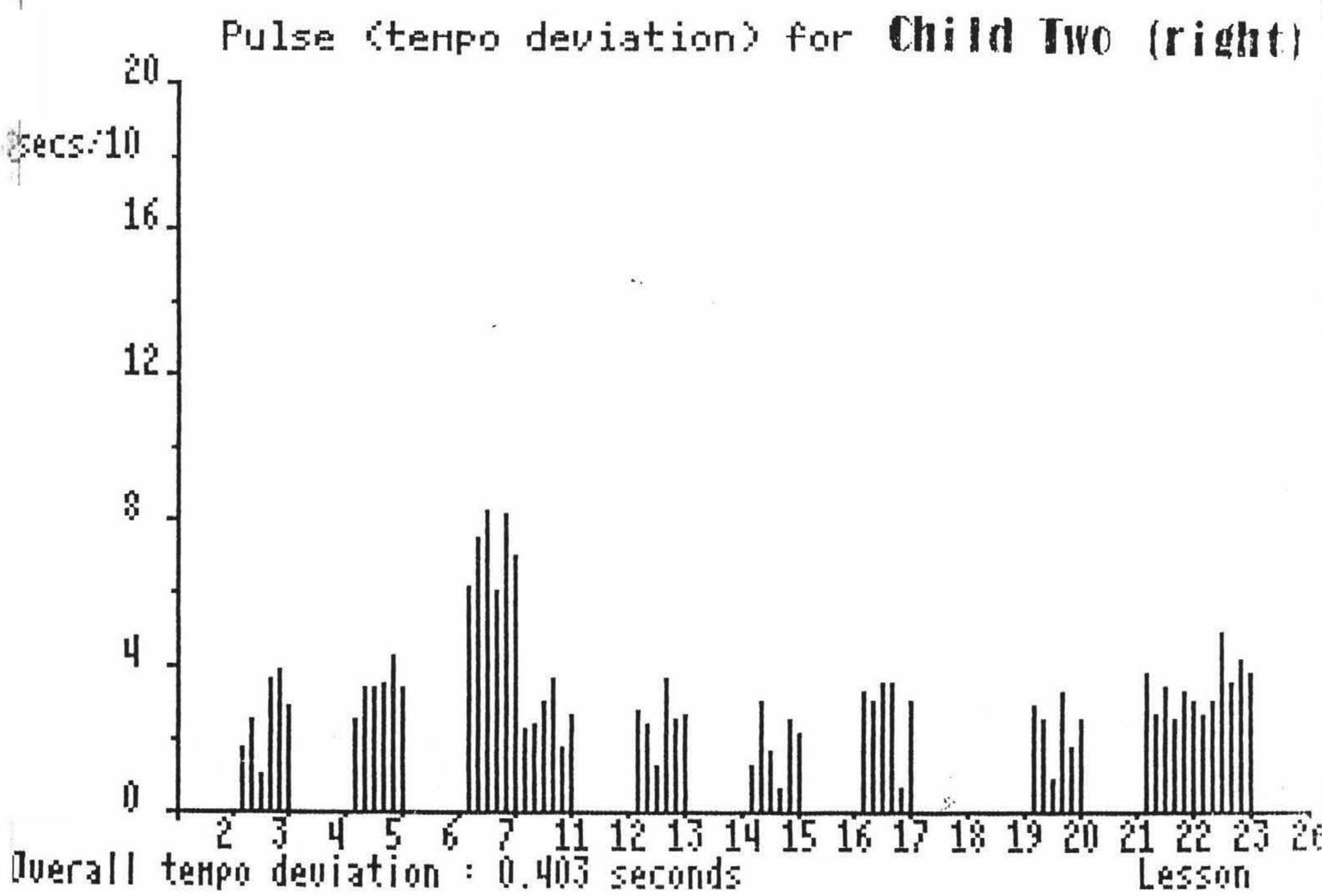
Average tempo for **Child Two (right)**



erall average tempo : 0.91 seconds

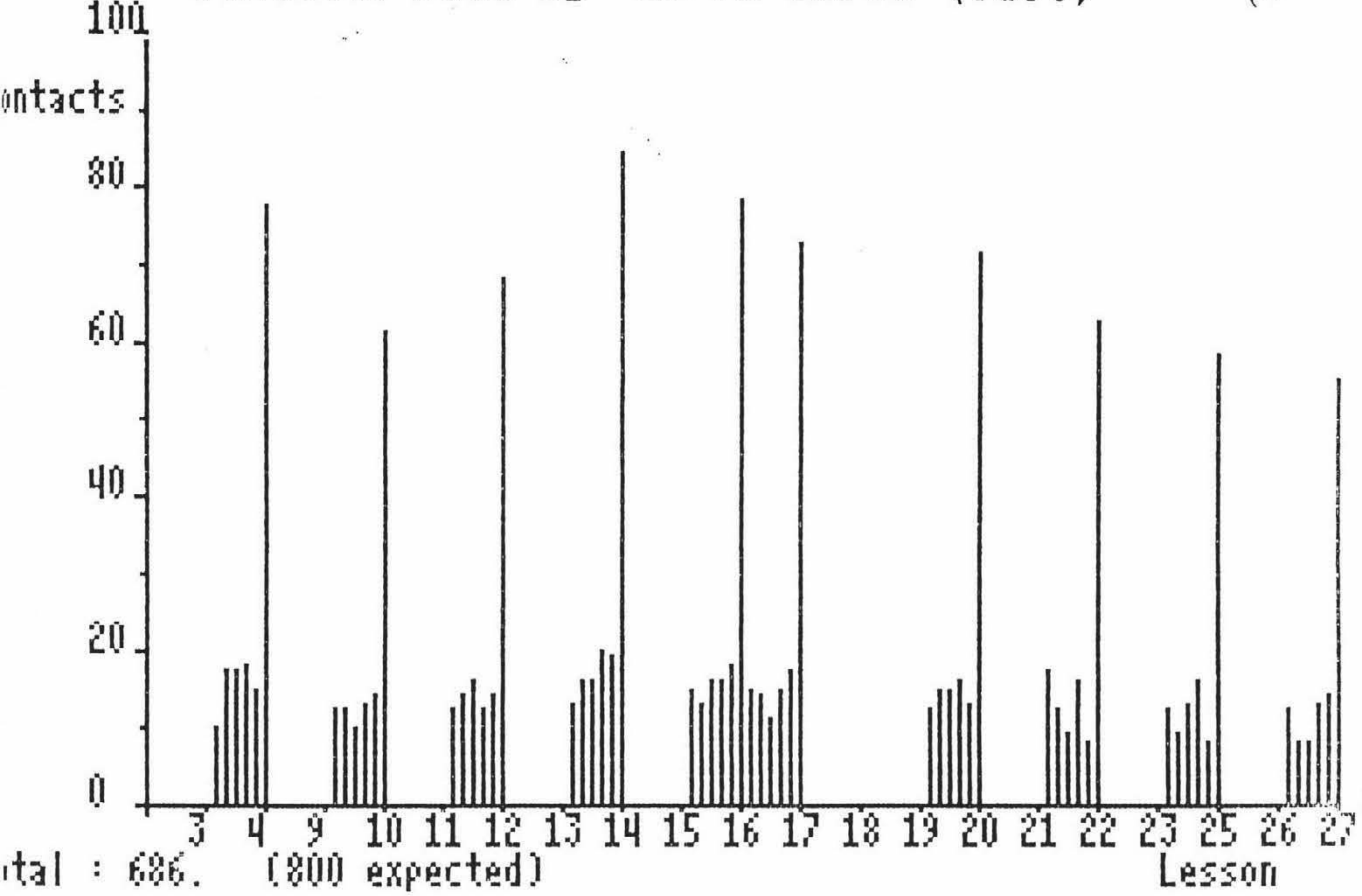


Pulse (tempo deviation) for Child Two (left)(vi)
20
secs/10
16
12
8
4
0
2 3 4 5 6 7 11 12 13 14 15 16 17 18 19 20 21 22 23 26
Overall tempo deviation : 0.786 seconds
Lesson

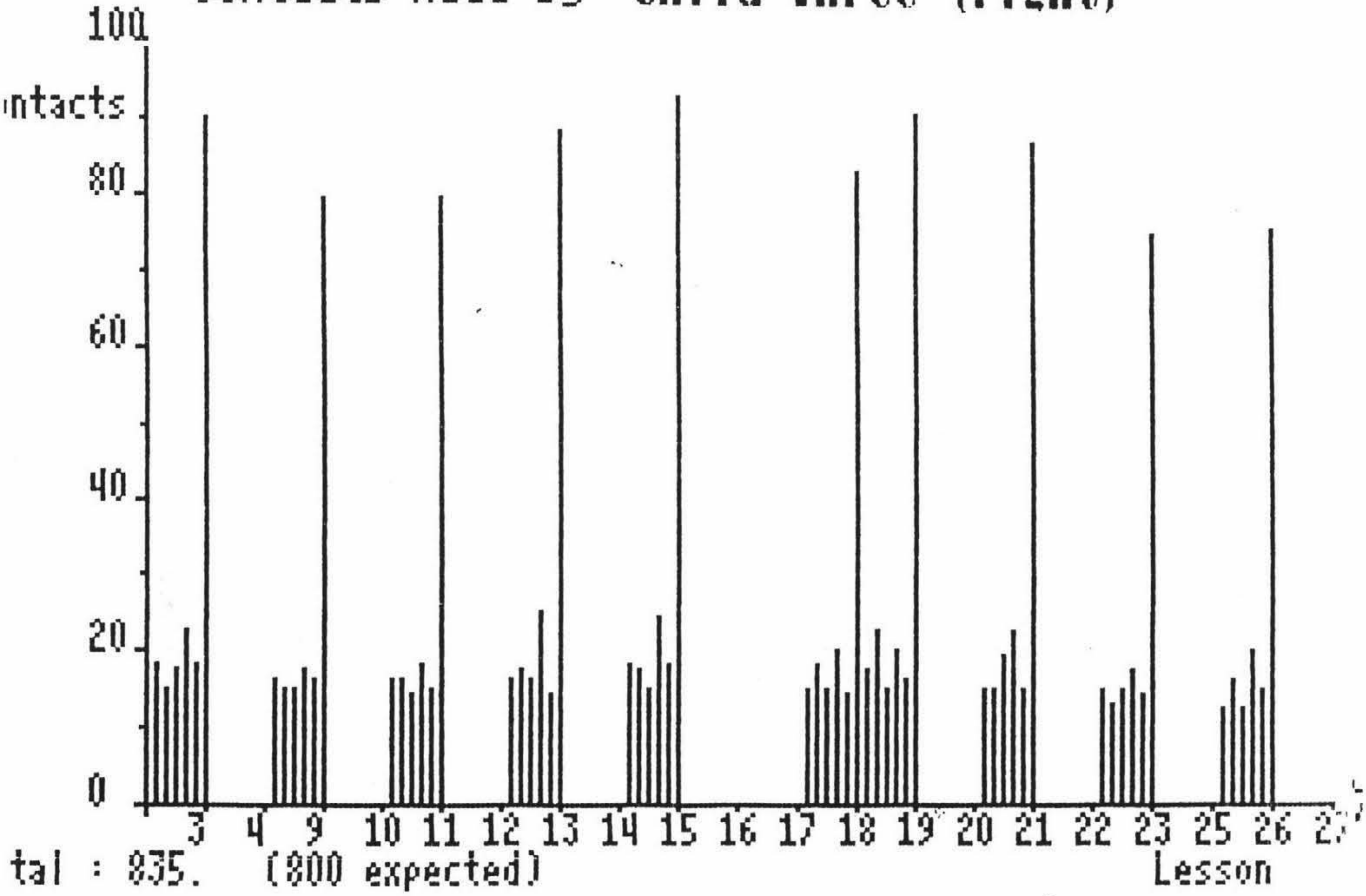


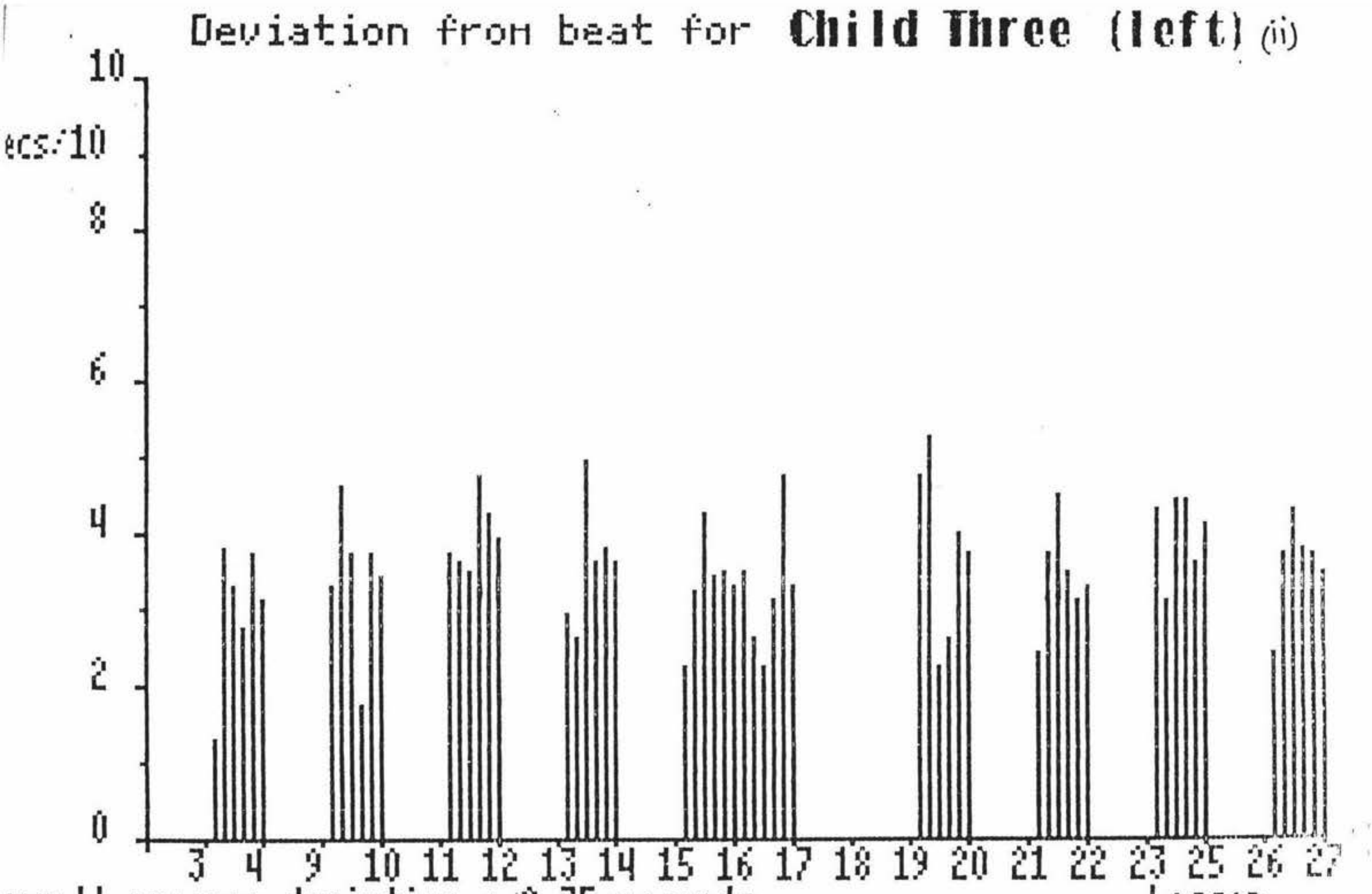
Pulse (tempo deviation) for Child Two (right)
20
secs/10
16
12
8
4
0
2 3 4 5 6 7 11 12 13 14 15 16 17 18 19 20 21 22 23 26
Overall tempo deviation : 0.403 seconds
Lesson

Contacts made by **Child Three (left)**

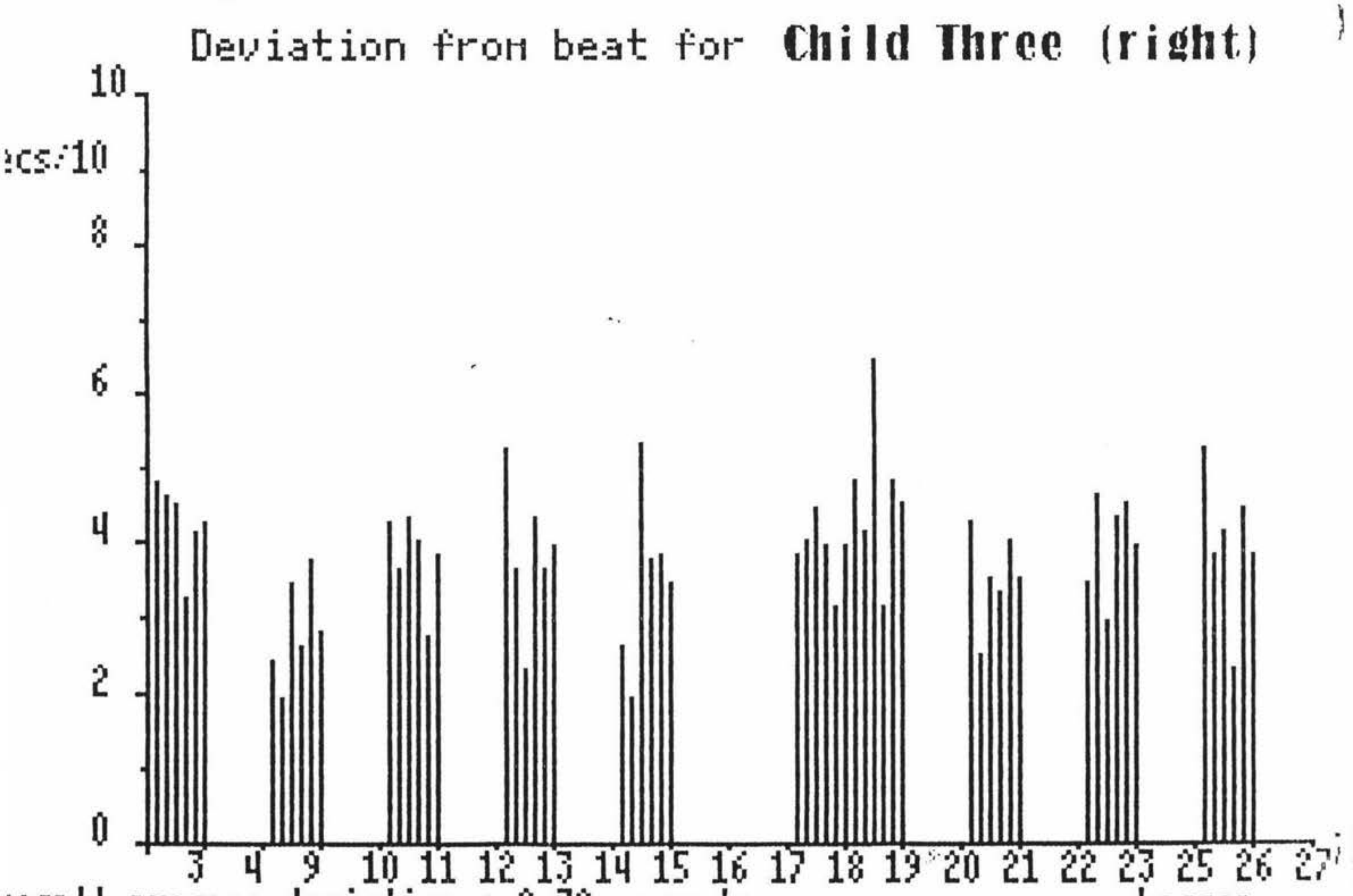


Contacts made by **Child Three (right)**



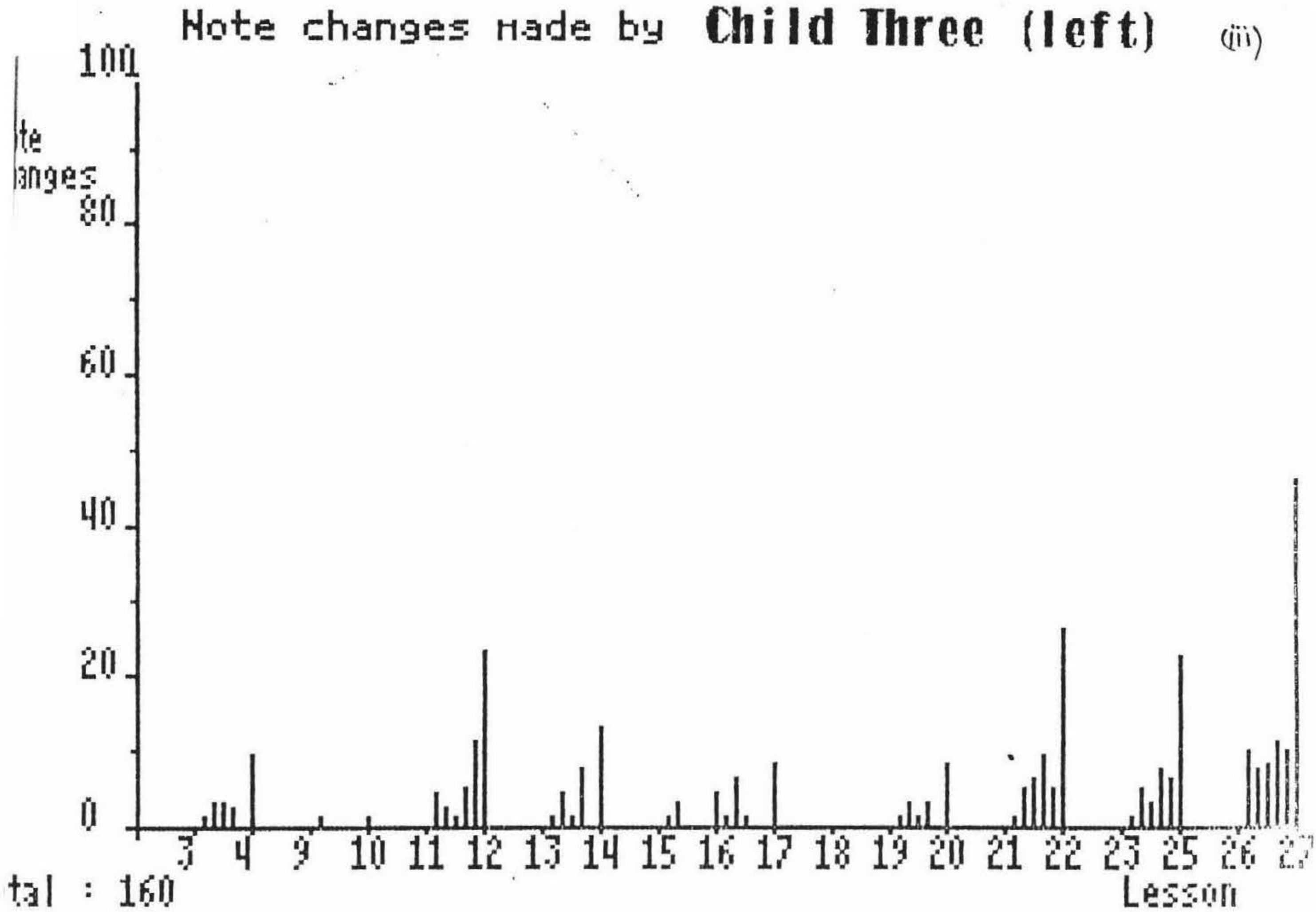


verall average deviation : 0.35 seconds

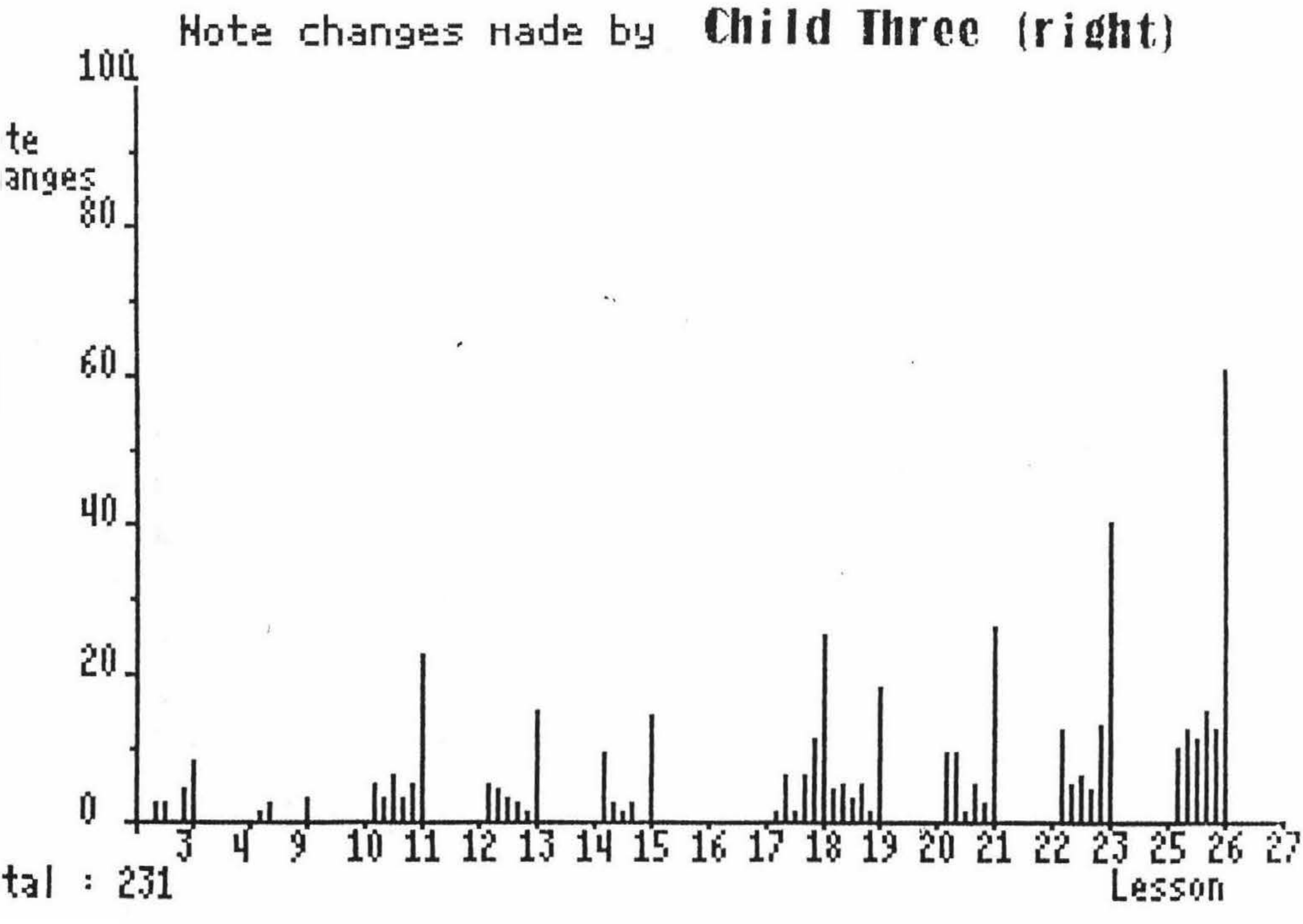


verall average deviation : 0.38 seconds

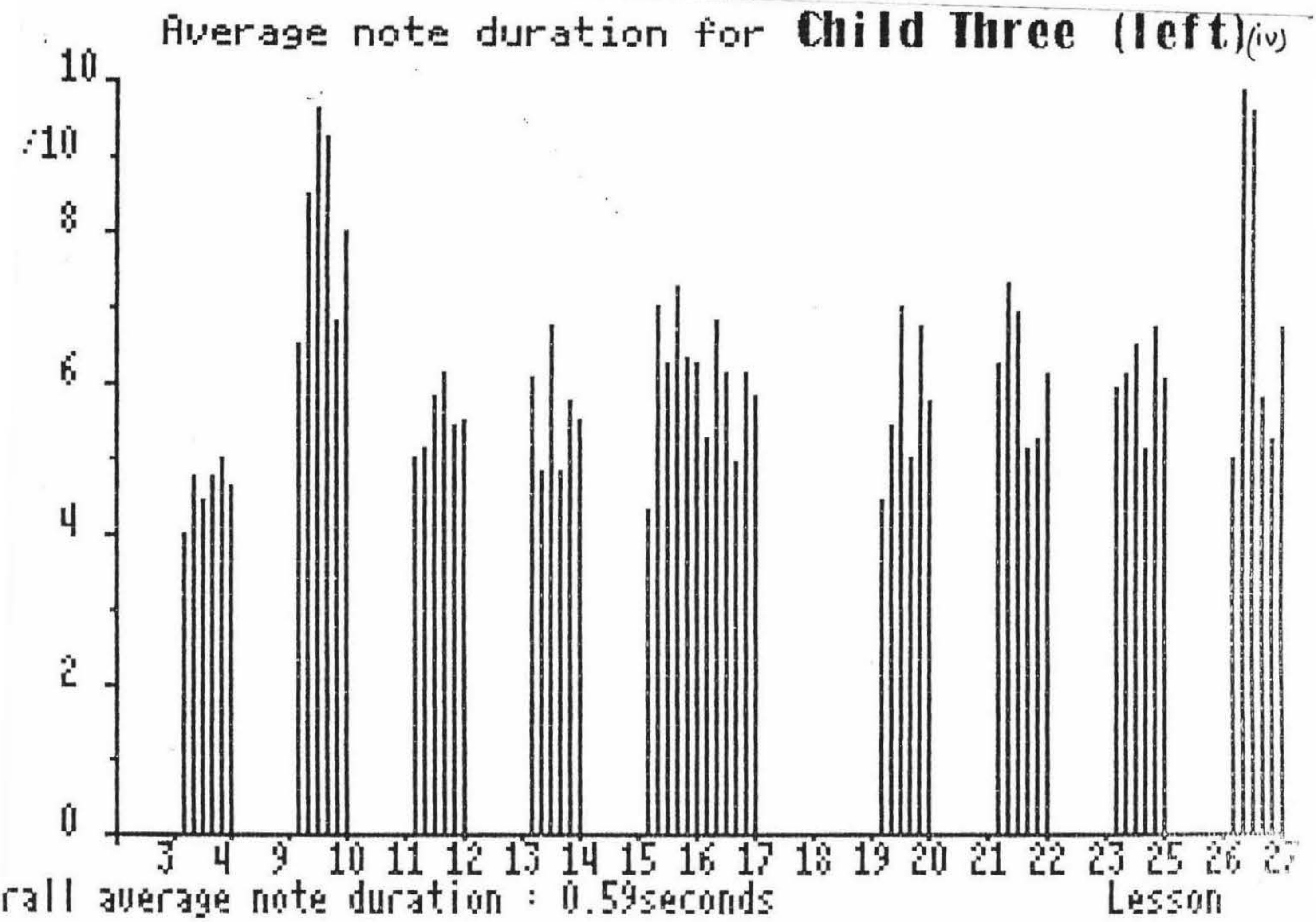
(iii)

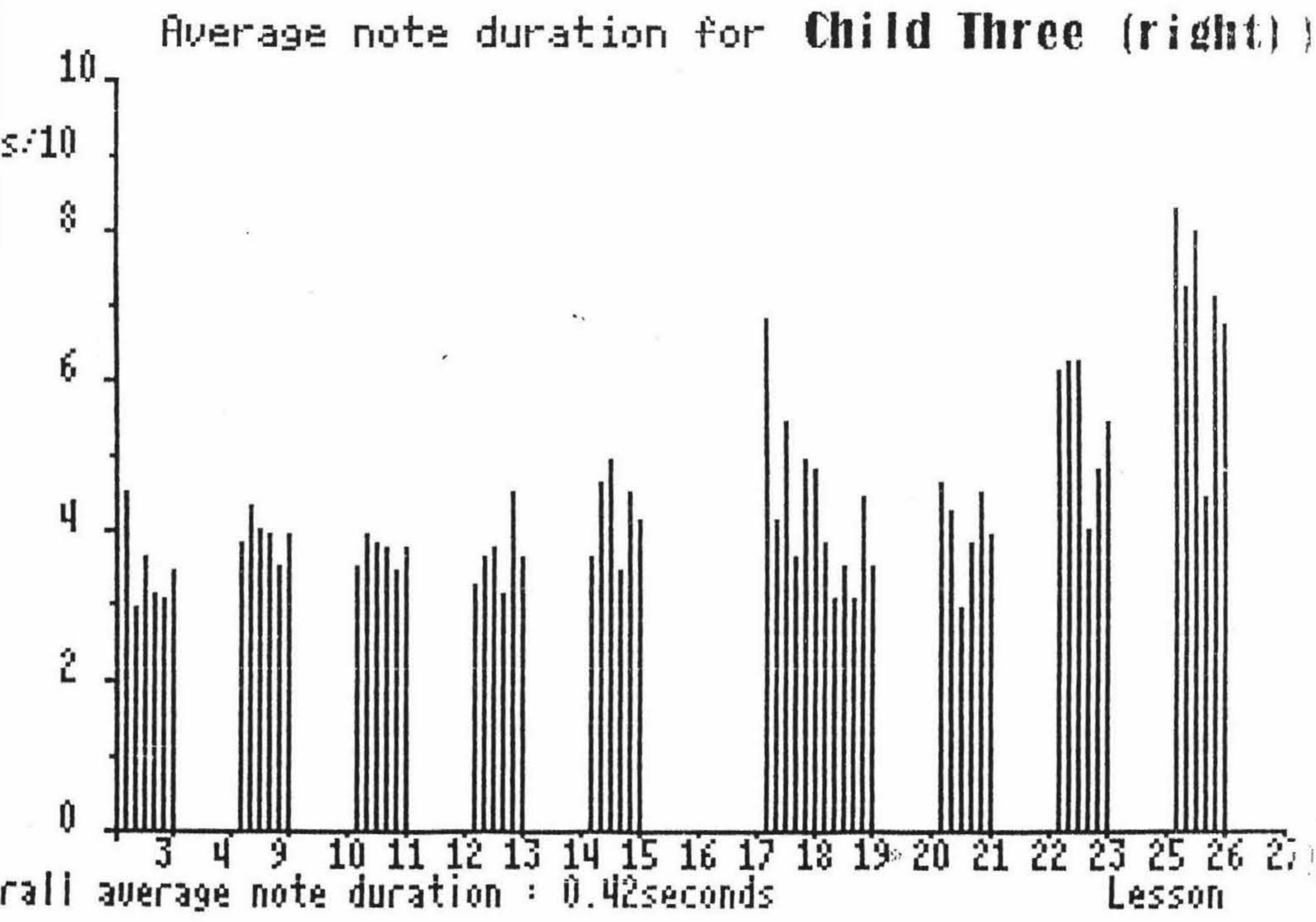


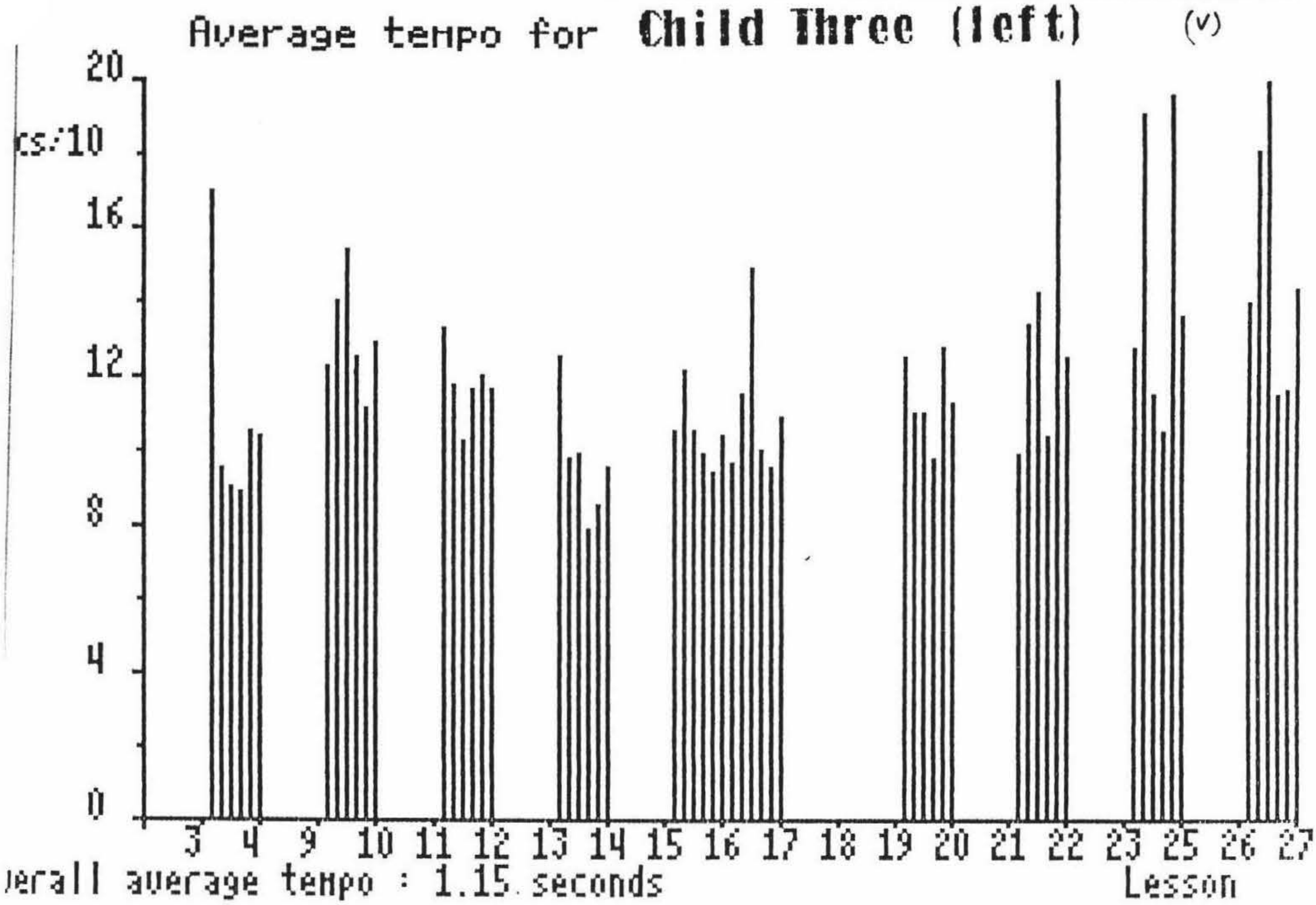
Note changes made by Child Three (left)
100
te
anges
80
60
40
20
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
tal : 160
Lesson



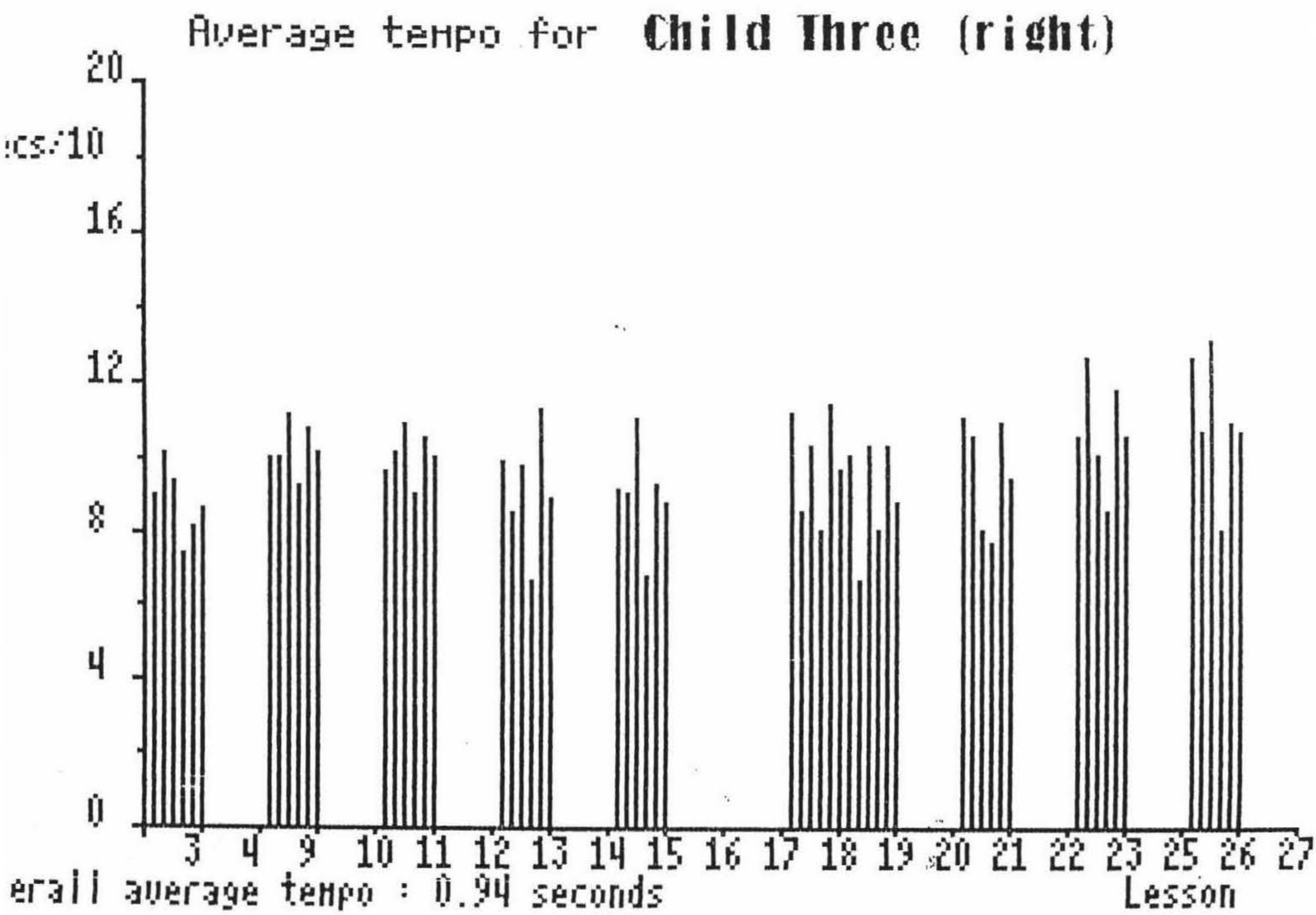
Note changes made by Child Three (right)
100
te
anges
80
60
40
20
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
tal : 231
Lesson


Average note duration for Child Three (left)(iv)
10
/10
8
6
4
2
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
rall average note duration : 0.59seconds
Lesson

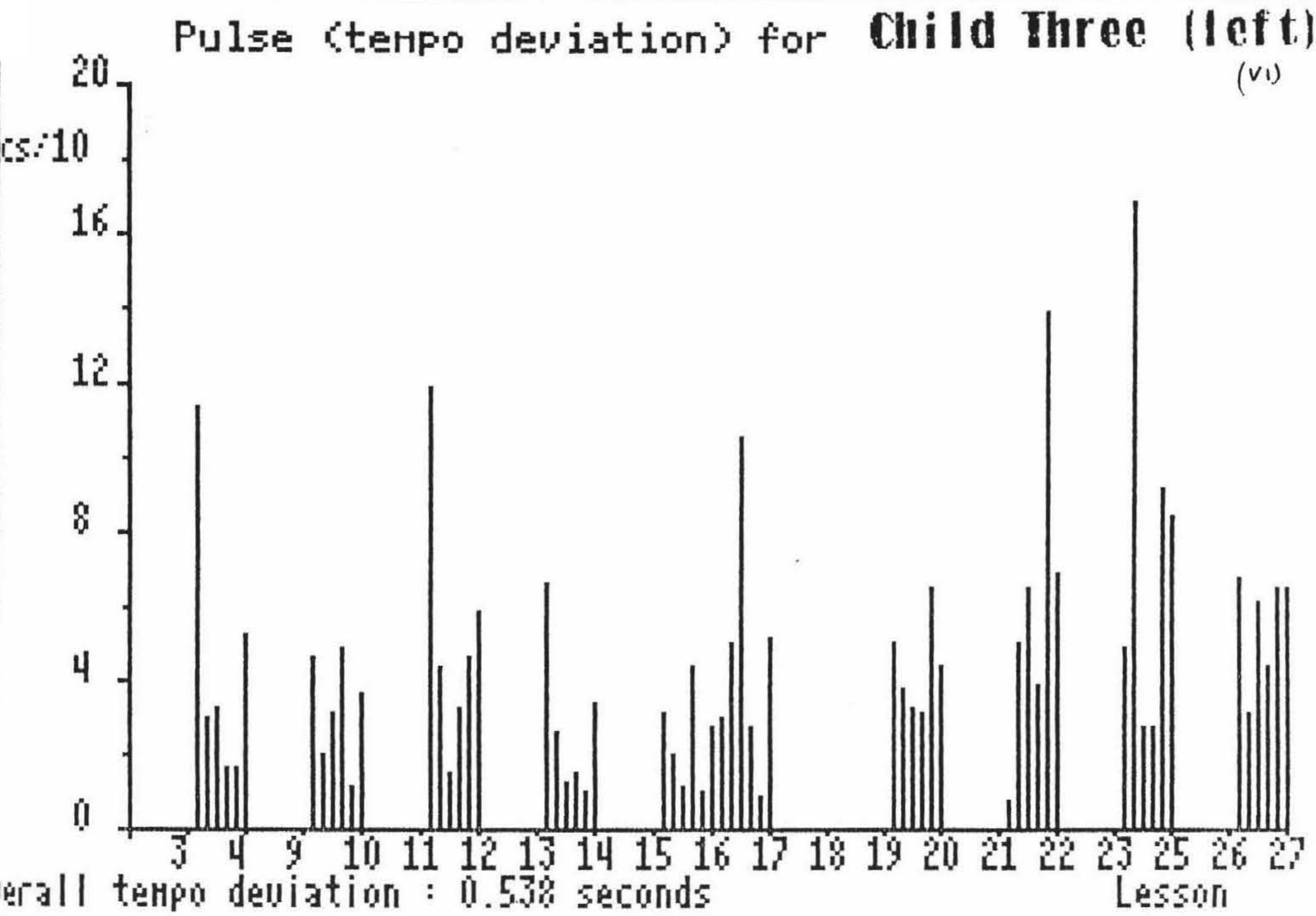

Average note duration for Child Three (right)
10
s/10
8
6
4
2
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
rall average note duration : 0.42seconds
Lesson

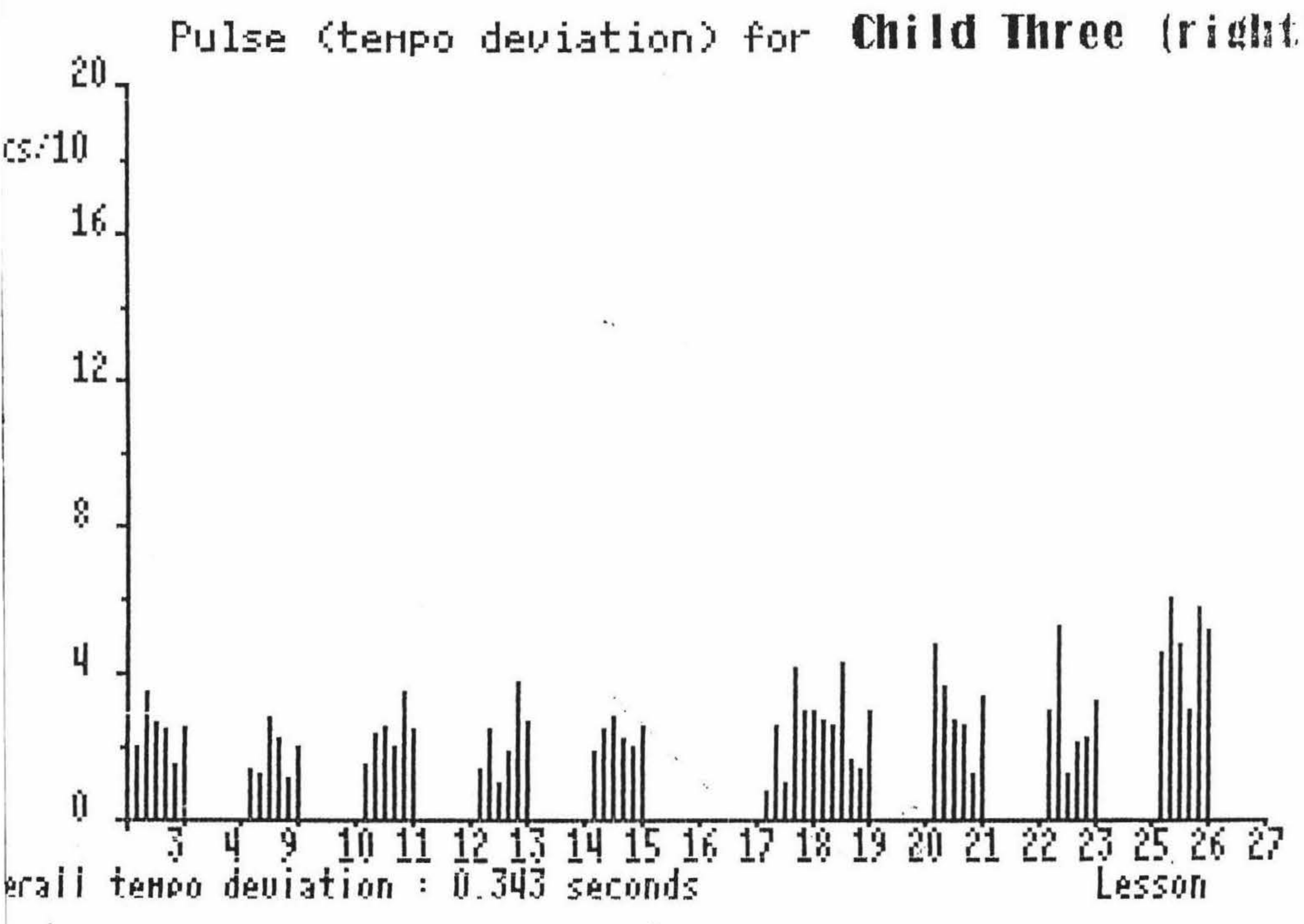


Average tempo for Child Three (left)
(v)
20
cs/10
16
12
8
4
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
verall average tempo : 1.15 seconds
Lesson



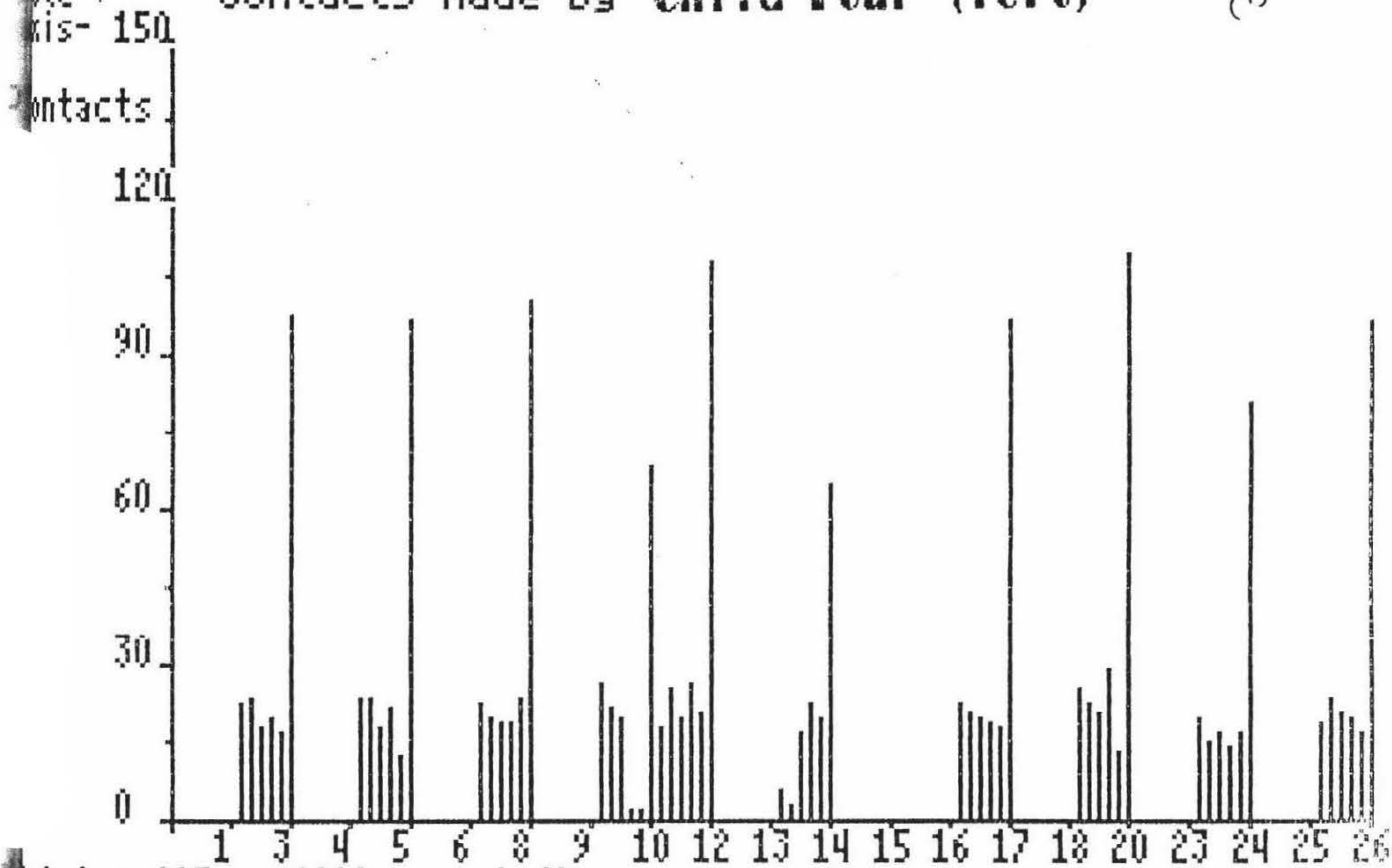
Average tempo for Child Three (right)
20
cs/10
16
12
8
4
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
erall average tempo : 0.94 seconds
Lesson


Pulse (tempo deviation) for Child Three (left)
(vi)
20
cs/10
16
12
8
4
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
erall tempo deviation : 0.538 seconds
Lesson


Pulse (tempo deviation) for Child Three (right)
20
cs/10
16
12
8
4
0
3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 25 26 27
erall tempo deviation : 0.343 seconds
Lesson

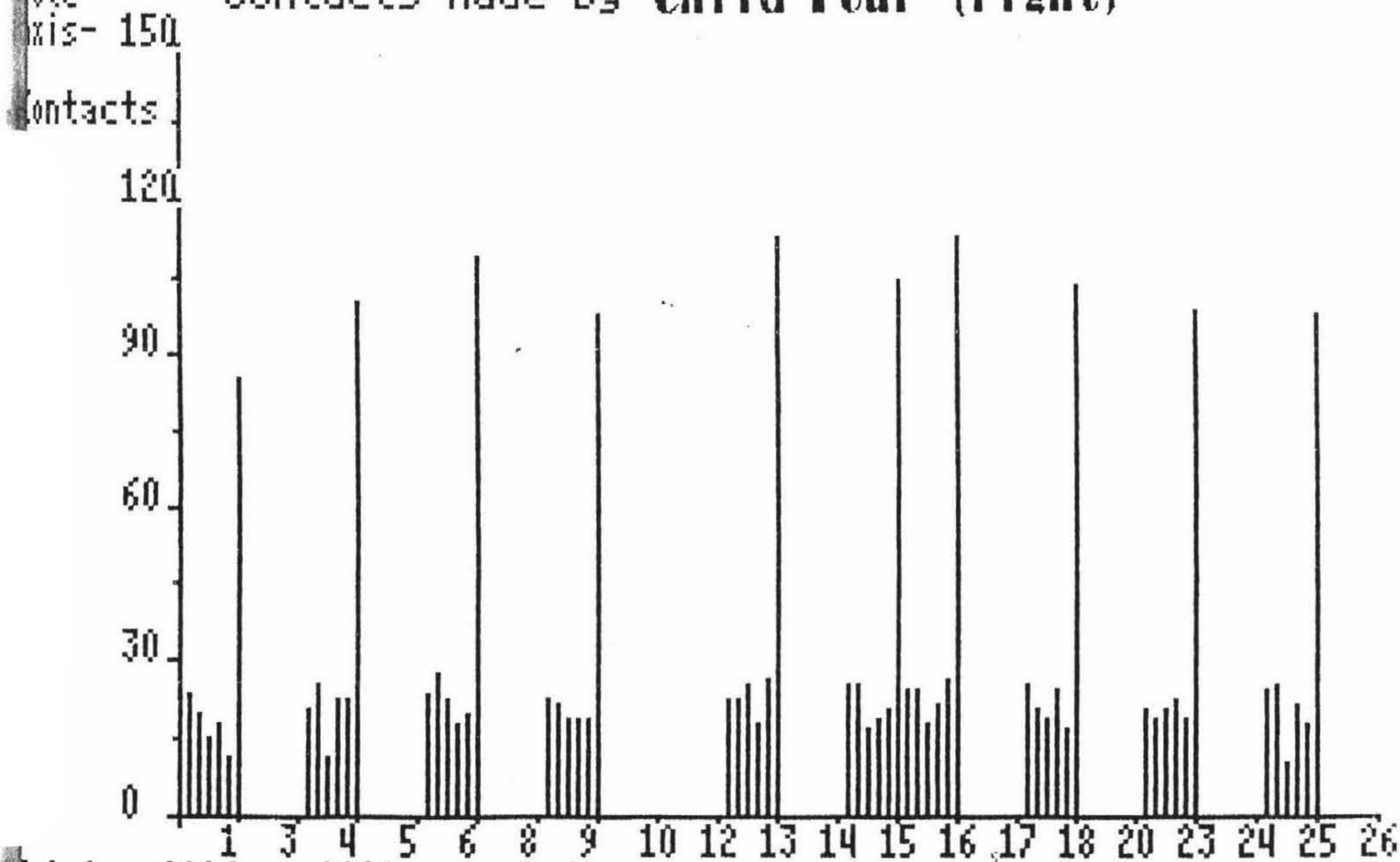
(i)

Contacts made by **Child Four (left)**

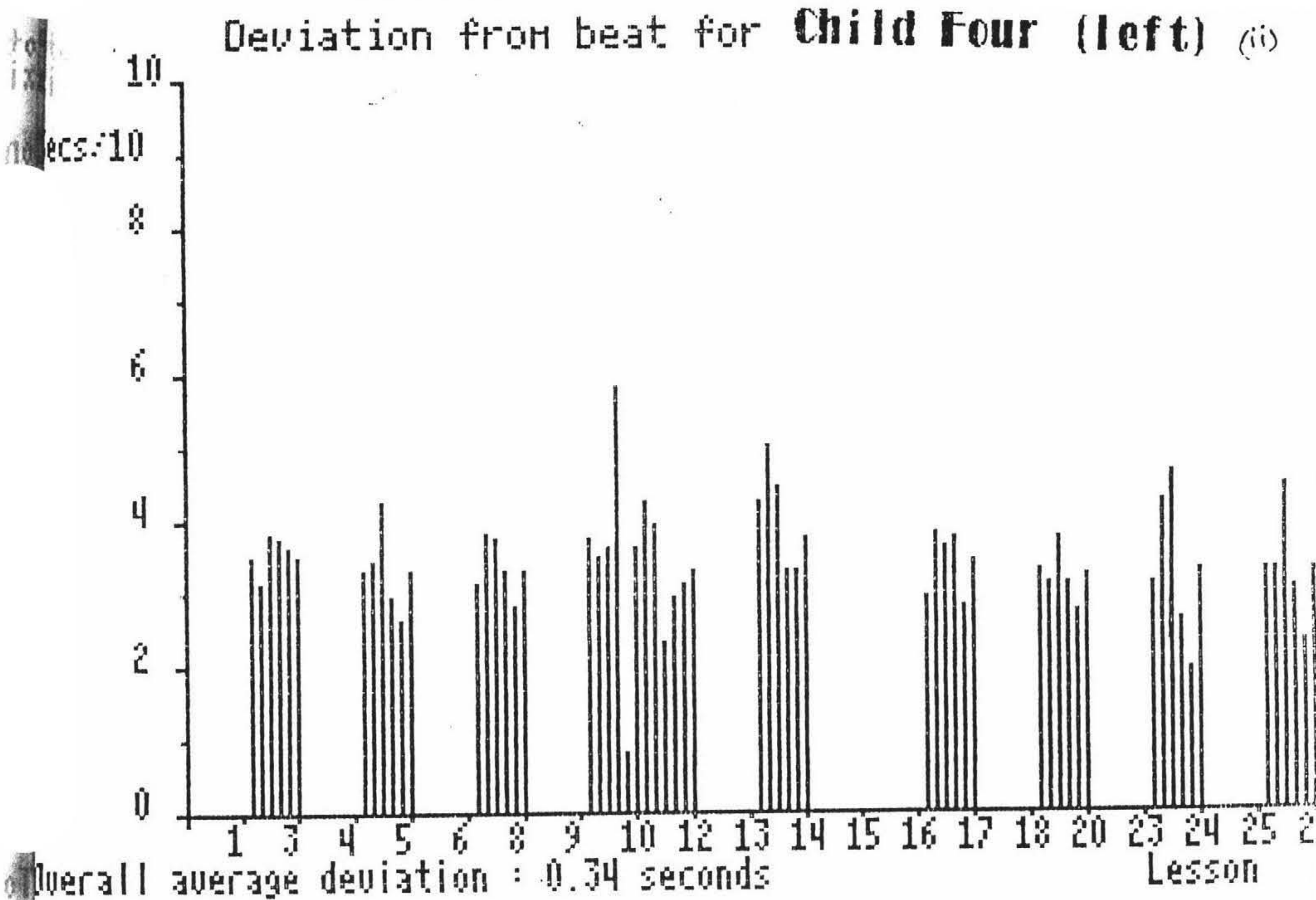


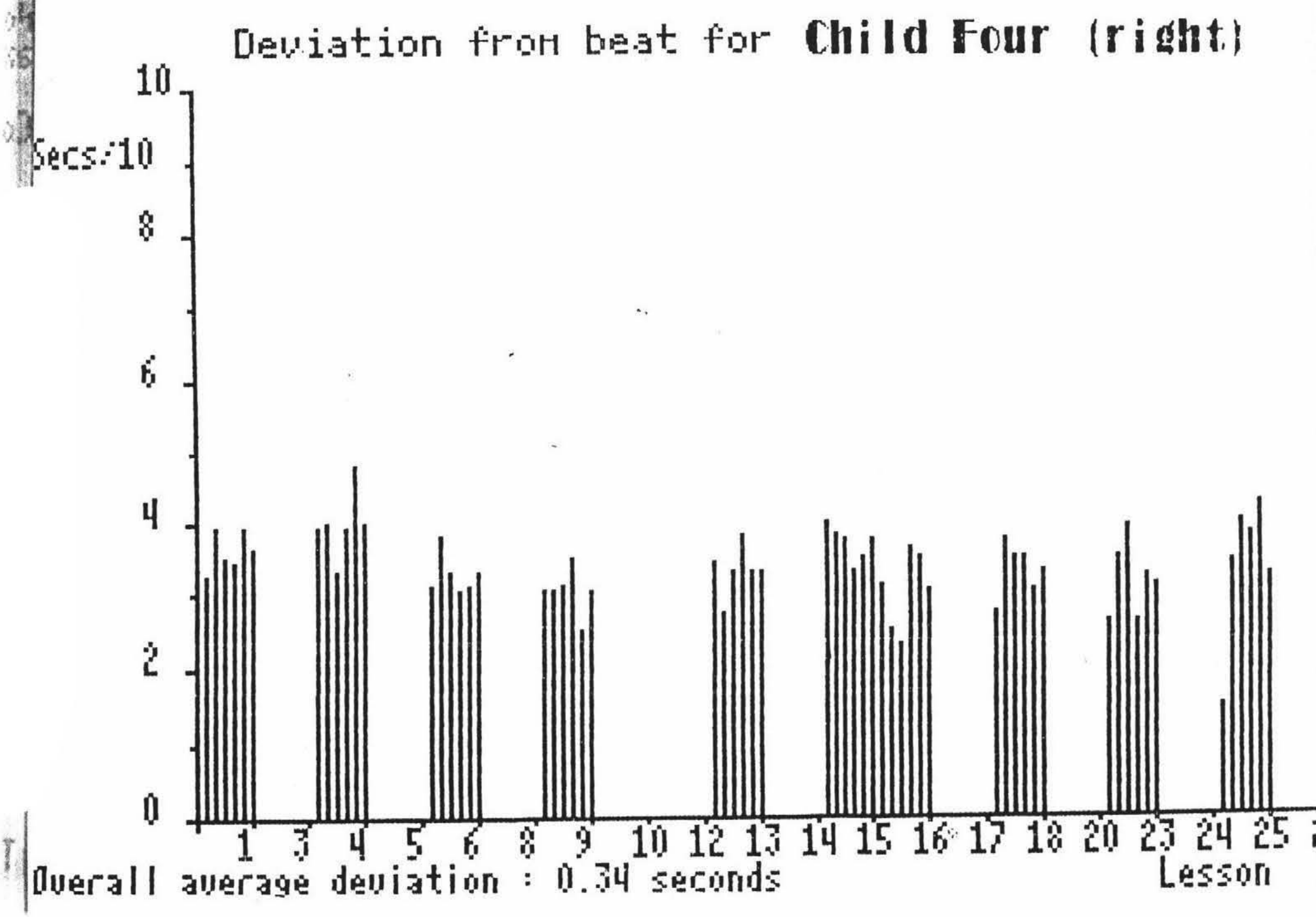
otal : 913. (800 expected)

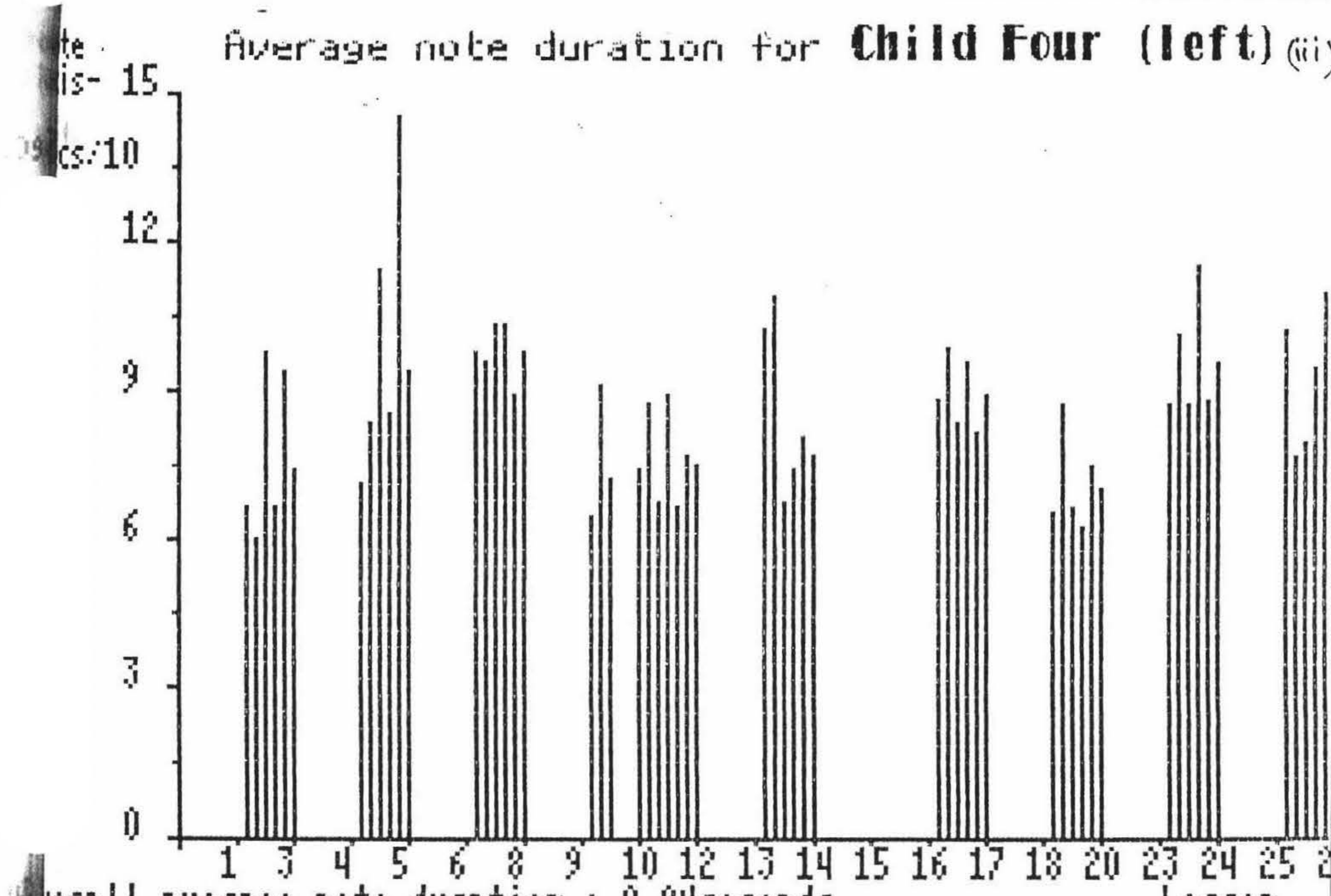
Contacts made by **Child Four (right)**



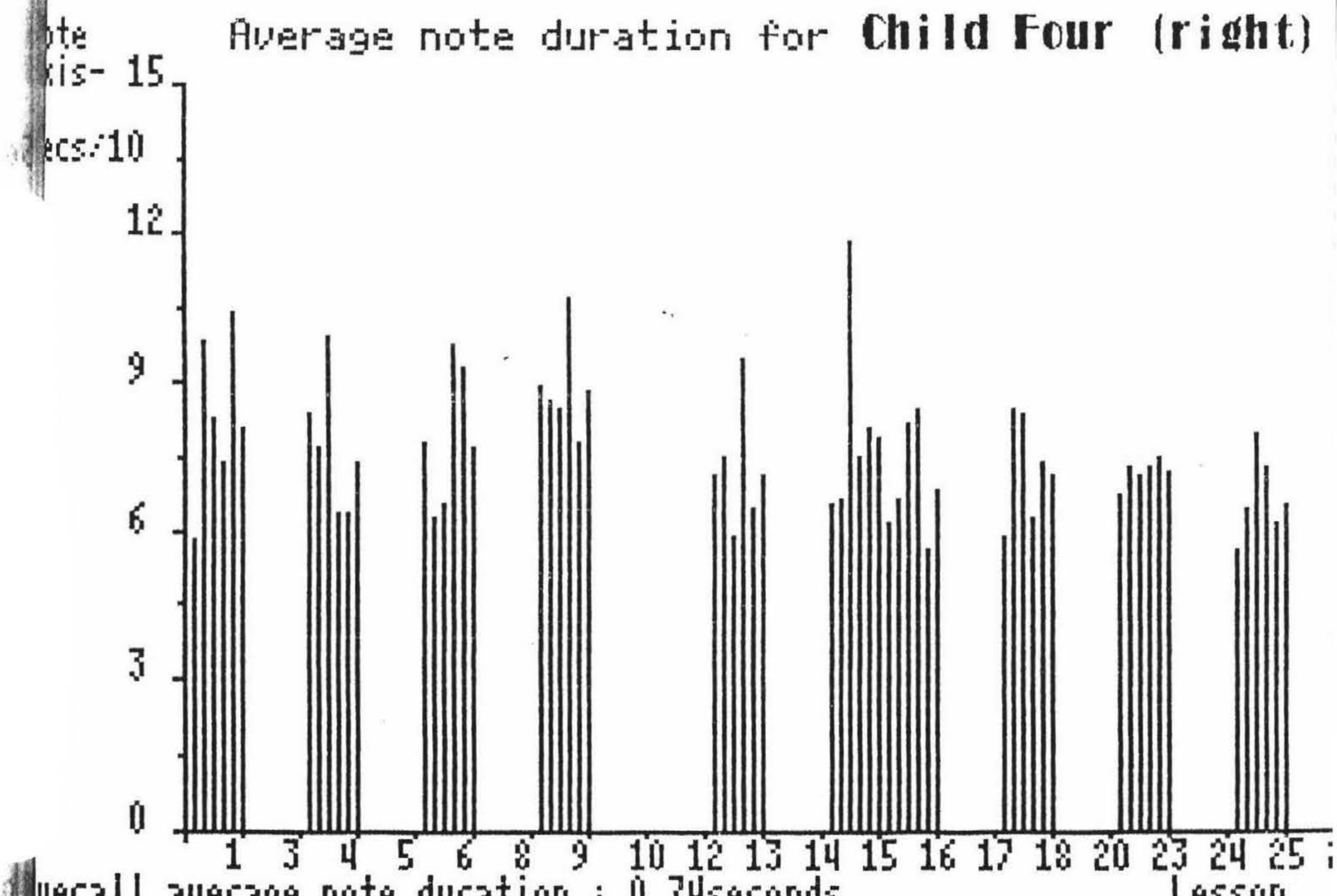
otal : 1016. (800 expected)


Deviation from beat for Child Four (left) (ii)
10
Secs/10
8
6
4
2
0
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25
Lesson
Overall average deviation : 0.34 seconds

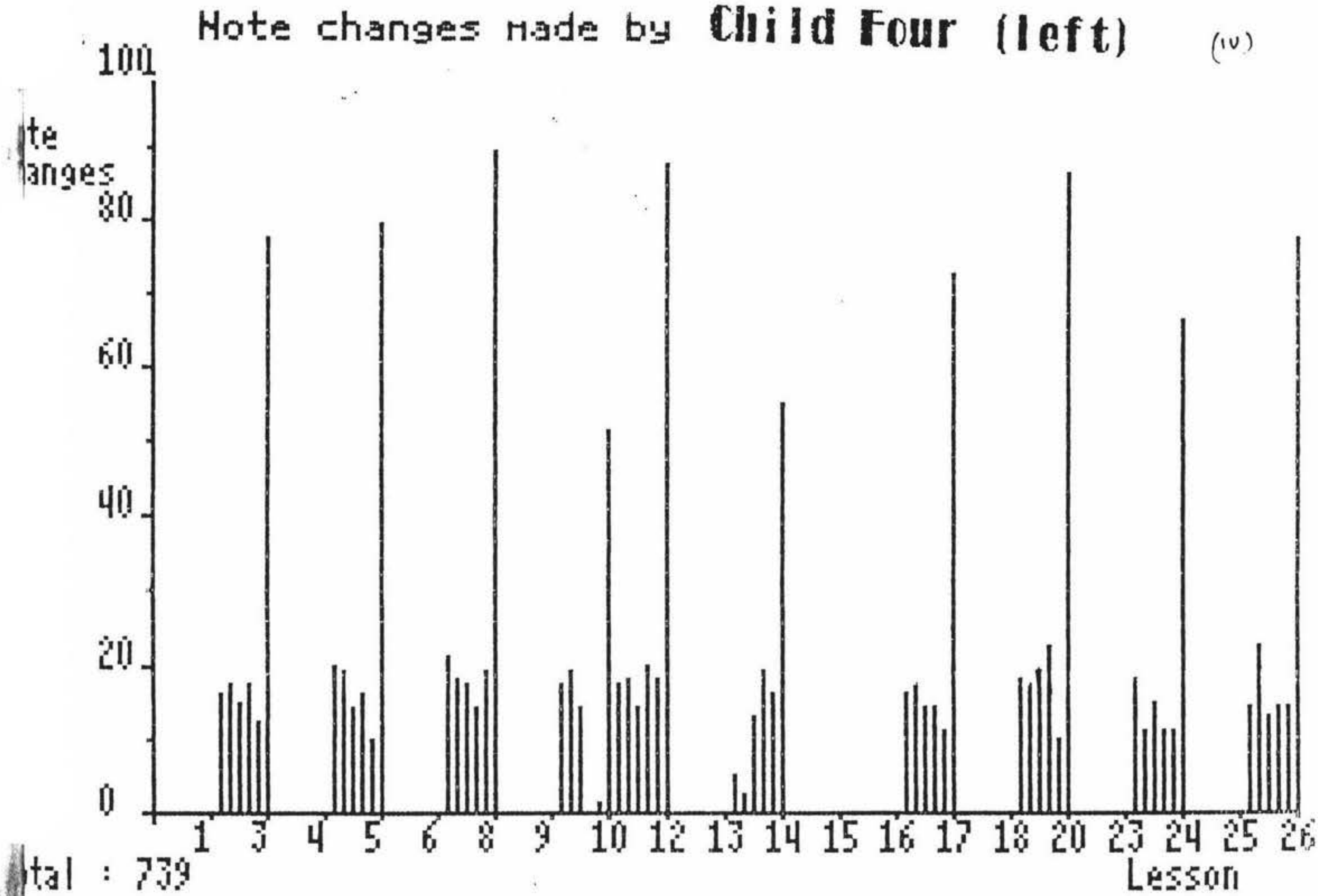

Deviation from beat for Child Four (right)
10
Secs/10
8
6
4
2
0
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25
Lesson
Overall average deviation : 0.34 seconds

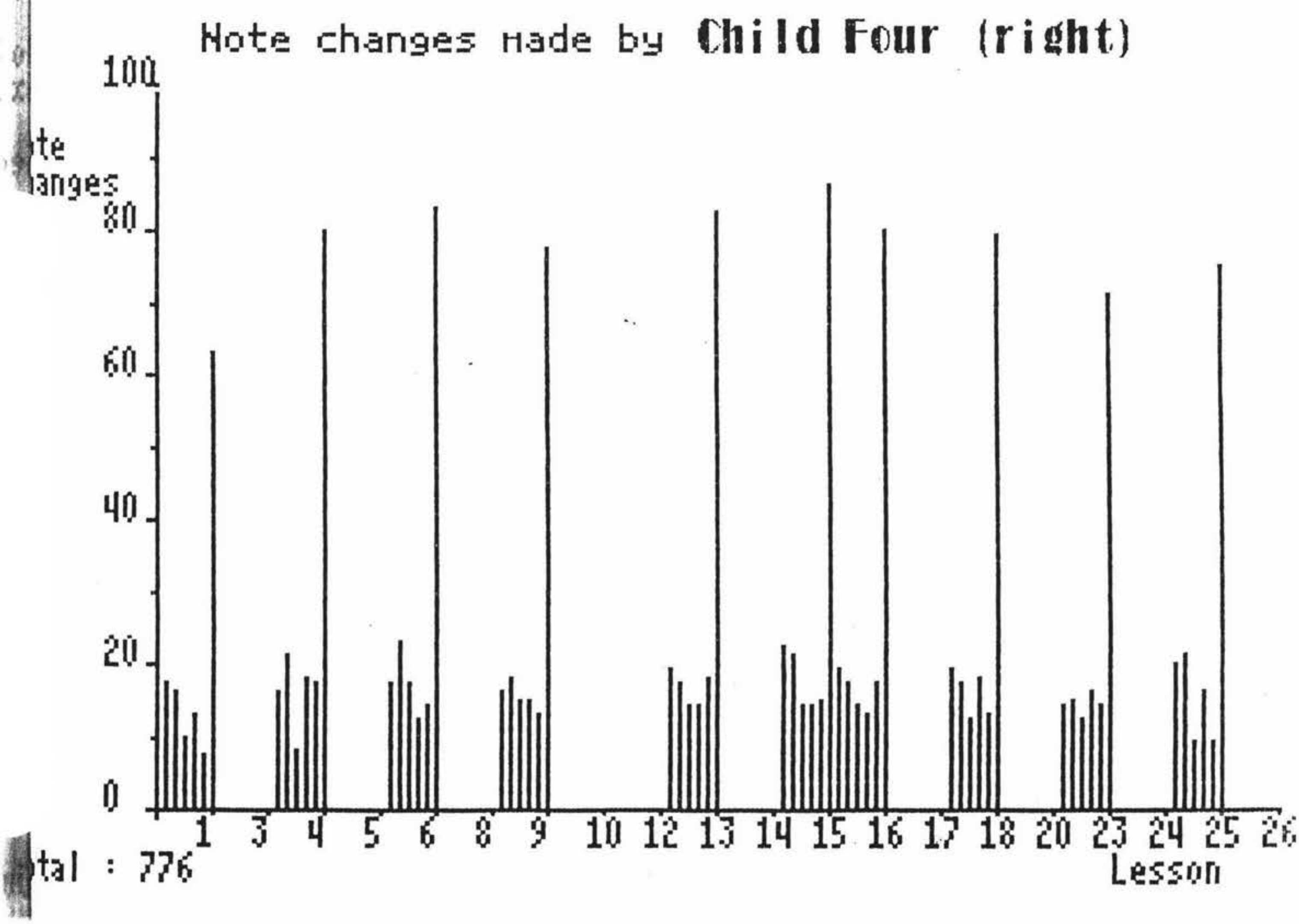


Overall average note duration : 0.84seconds

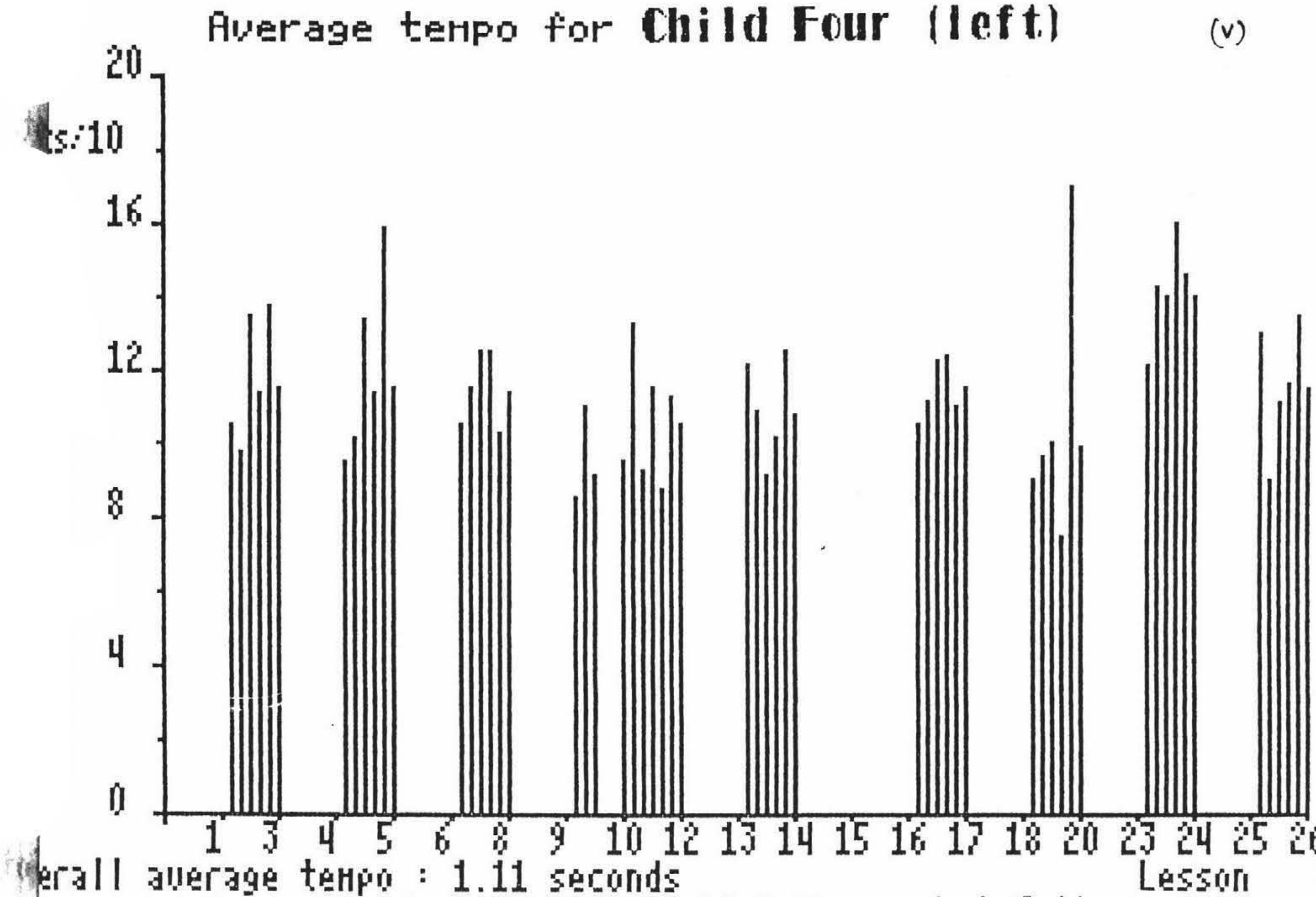


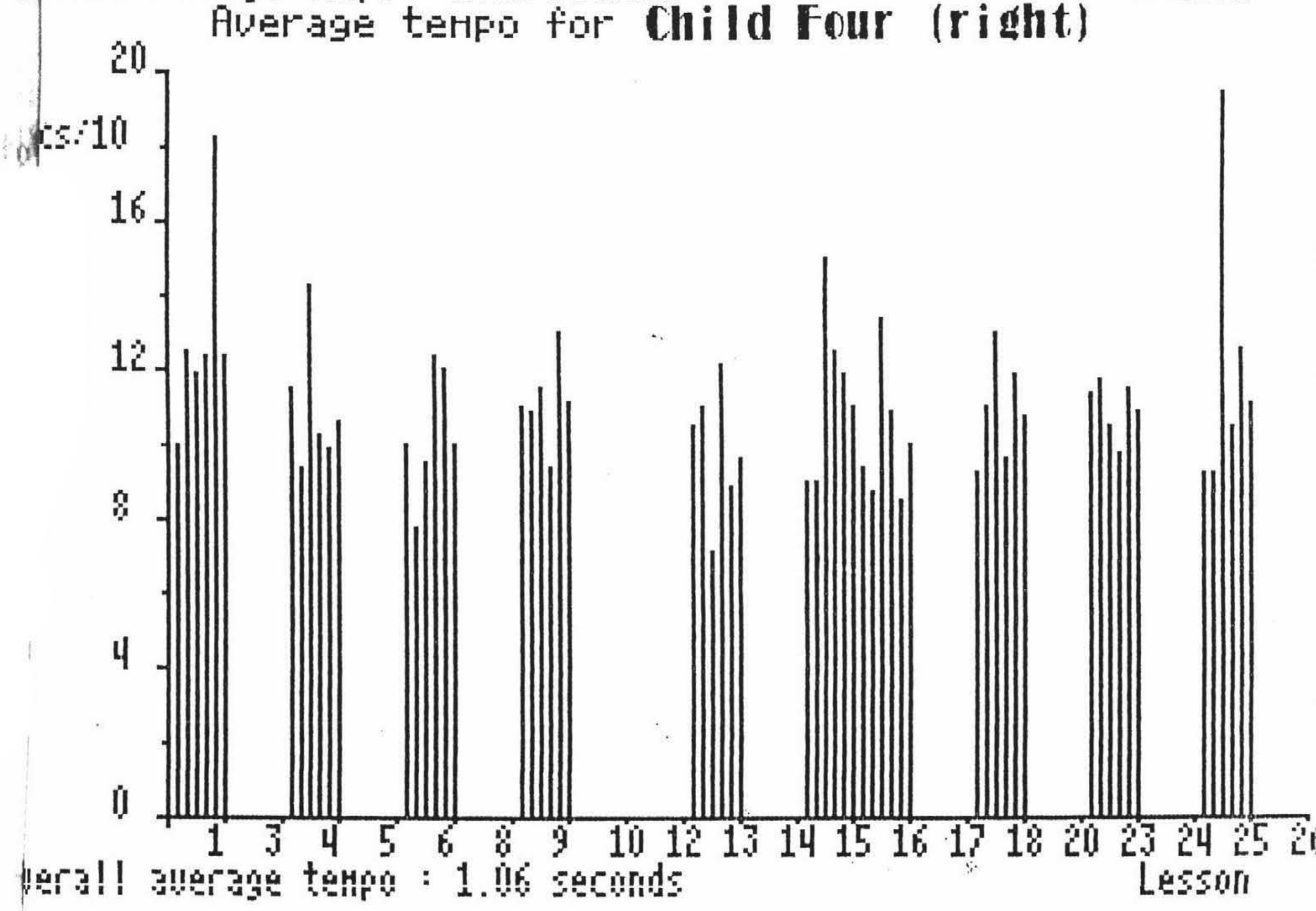
Overall average note duration : 0.74seconds

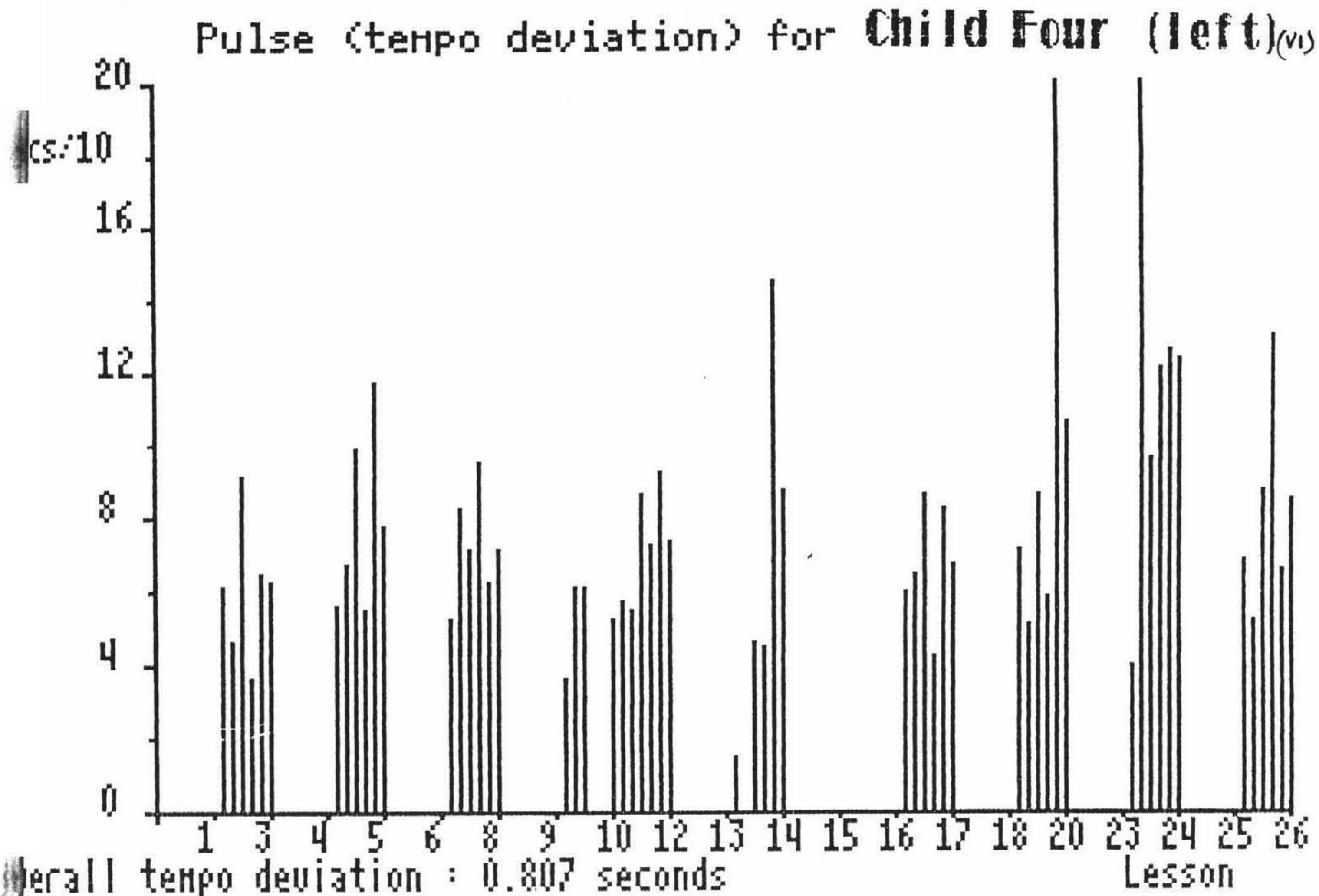

Note changes made by Child Four (left)
(iv)
100
80
60
40
20
0
te
anges
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25 26
tal : 739
Lesson

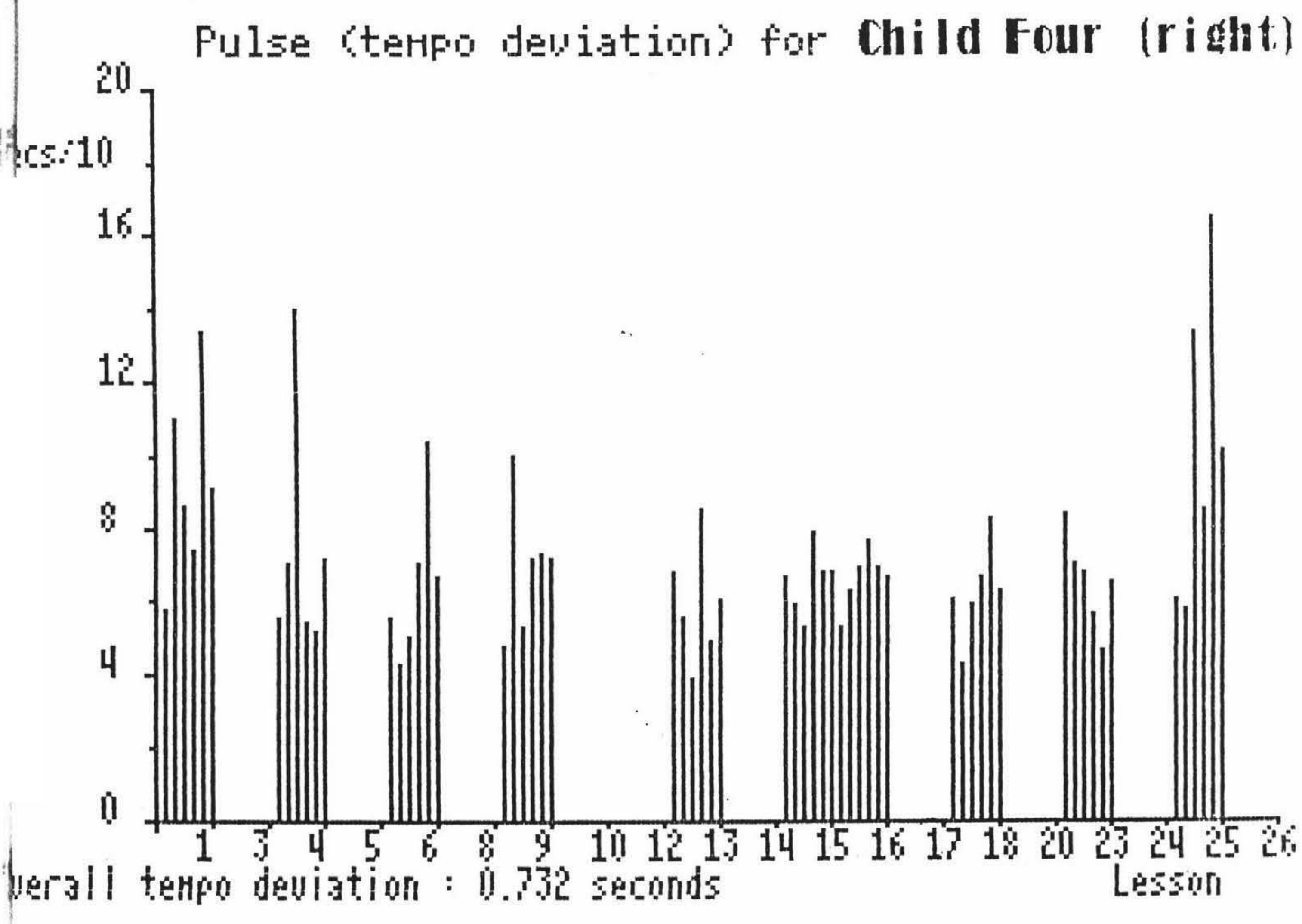

Note changes made by Child Four (right)
100
80
60
40
20
0
te
anges
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25 26
tal : 776
Lesson

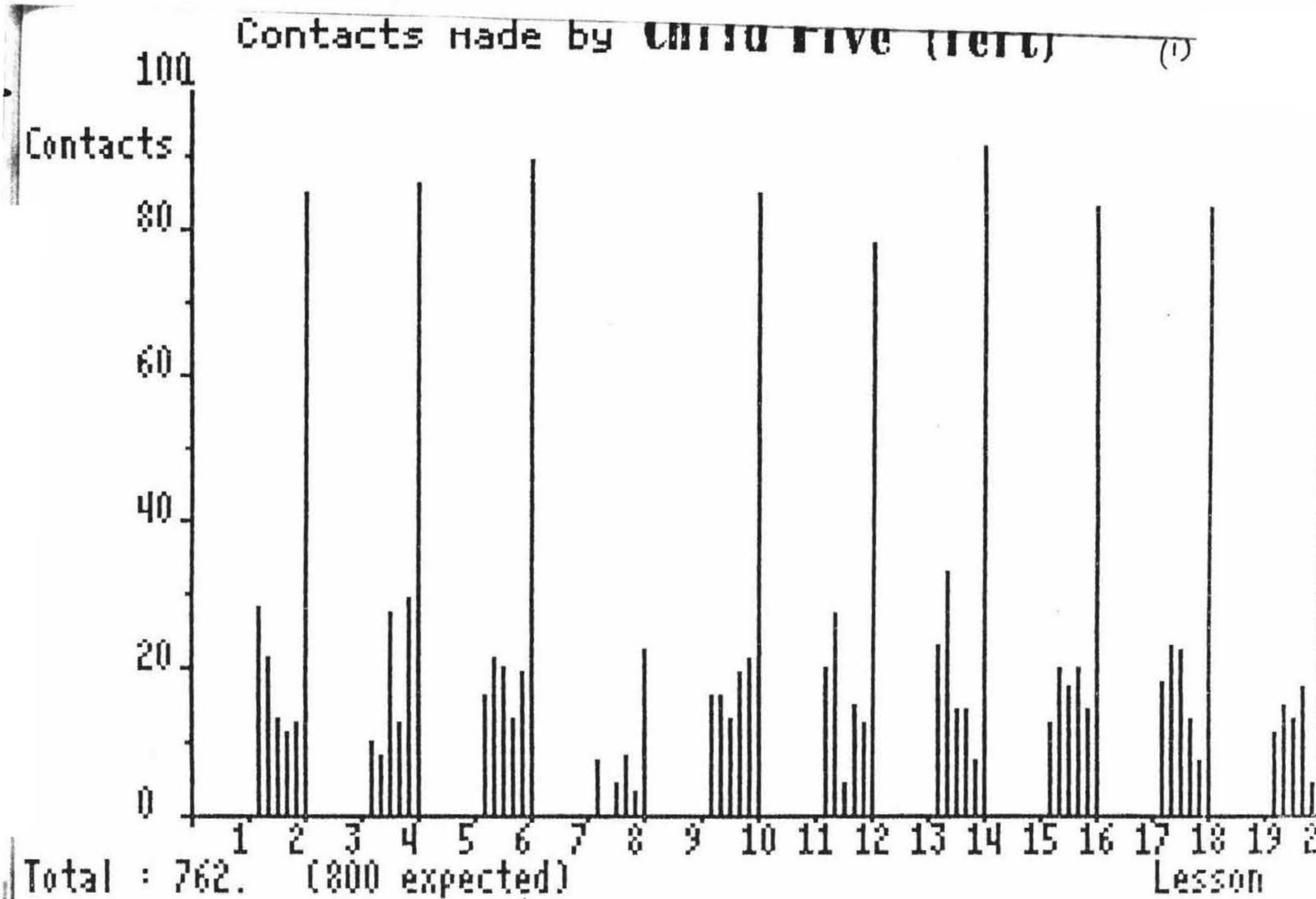
(v)


Average tempo for **Child Four (left)**
20
cs/10
16
12
8
4
0
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25
erall average tempo : 1.11 seconds
Lesson

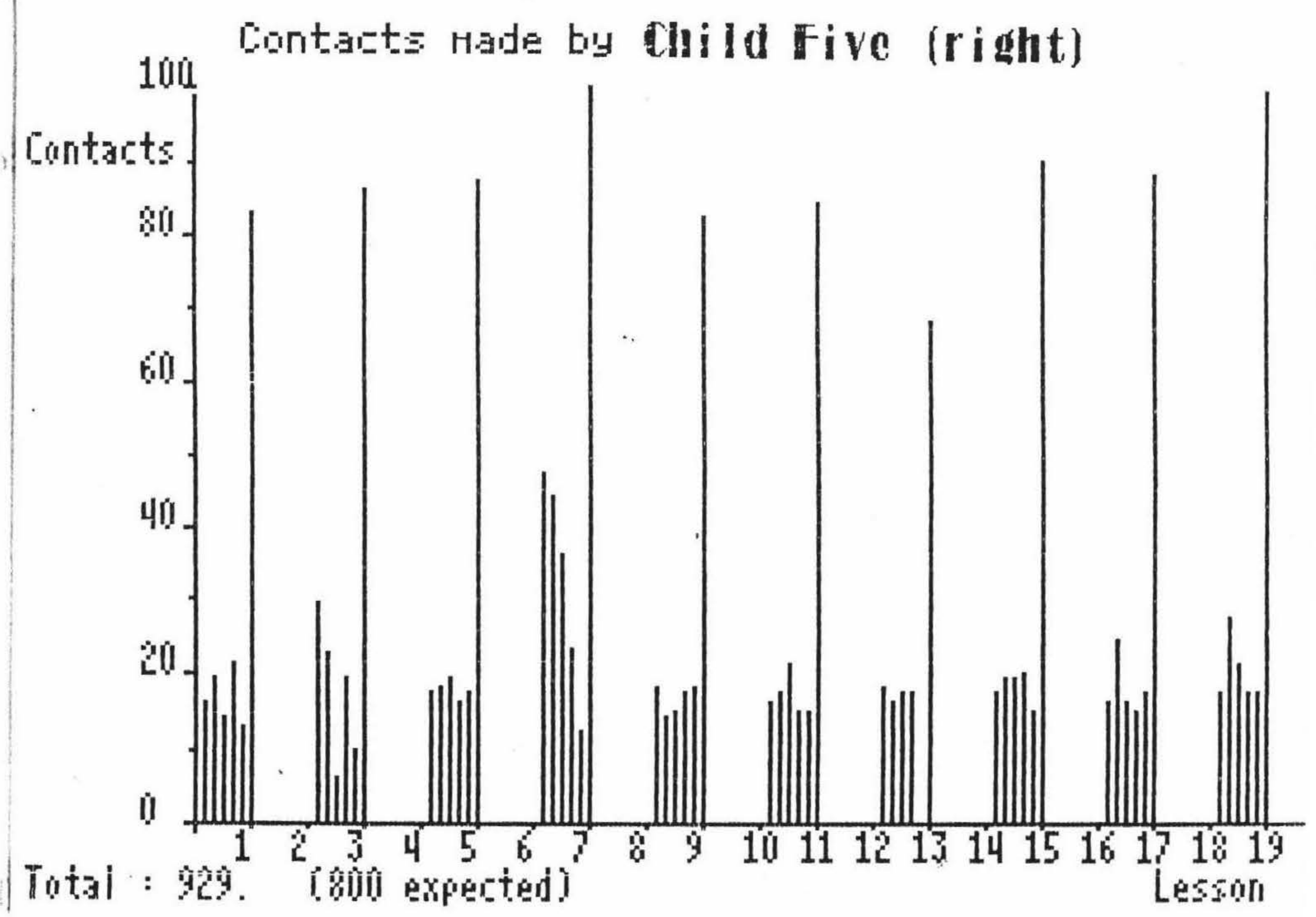

Average tempo for **Child Four (right)**
20
cs/10
16
12
8
4
0
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25
erall average tempo : 1.06 seconds
Lesson


Pulse (tempo deviation) for Child Four (left)
cs/10
20
16
12
8
4
0
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25 26
Lesson
erall tempo deviation : 0.807 seconds

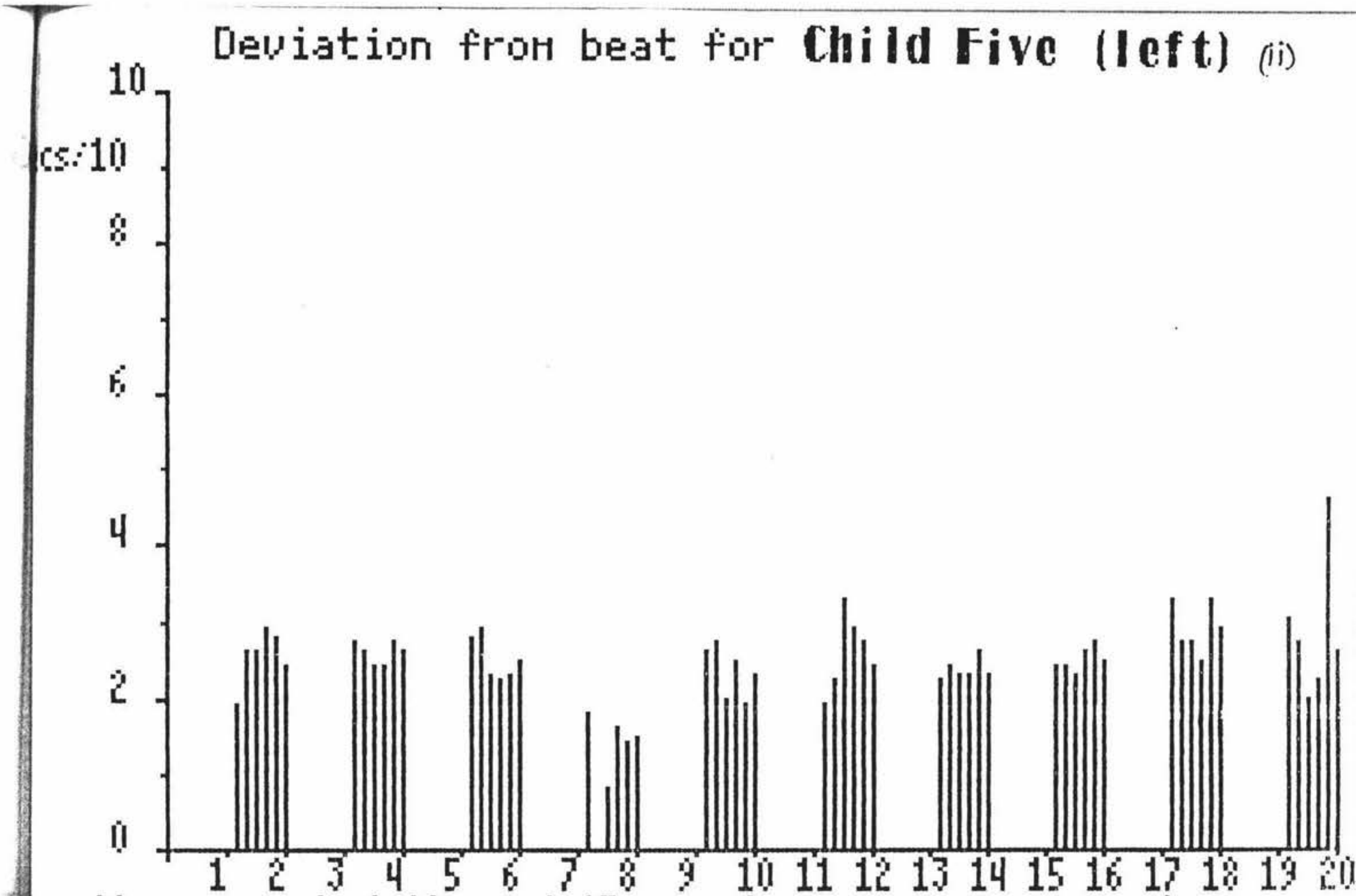

Pulse (tempo deviation) for Child Four (right)
cs/10
20
16
12
8
4
0
1 3 4 5 6 8 9 10 12 13 14 15 16 17 18 20 23 24 25 26
Lesson
erall tempo deviation : 0.732 seconds



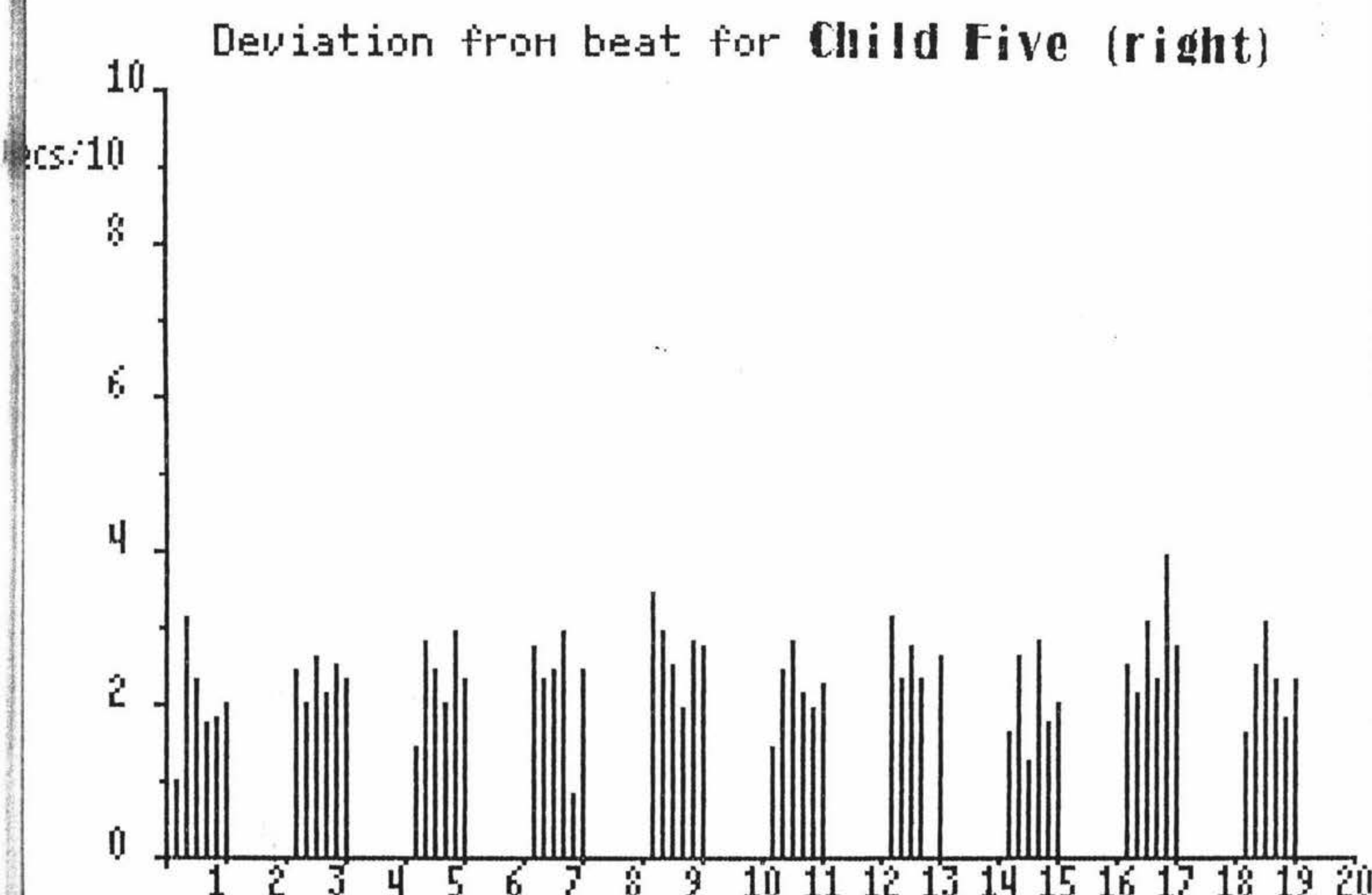
Contacts made by Child Five (left)
(1)
100
Contacts
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Total : 762. (800 expected)
Lesson



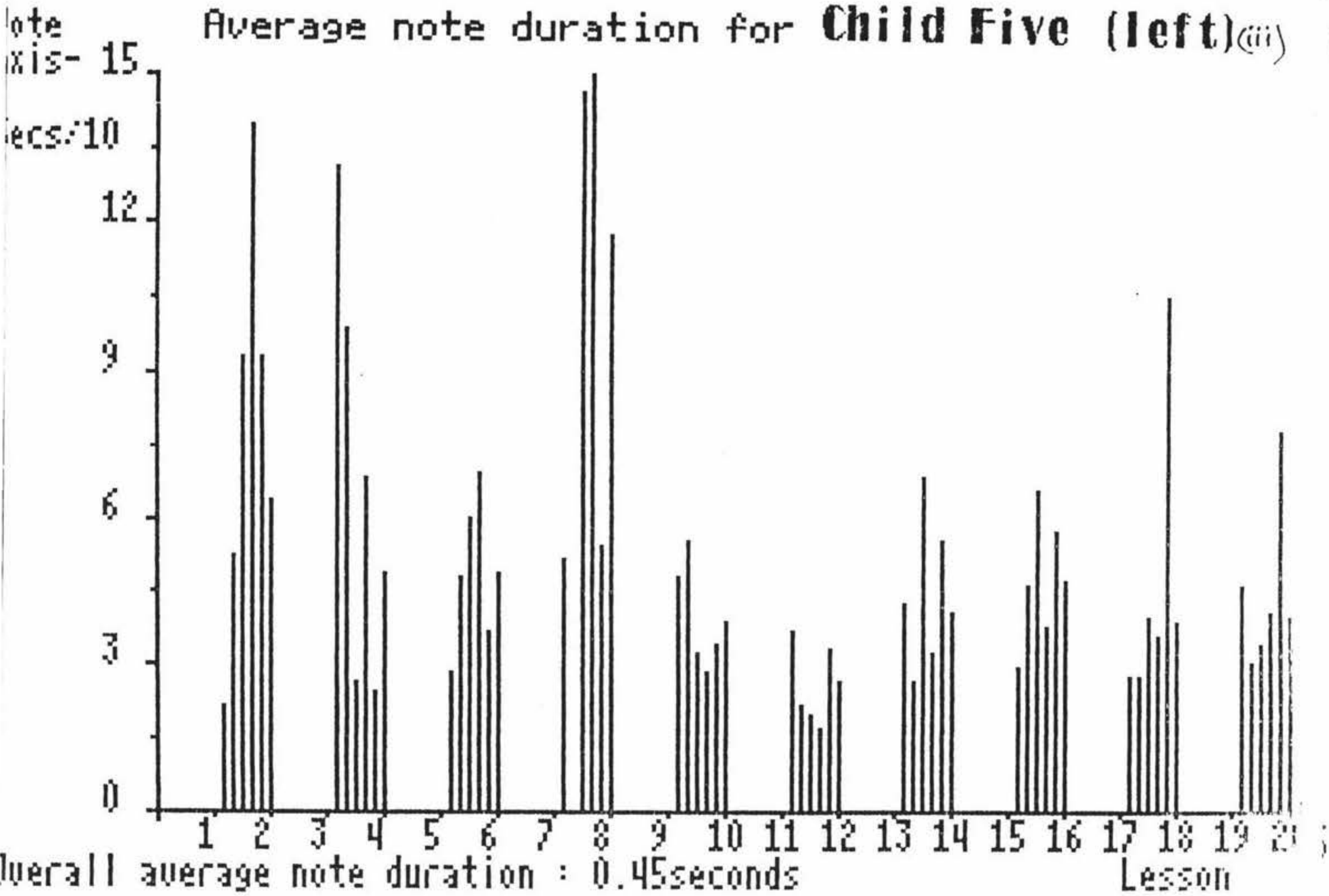
Contacts made by Child Five (right)
100
Contacts
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Total : 929. (800 expected)
Lesson



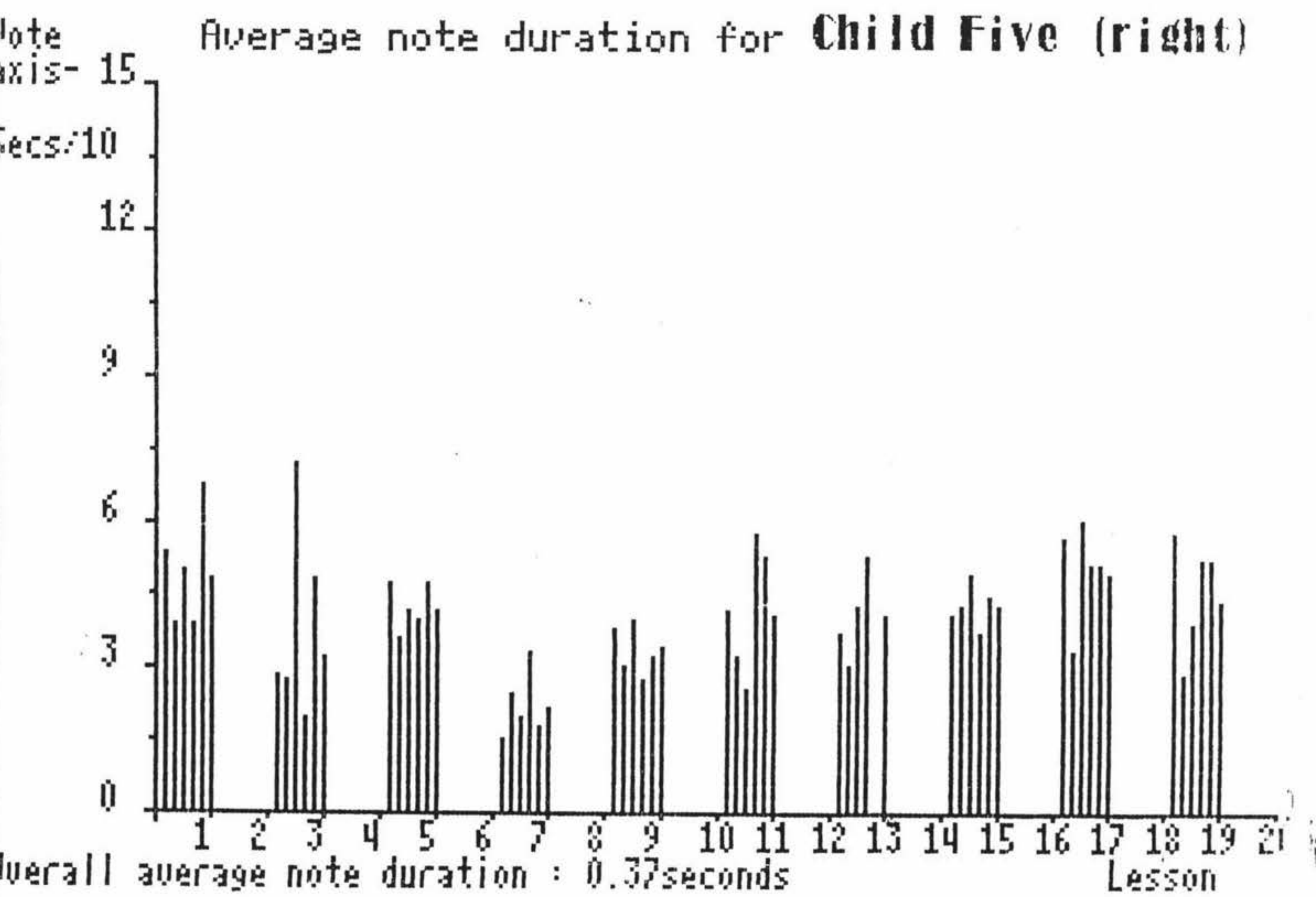
Overall average deviation : 0.25 seconds



Overall average deviation : 0.24 seconds

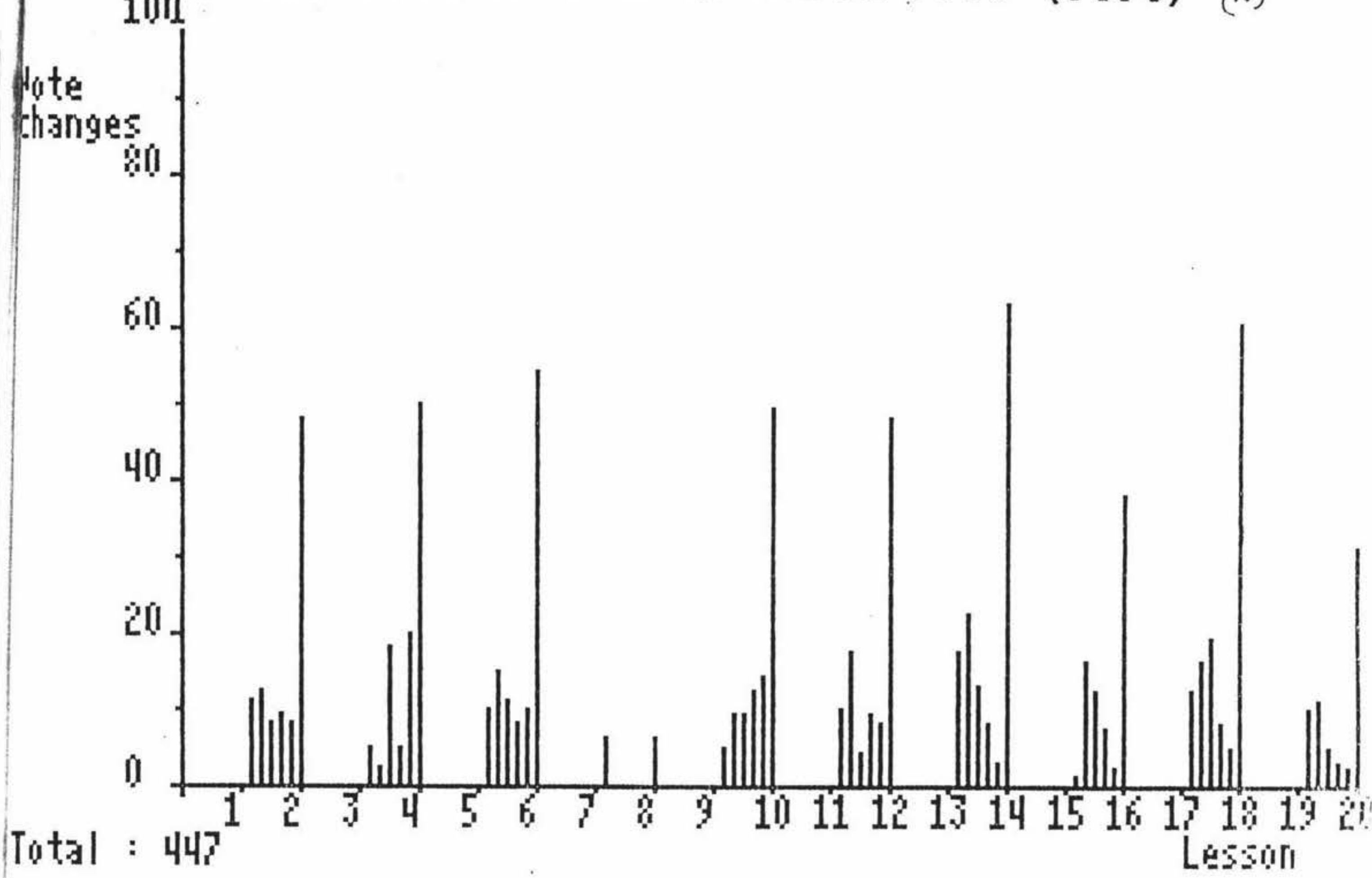


Average note duration for Child Five (left)(iii)
Note axis- Secs/10
15
12
9
6
3
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Overall average note duration : 0.45seconds
Lesson

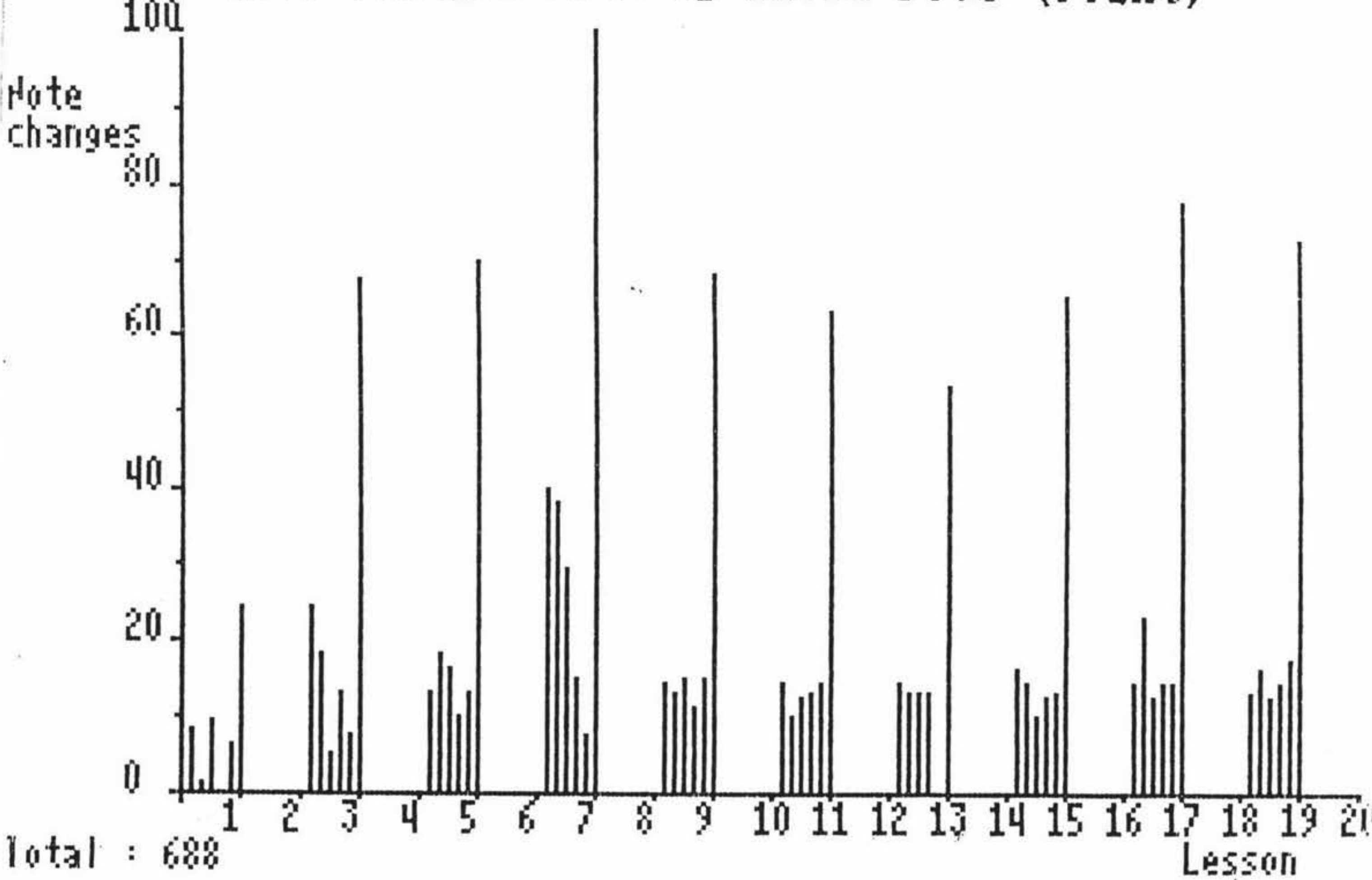


Average note duration for Child Five (right)
Note axis- Secs/10
15
12
9
6
3
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Overall average note duration : 0.37seconds
Lesson

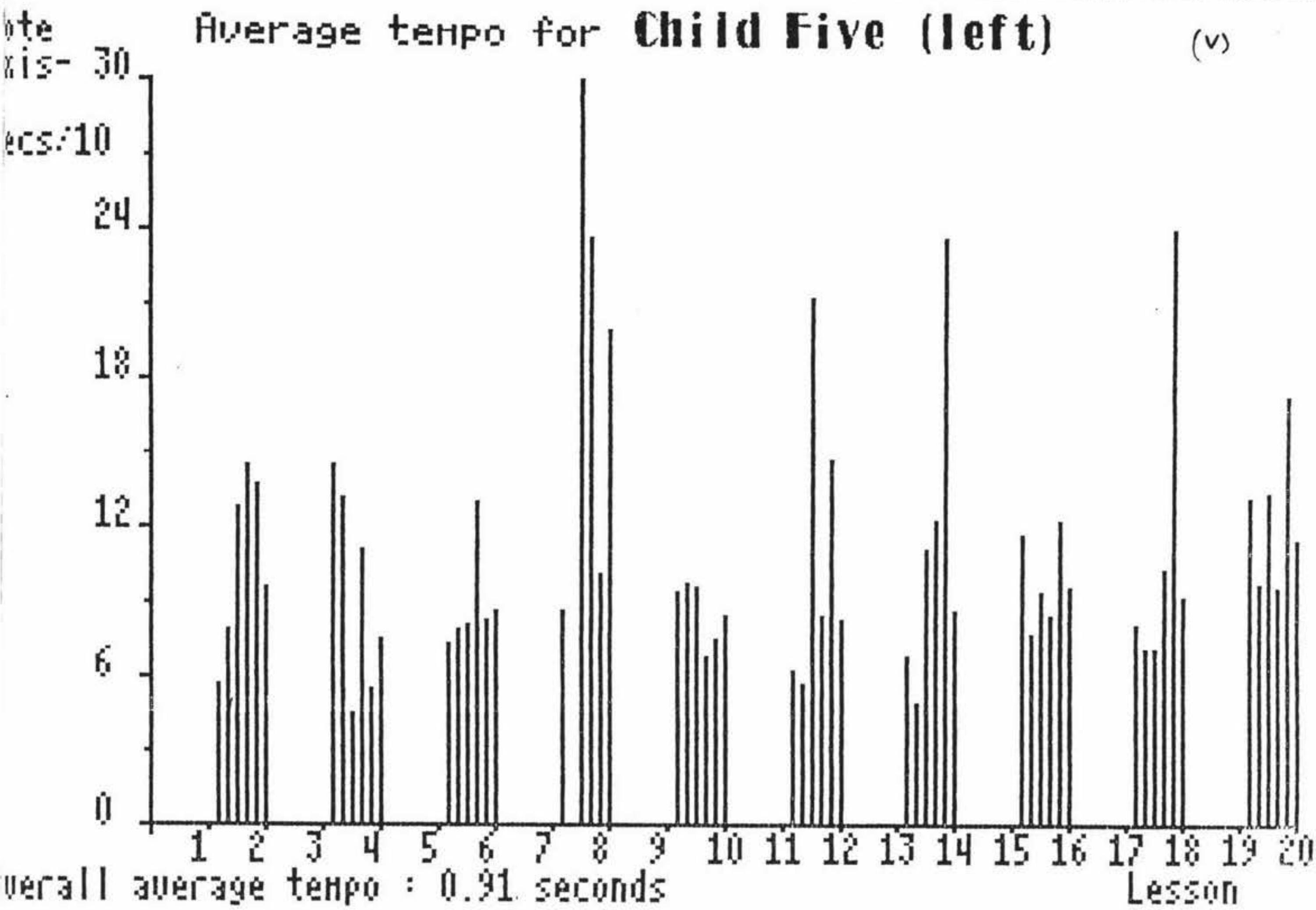
Note changes made by **Child Five (left)** (iv)

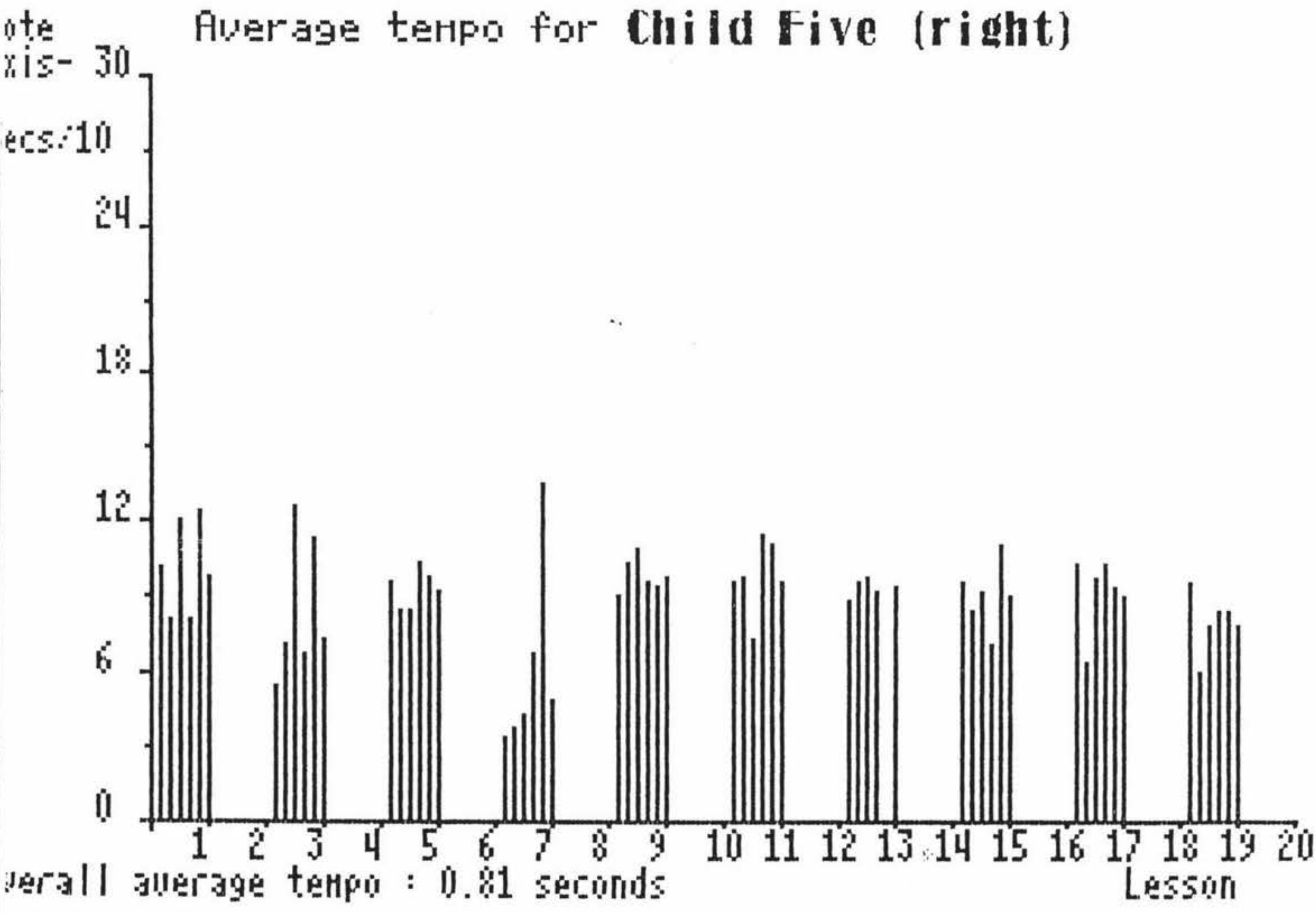


Note changes made by **Child Five (right)**

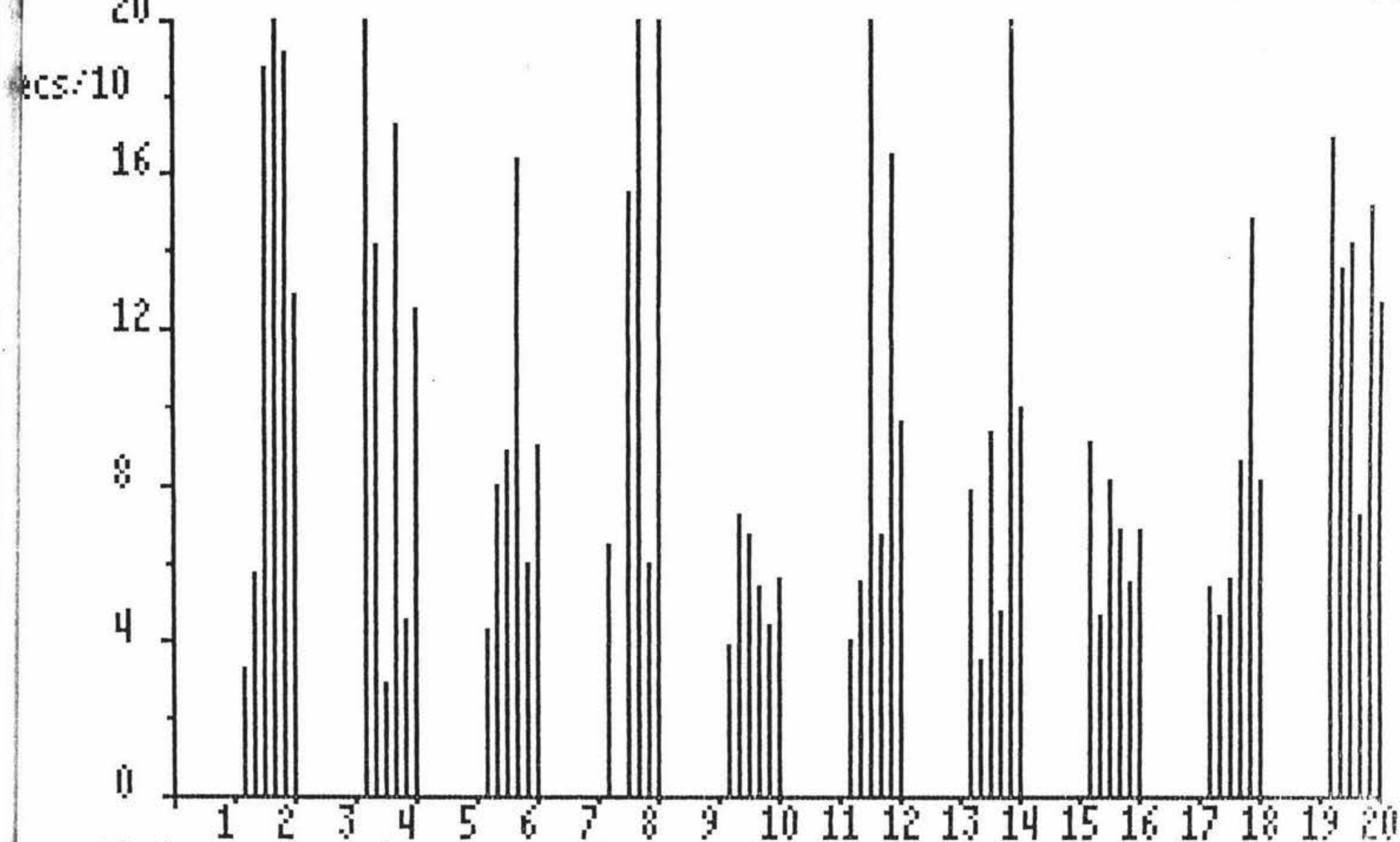


(v)


Average tempo for Child Five (left)
ote
xis- 30
ecs/10
24
18
12
6
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
verall average tempo : 0.91 seconds
Lesson

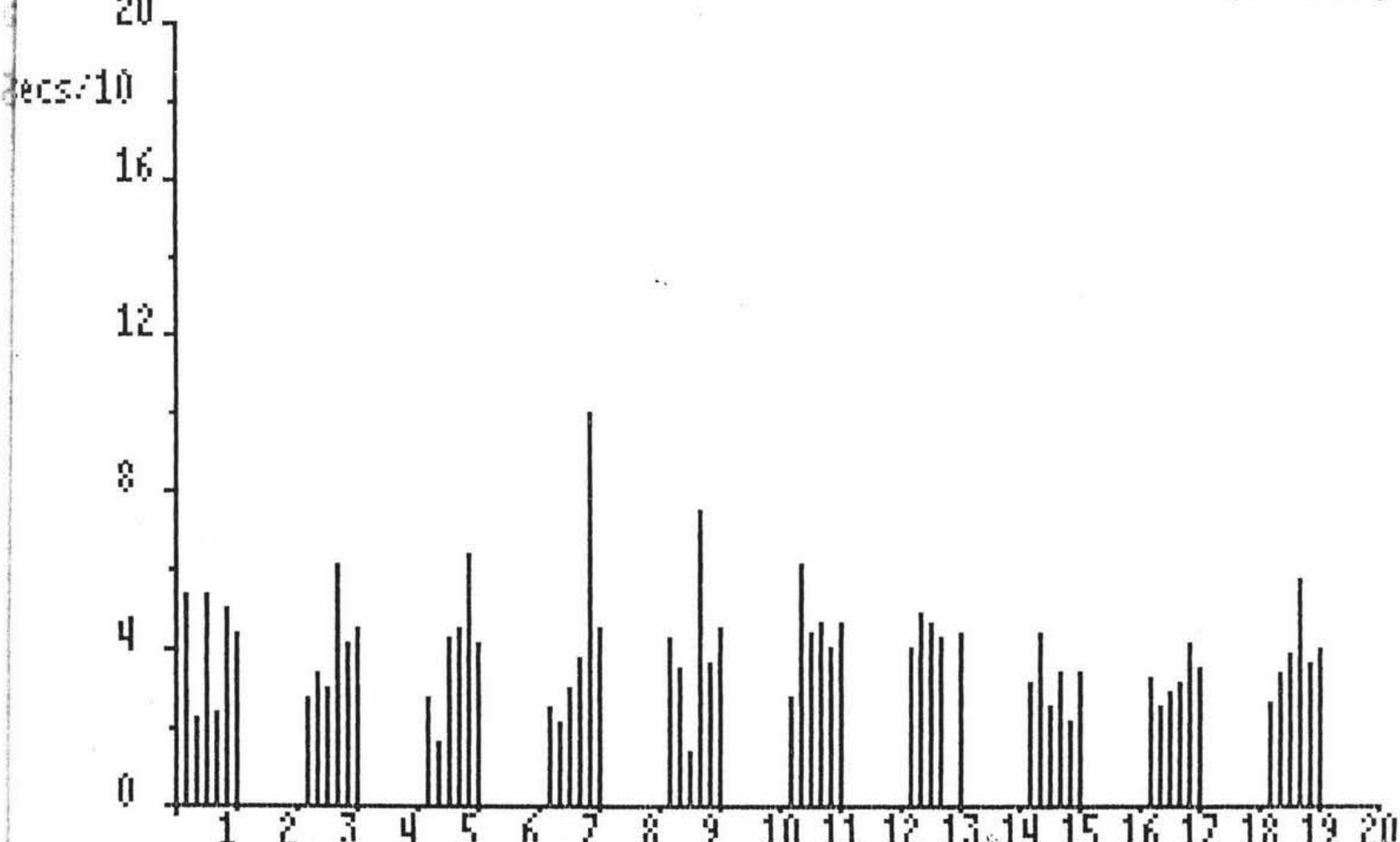

Average tempo for Child Five (right)
ote
xis- 30
ecs/10
24
18
12
6
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
verall average tempo : 0.81 seconds
Lesson

Pulse (tempo deviation) for **Child Five (left)**(vi)



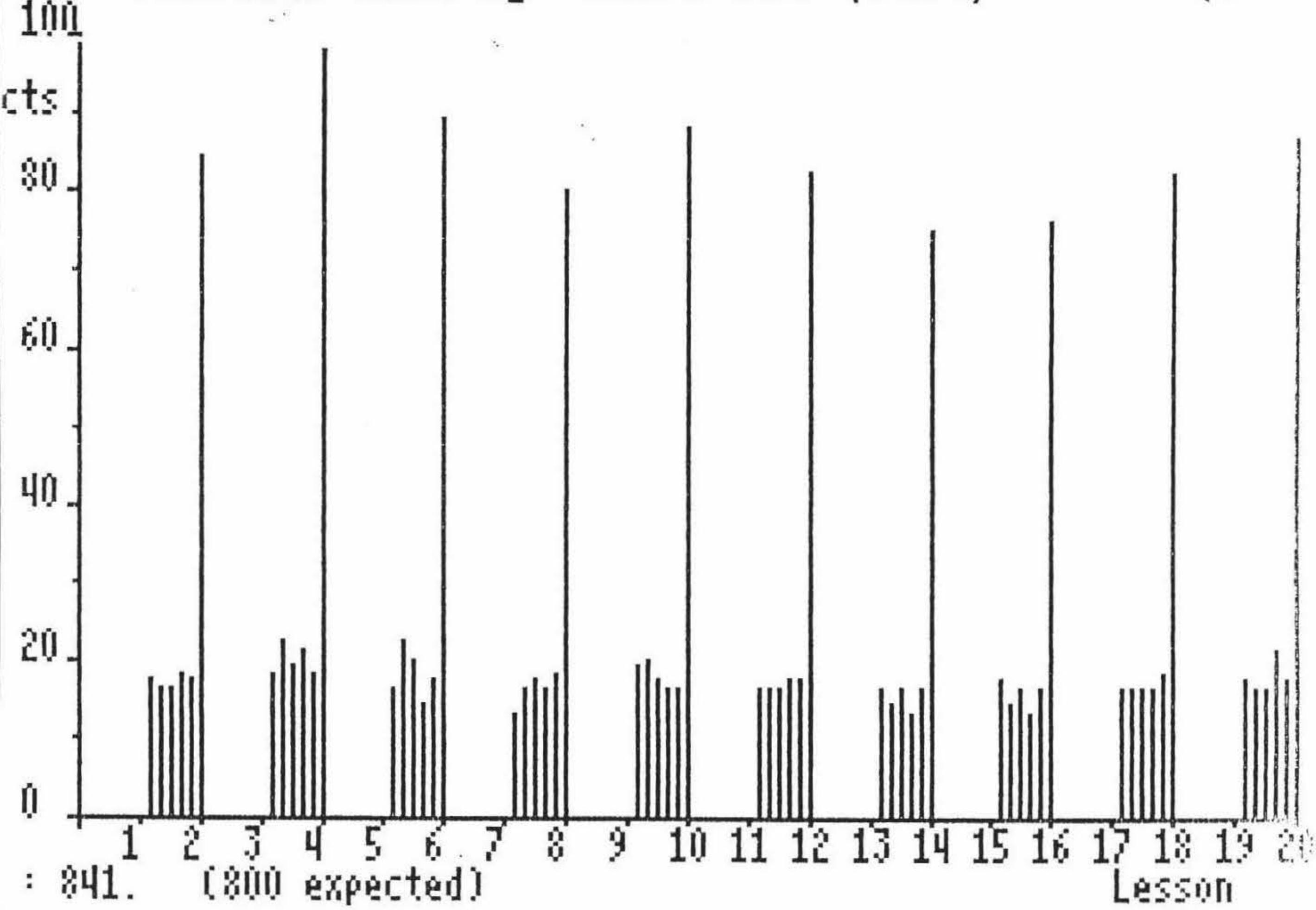
Overall tempo deviation : 1.035 seconds

Pulse (tempo deviation) for **Child Five (right)**

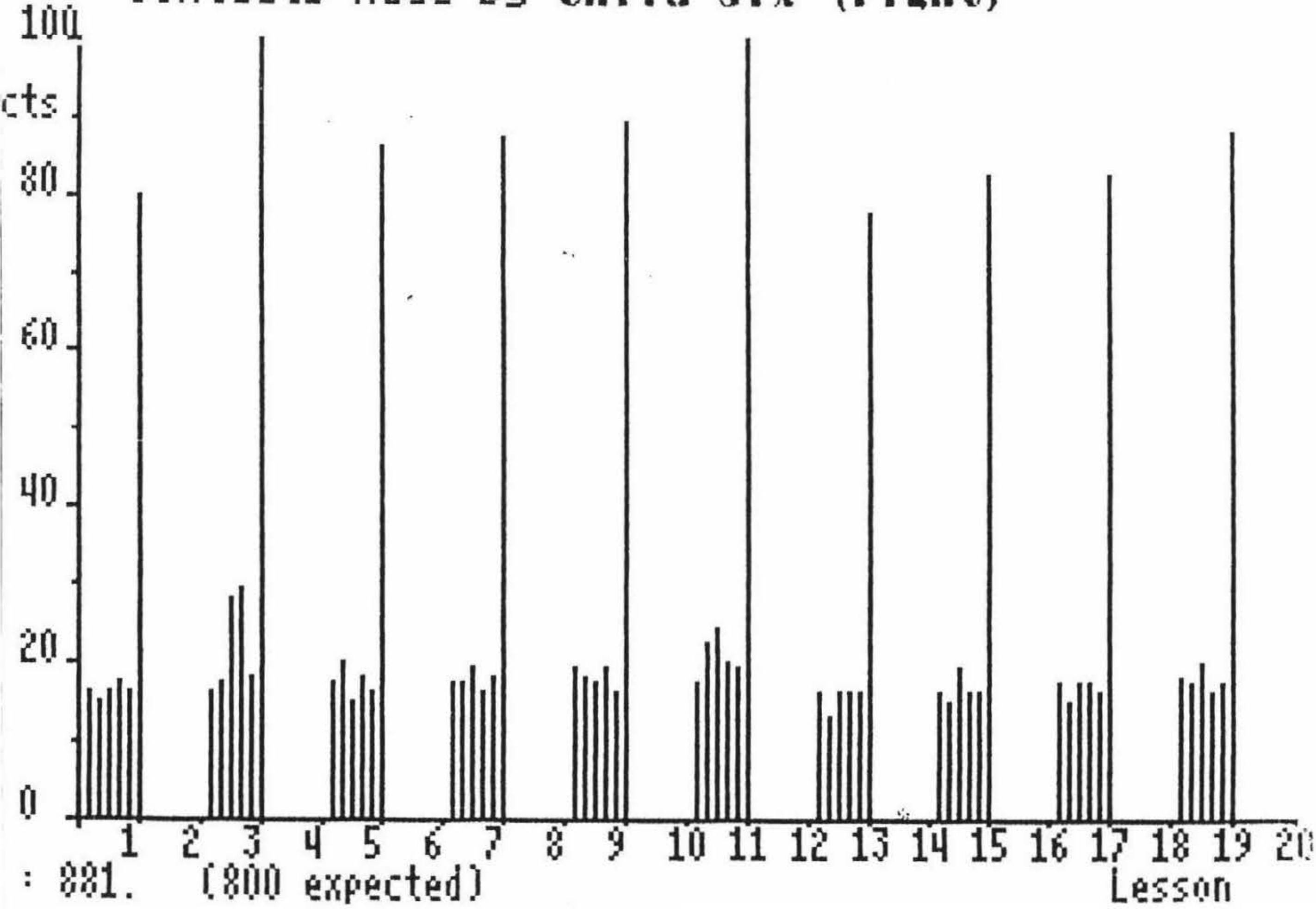


Overall tempo deviation : 0.498 seconds

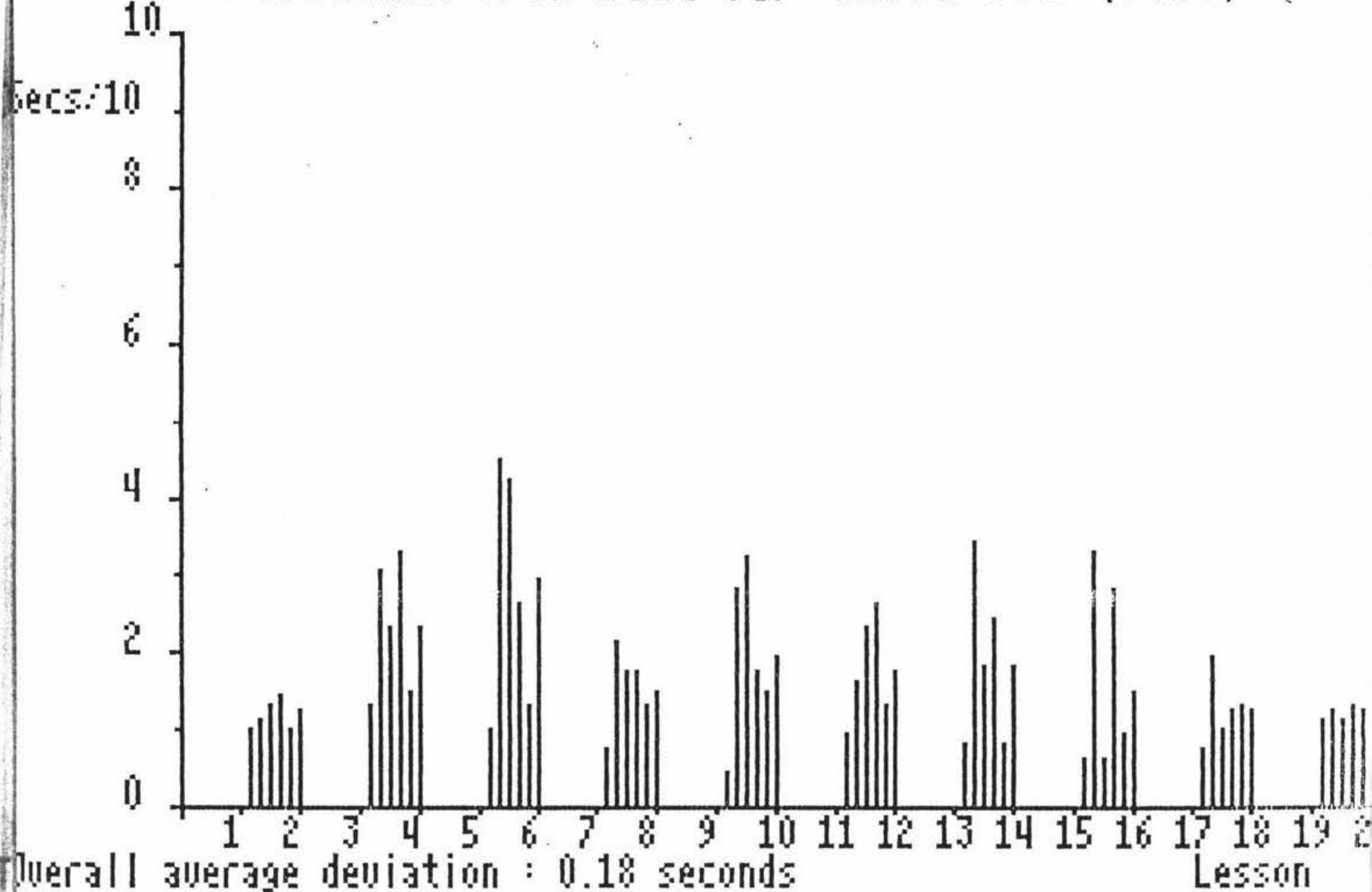
Contacts made by **Child Six (left)**



Contacts made by **Child Six (right)**

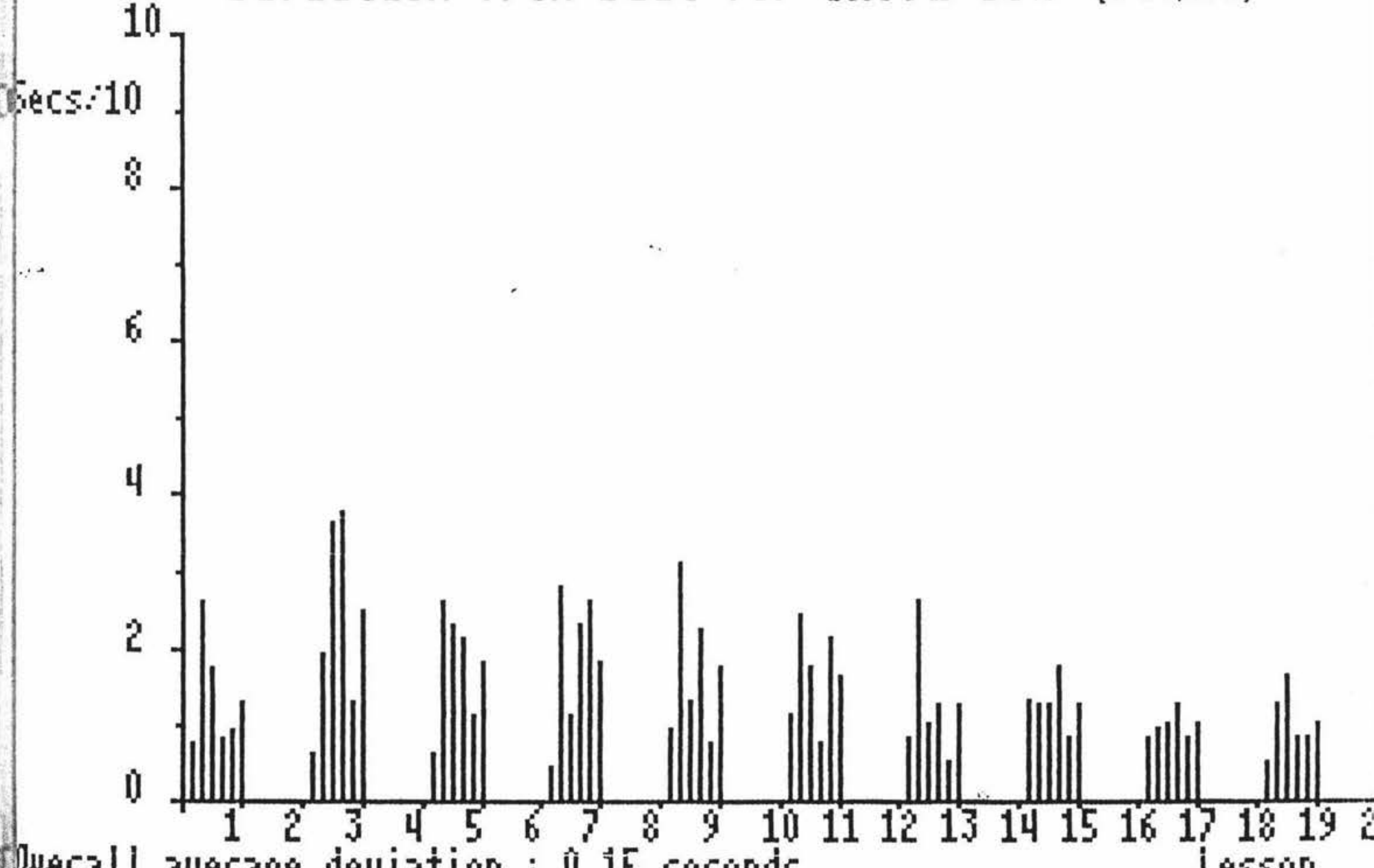


Deviation from beat for **Child Six (left)** (ii)

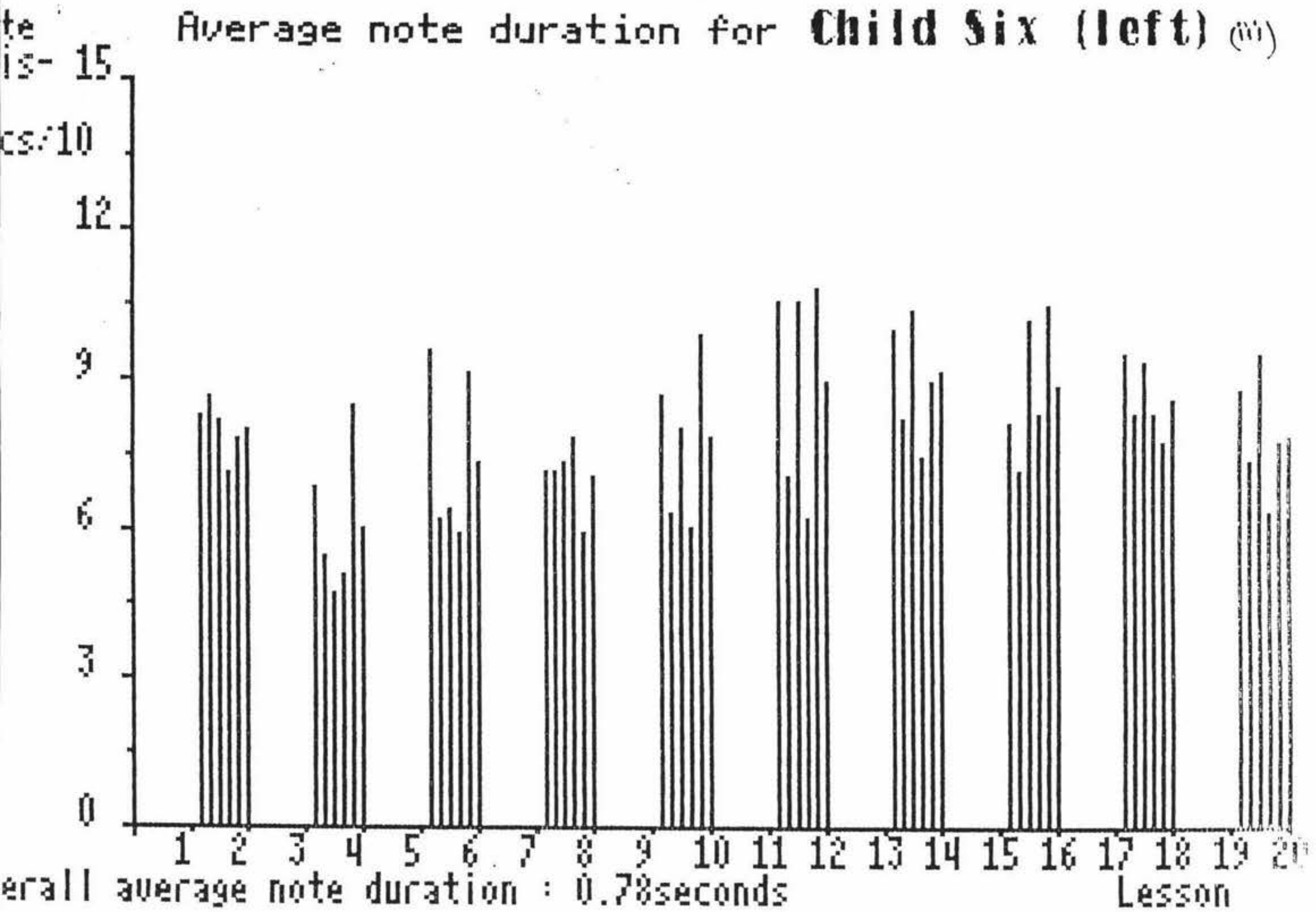


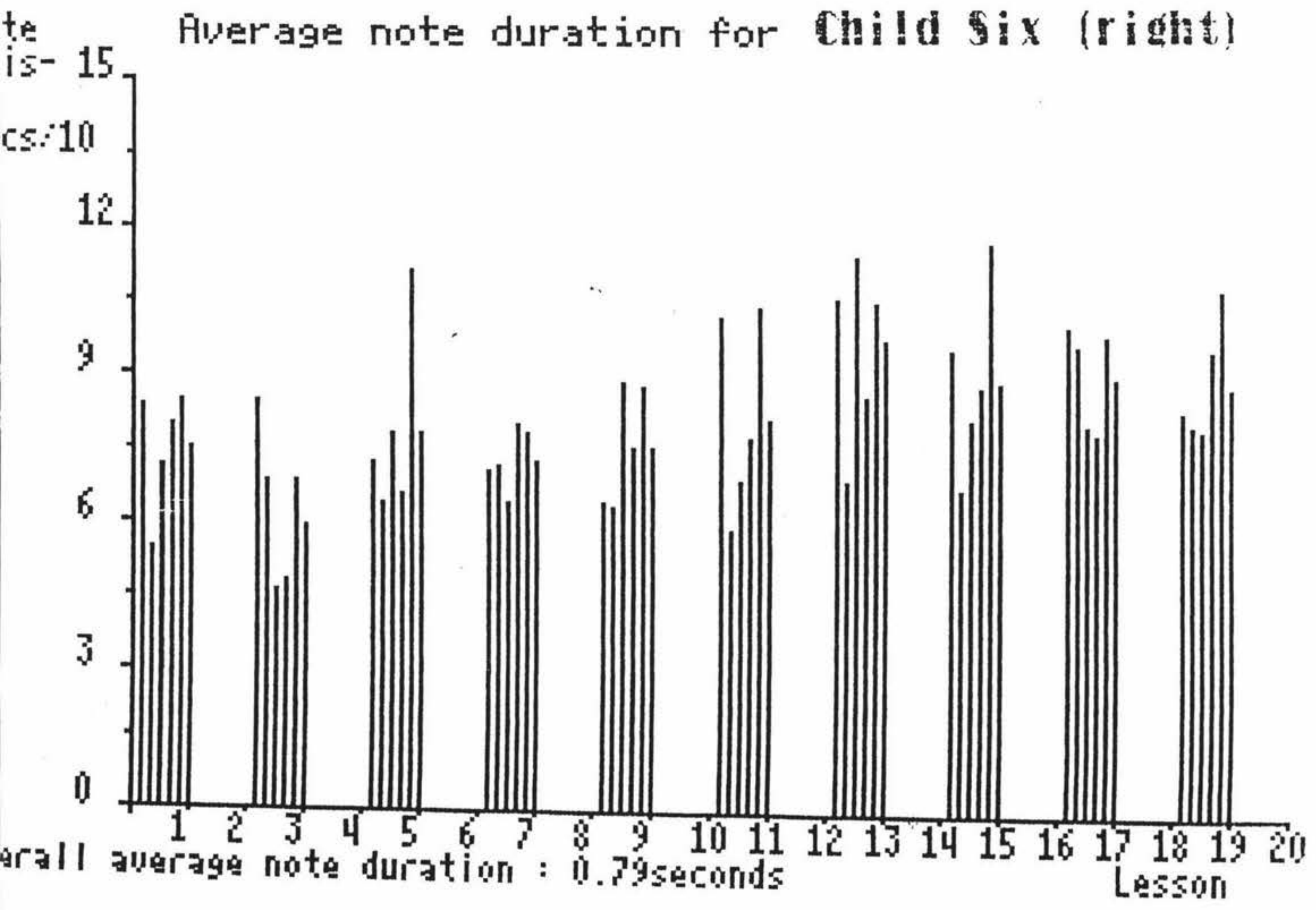
Overall average deviation : 0.18 seconds

Deviation from beat for **Child Six (right)**



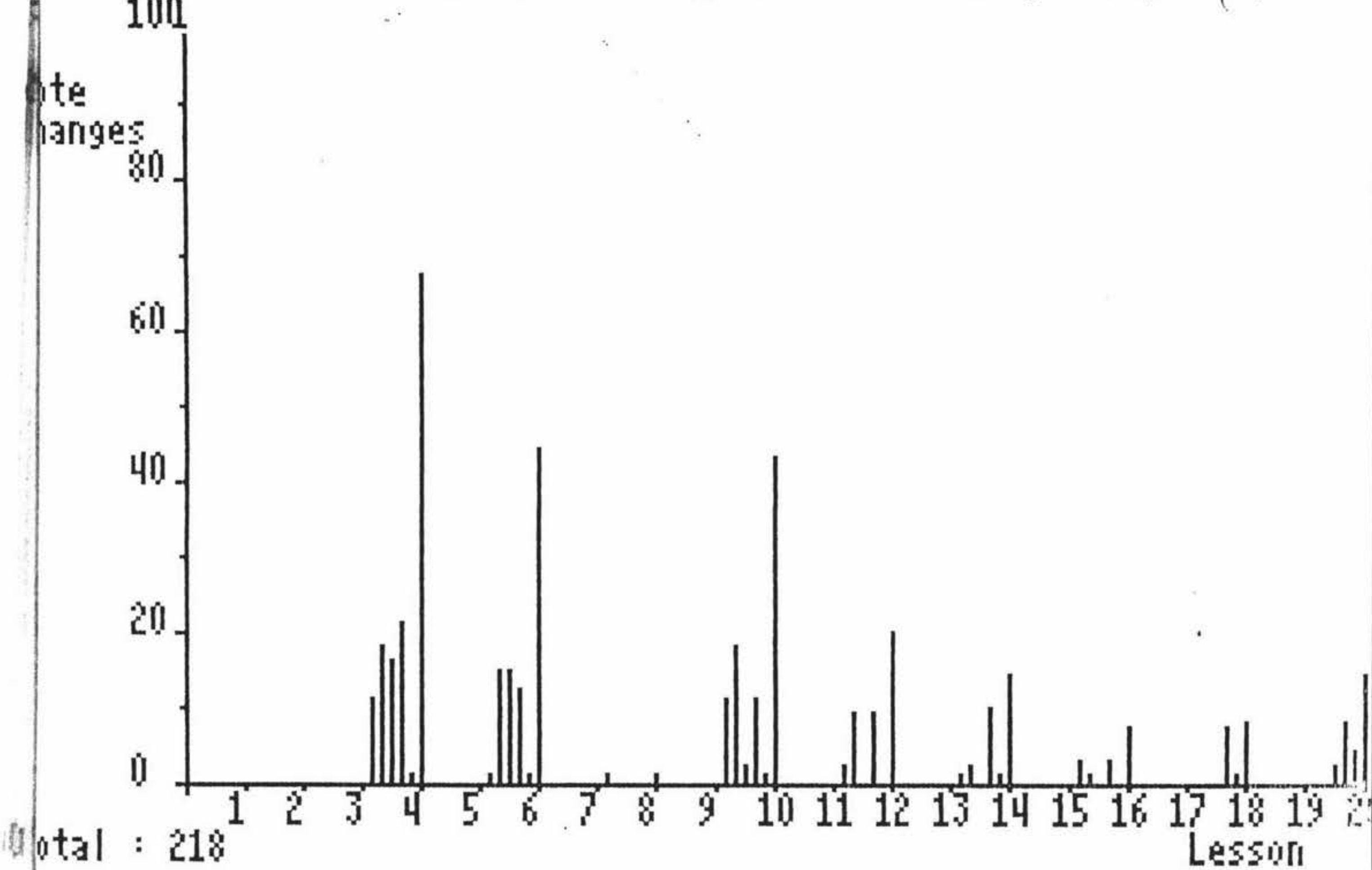
Overall average deviation : 0.15 seconds


Average note duration for Child Six (left) (iii)
te
is-
cs/10
15
12
9
6
3
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
erall average note duration : 0.78seconds
Lesson

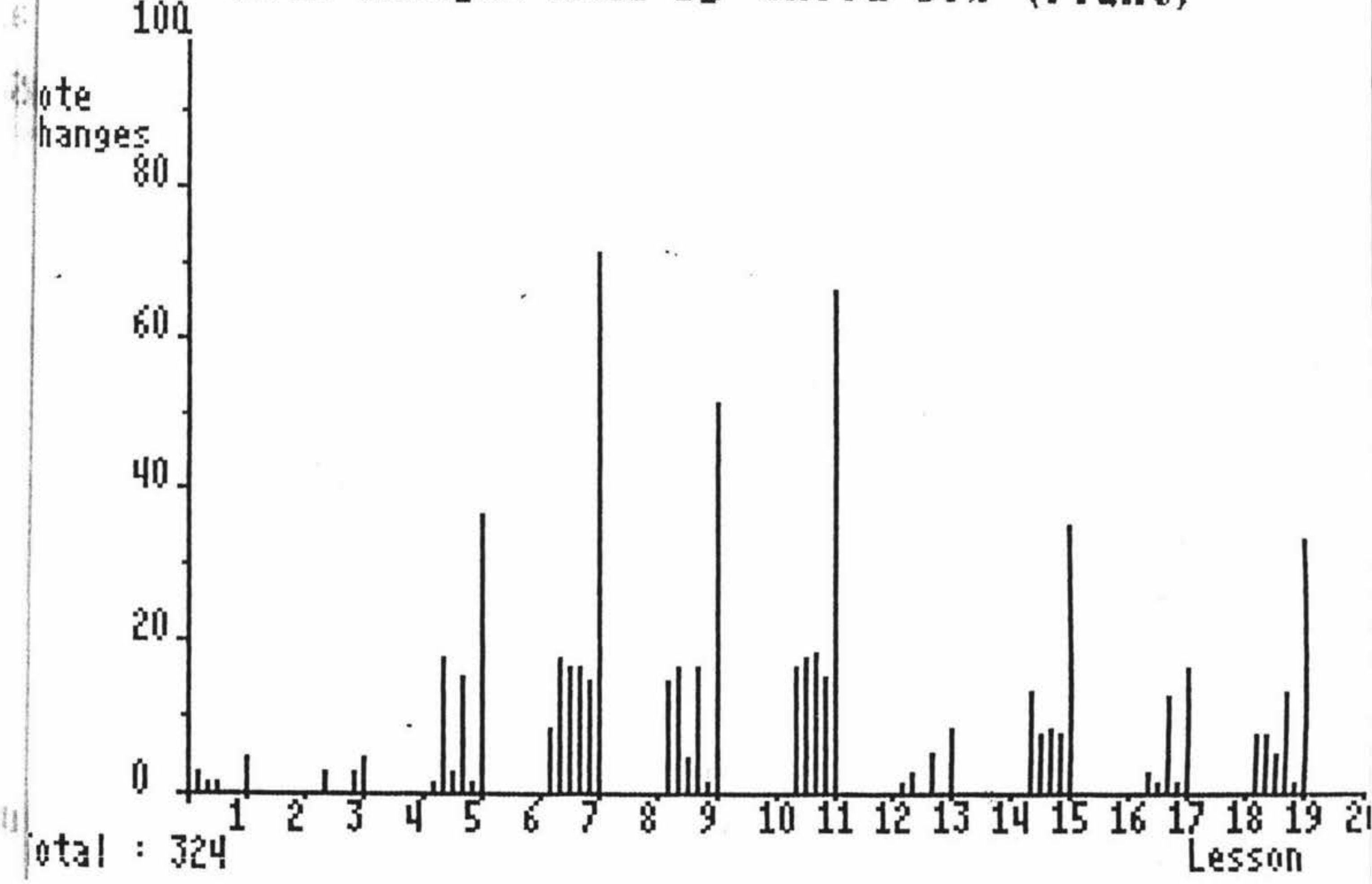

Average note duration for Child Six (right)
te
is-
cs/10
15
12
9
6
3
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
erall average note duration : 0.79seconds
Lesson

(iv)

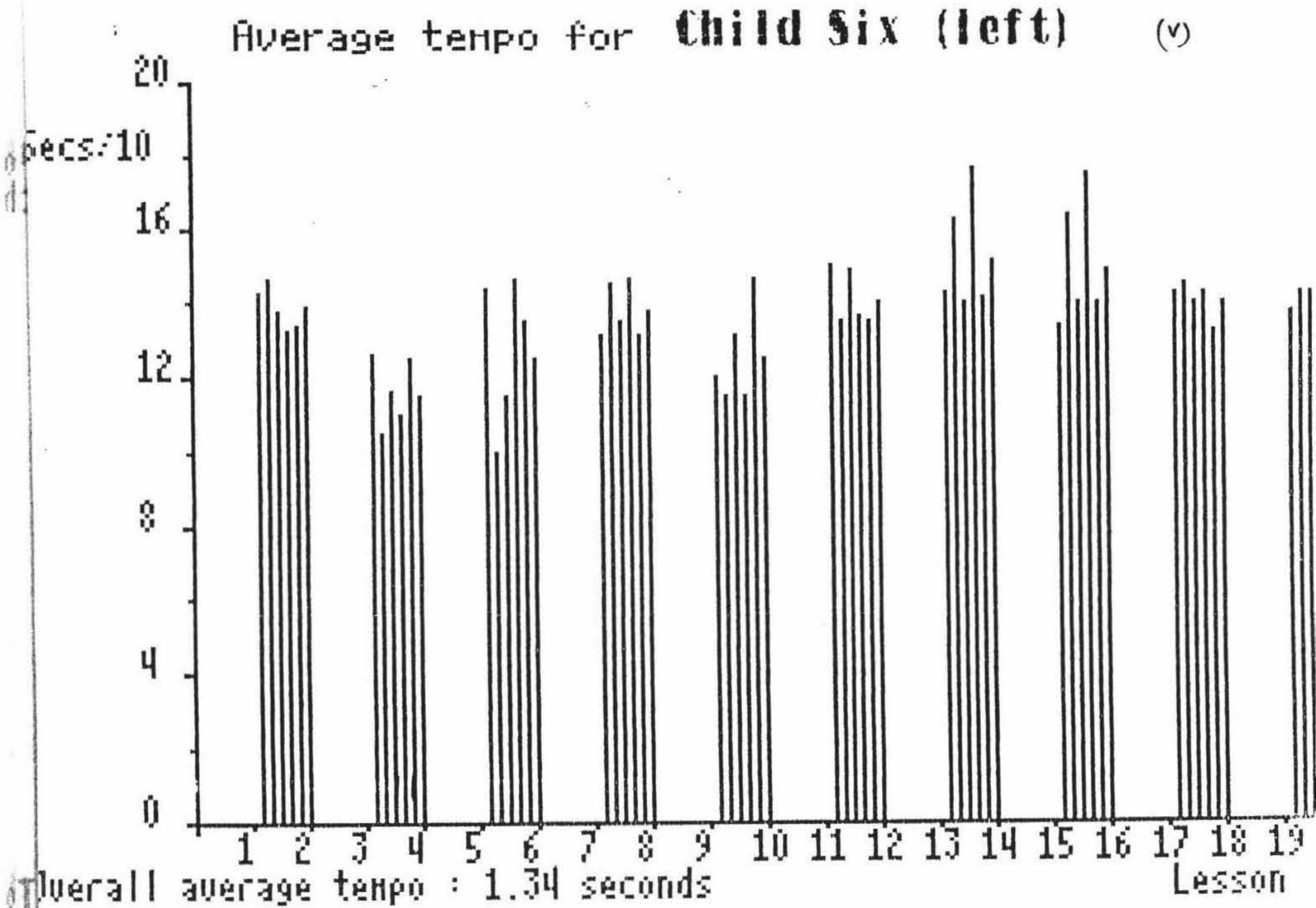
Note changes made by **Child Six (left)**



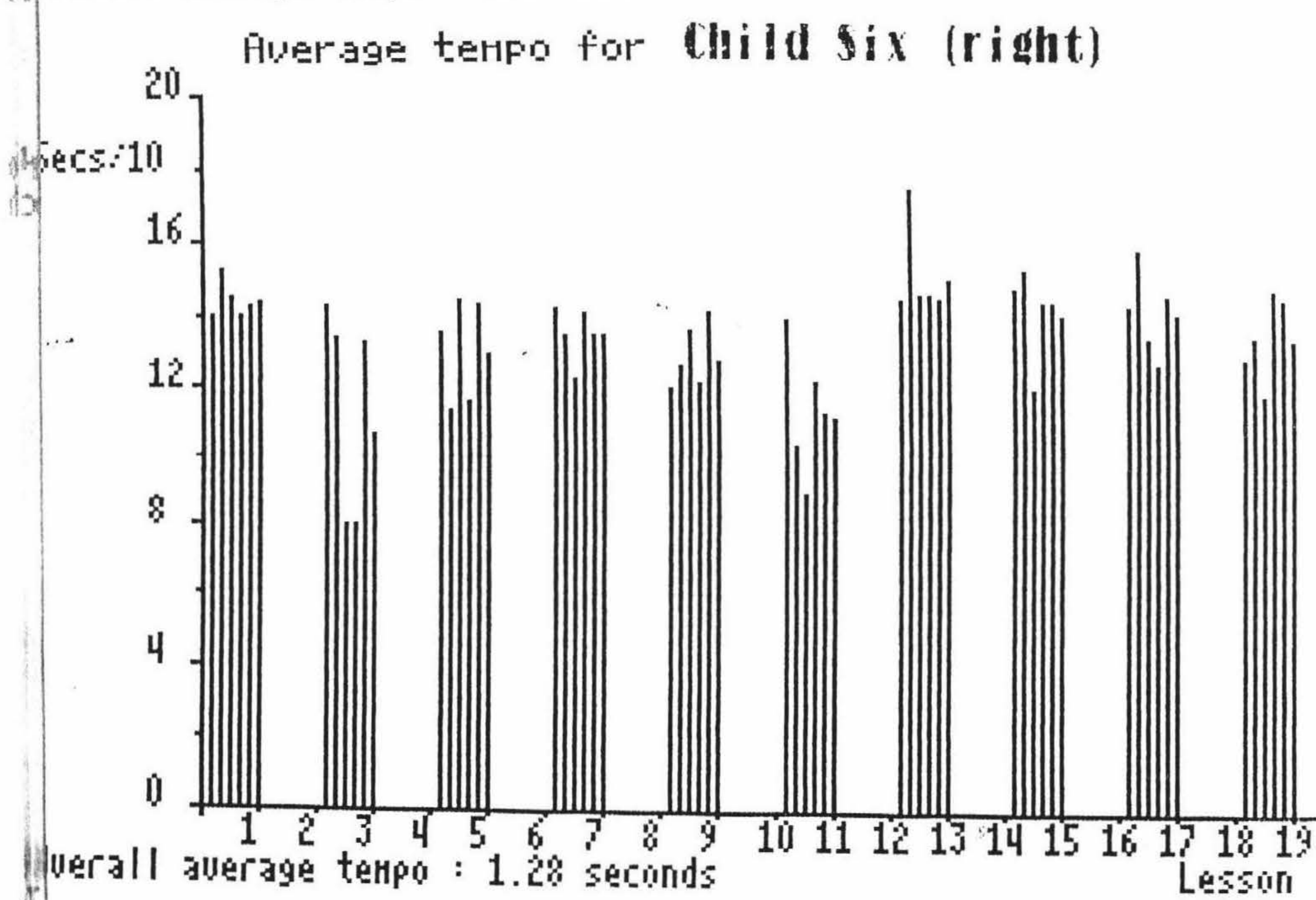
Note changes made by **Child Six (right)**



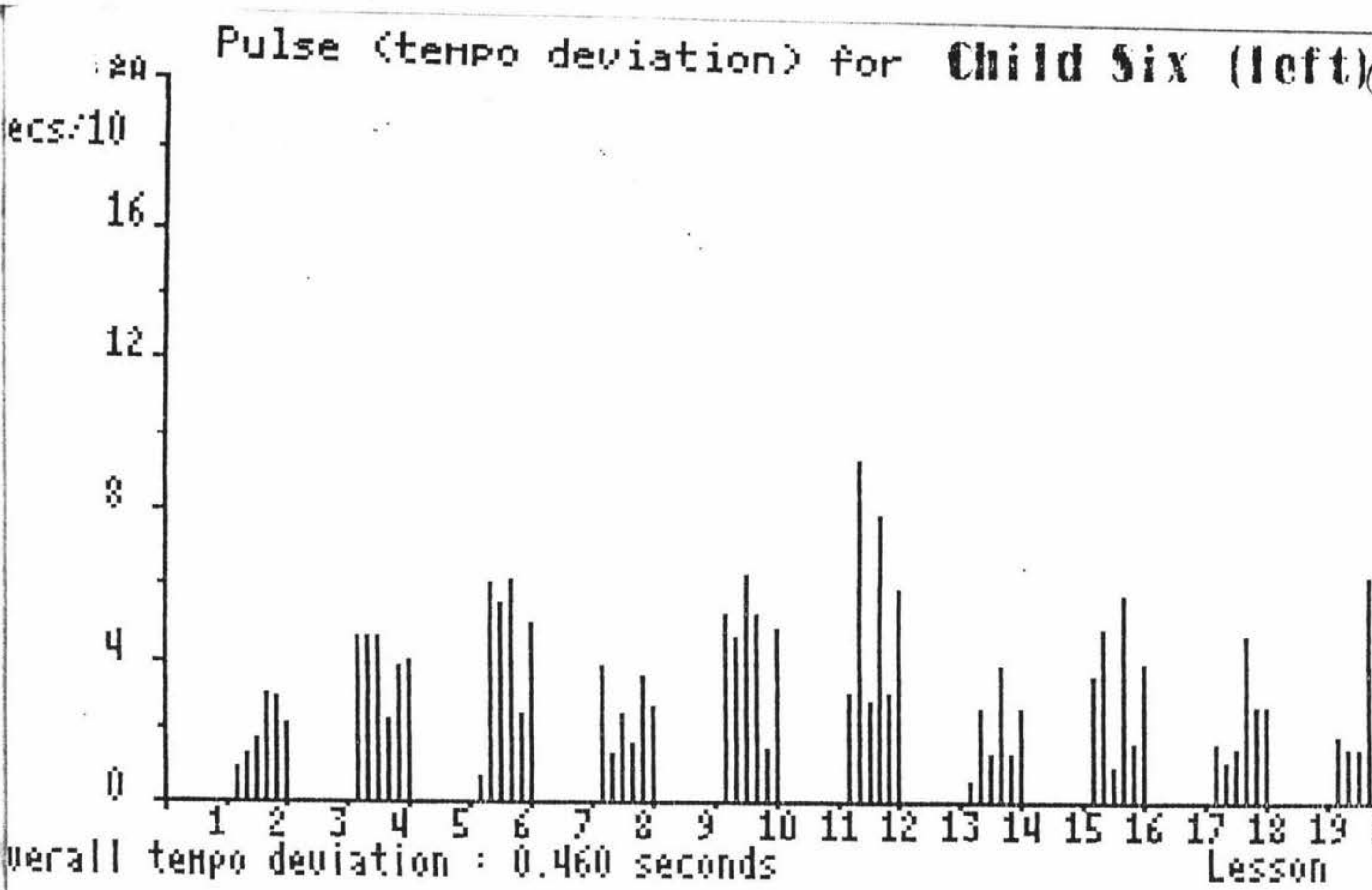
(v)

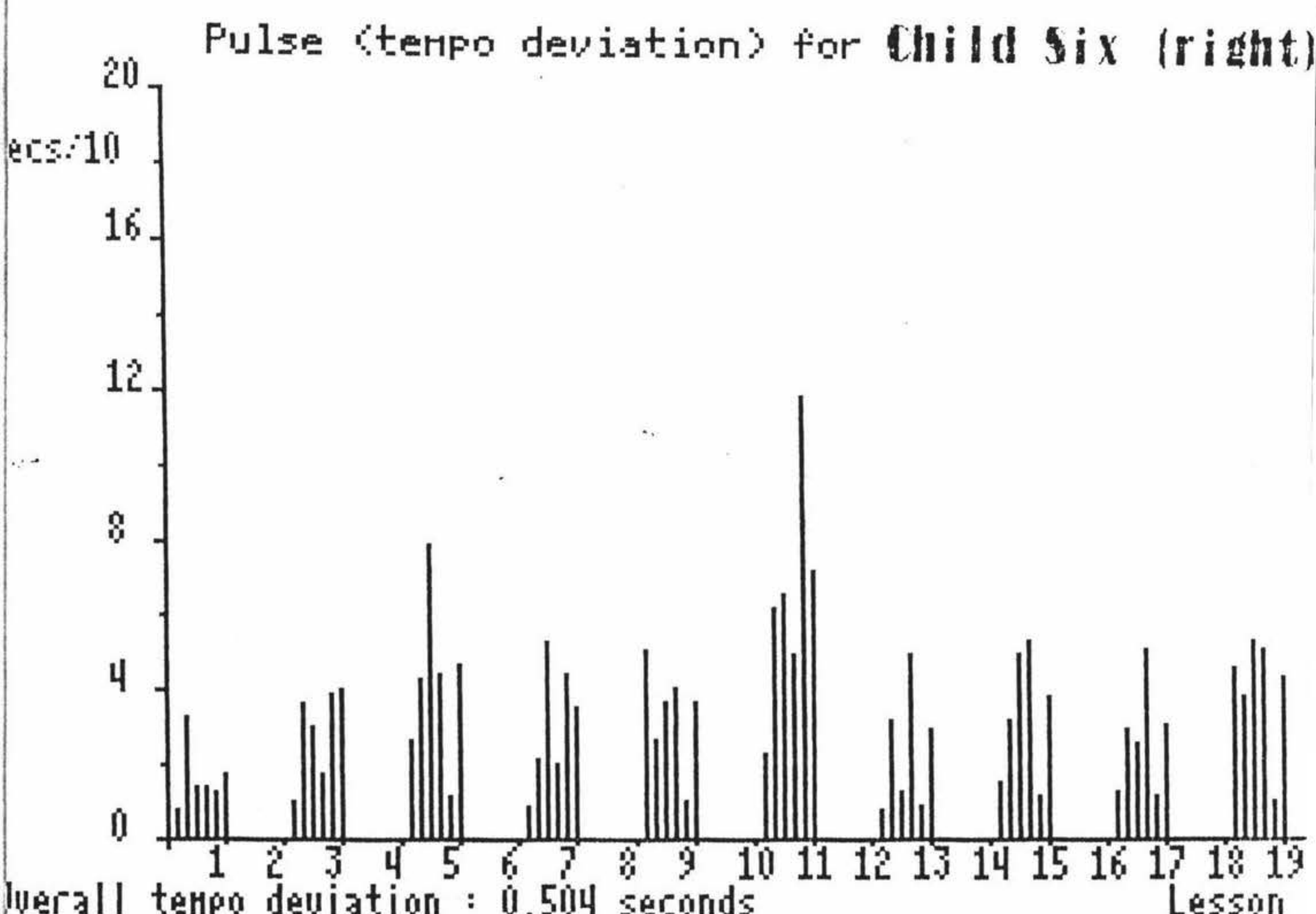


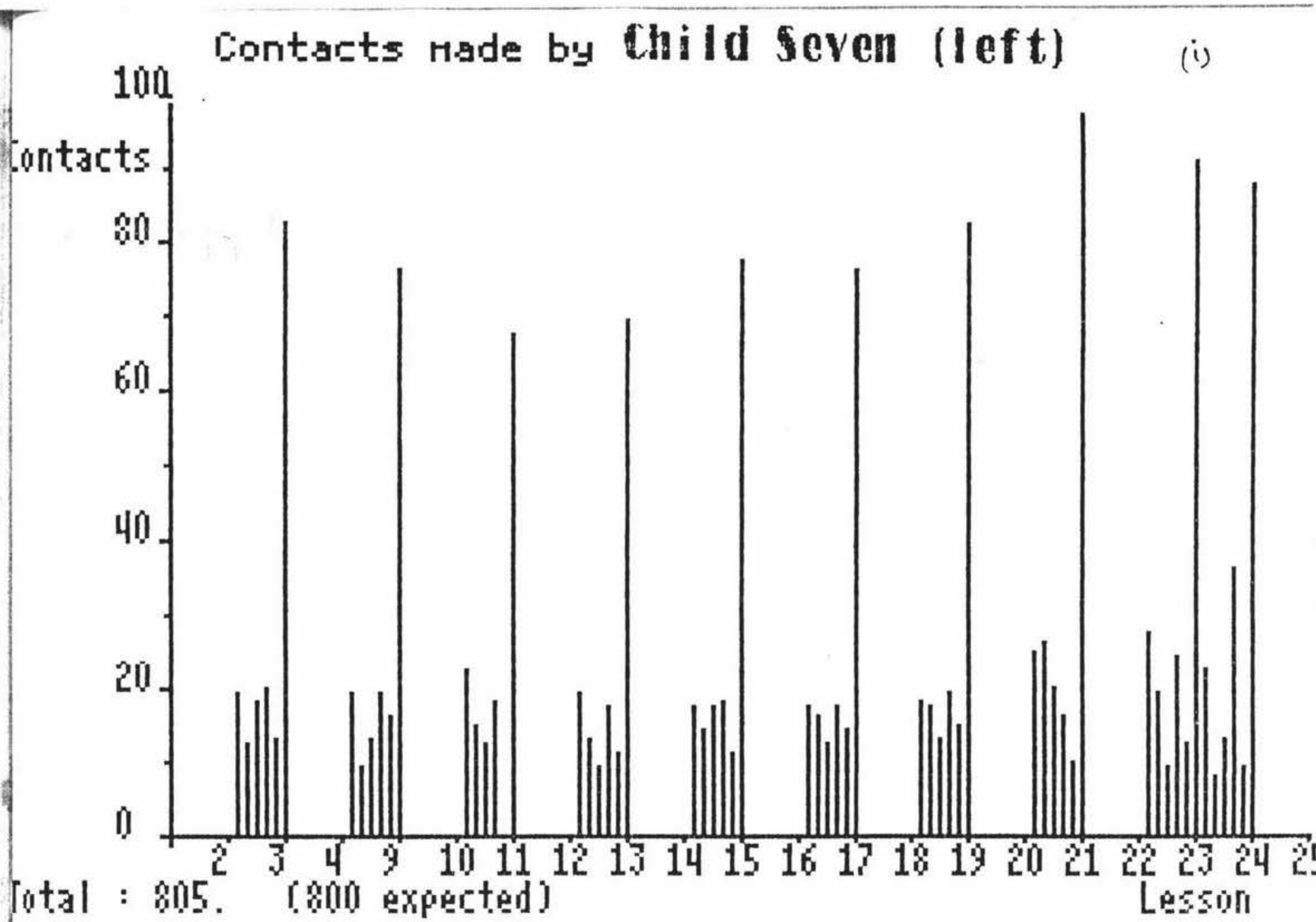
Average tempo for Child Six (left)
Secs/10
20
16
12
8
4
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Lesson
Overall average tempo : 1.34 seconds

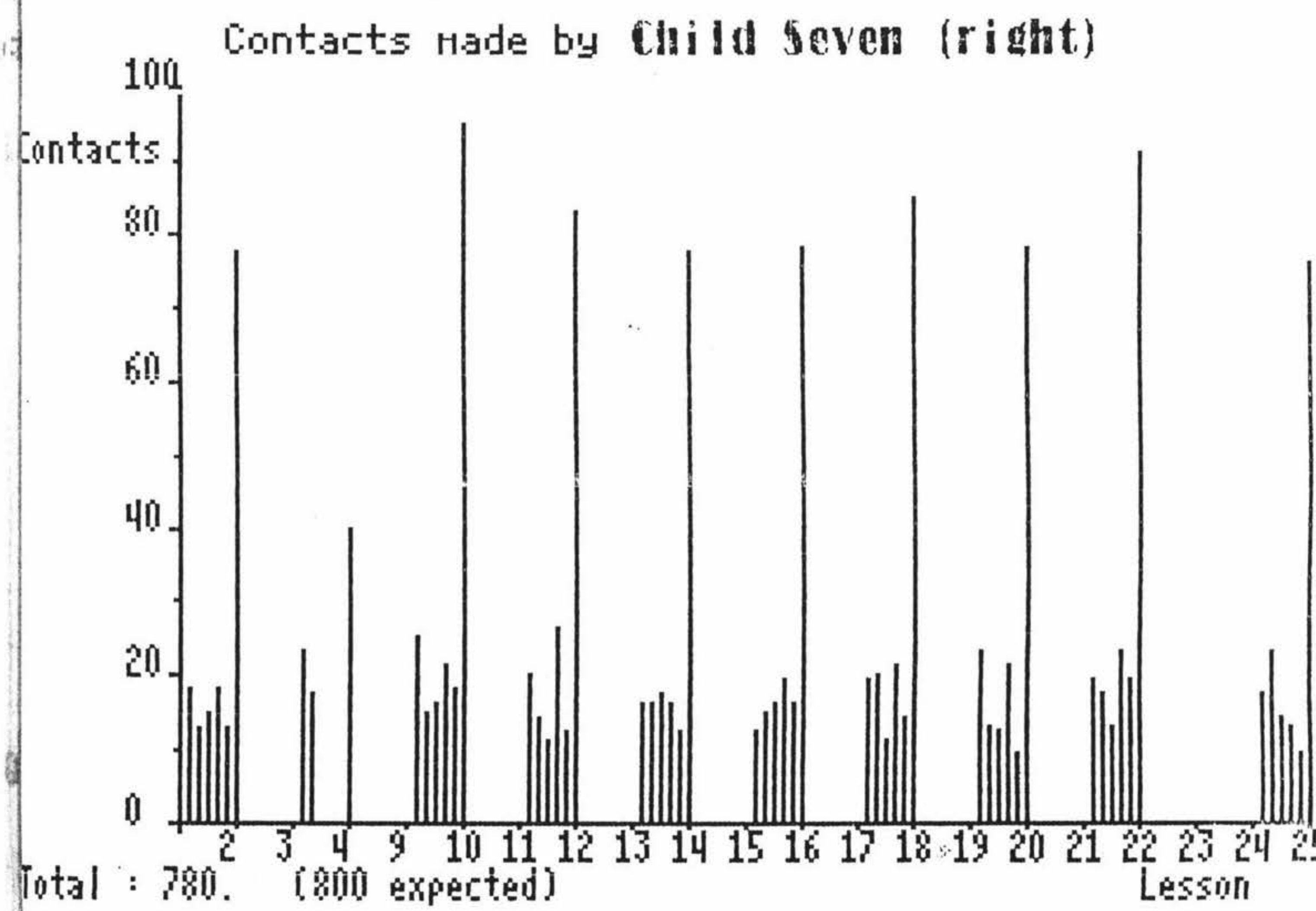


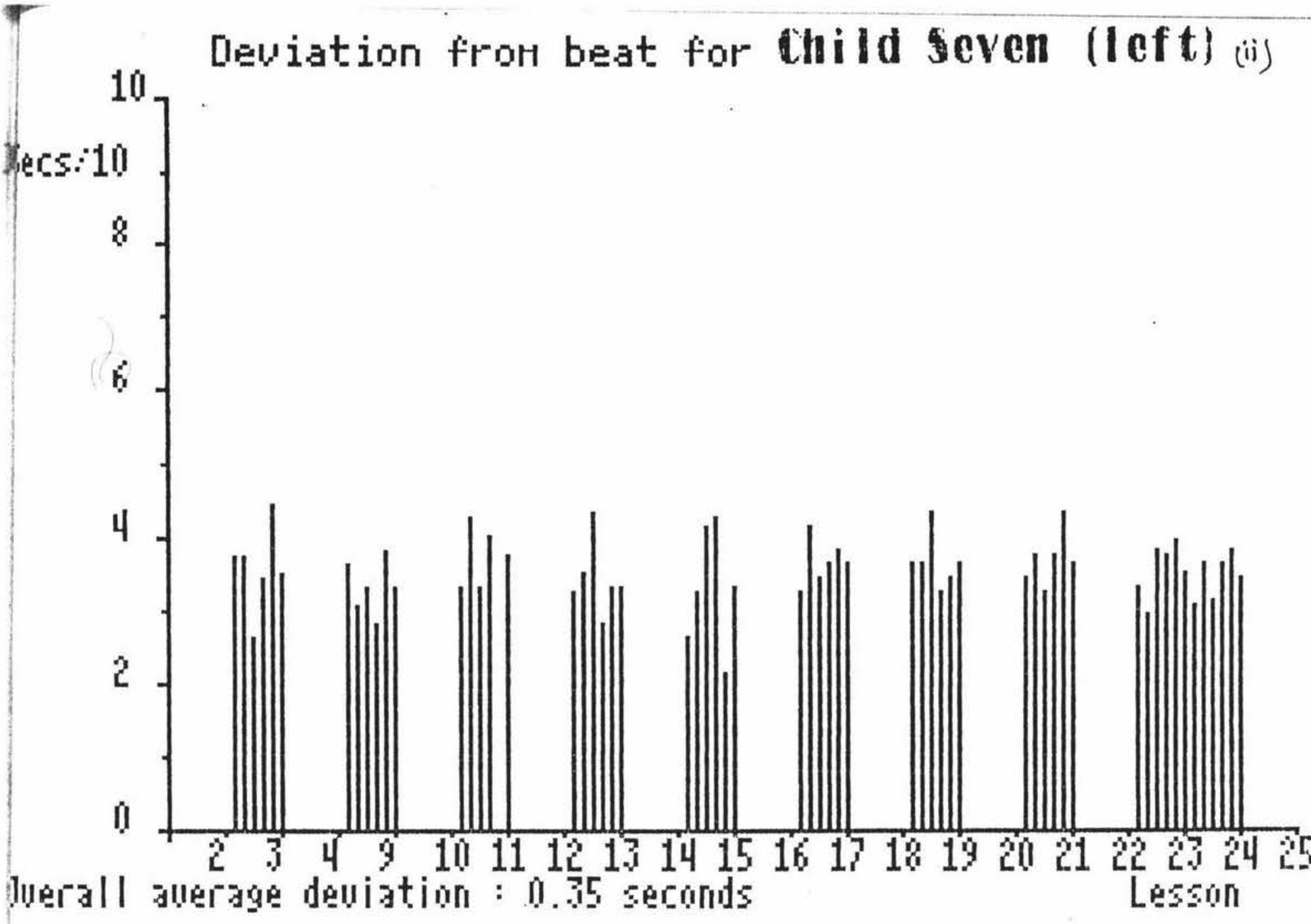
Average tempo for Child Six (right)
Secs/10
20
16
12
8
4
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Lesson
Overall average tempo : 1.28 seconds


Pulse (tempo deviation) for Child Six (left)
ecs/10
20
16
12
8
4
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
verall tempo deviation : 0.460 seconds
Lesson

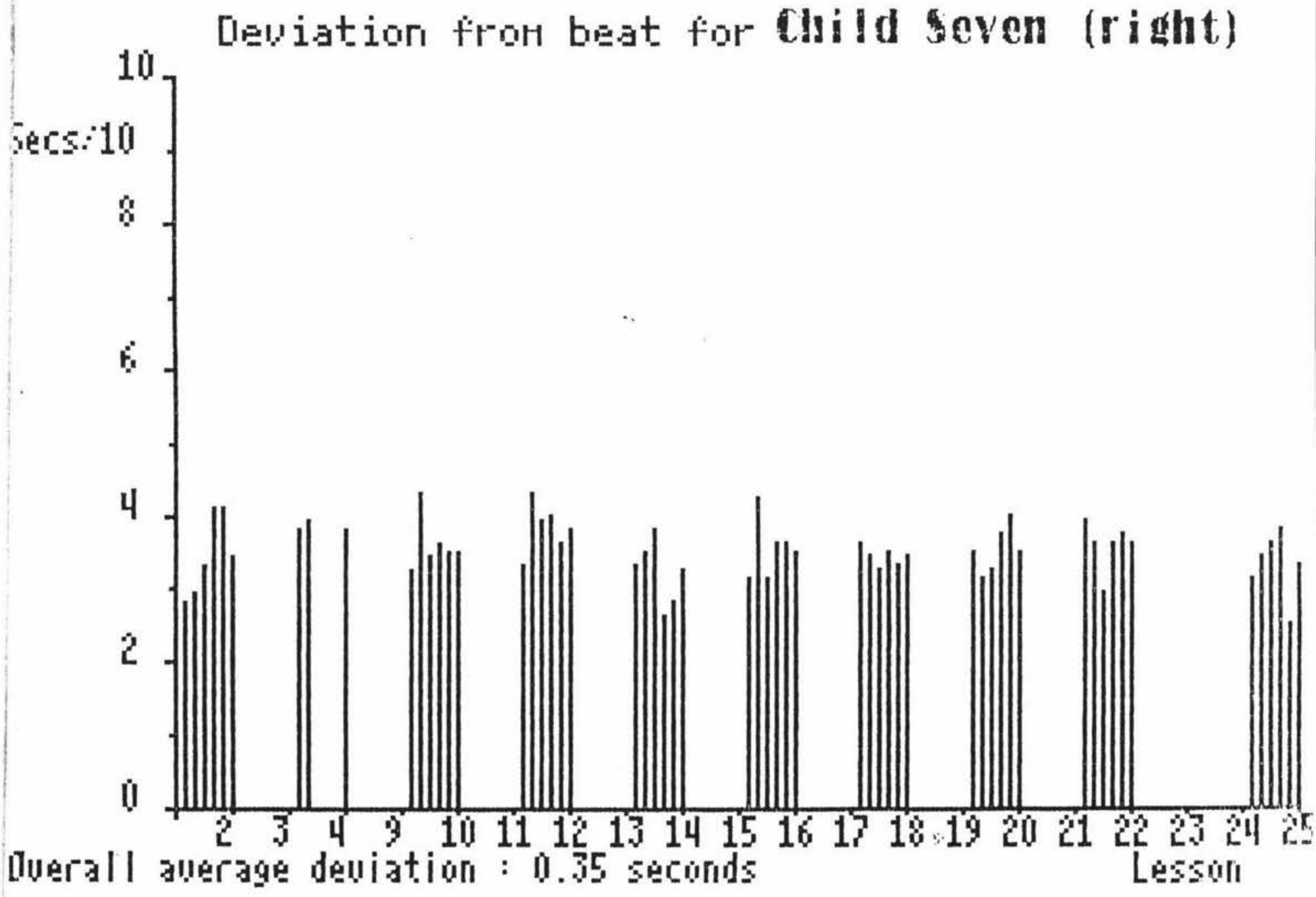

Pulse (tempo deviation) for Child Six (right)
20
ecs/10
16
12
8
4
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Overall tempo deviation : 0.504 seconds
Lesson


Contacts made by Child Seven (left)
(i)
100
Contacts
80
60
40
20
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Total : 805. (800 expected)
Lesson

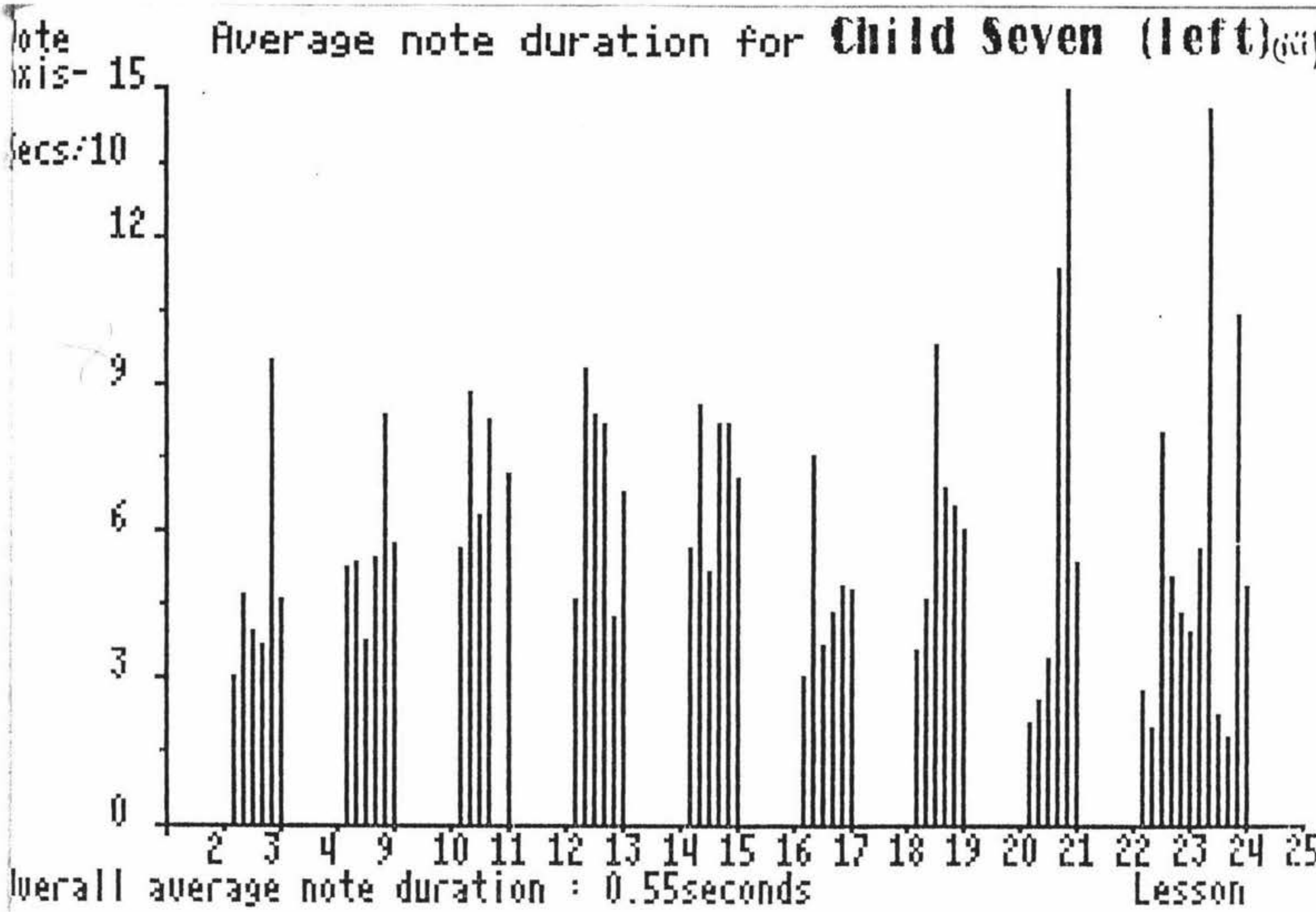

Contacts made by Child Seven (right)
100
Contacts
80
60
40
20
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Total : 780. (800 expected)
Lesson



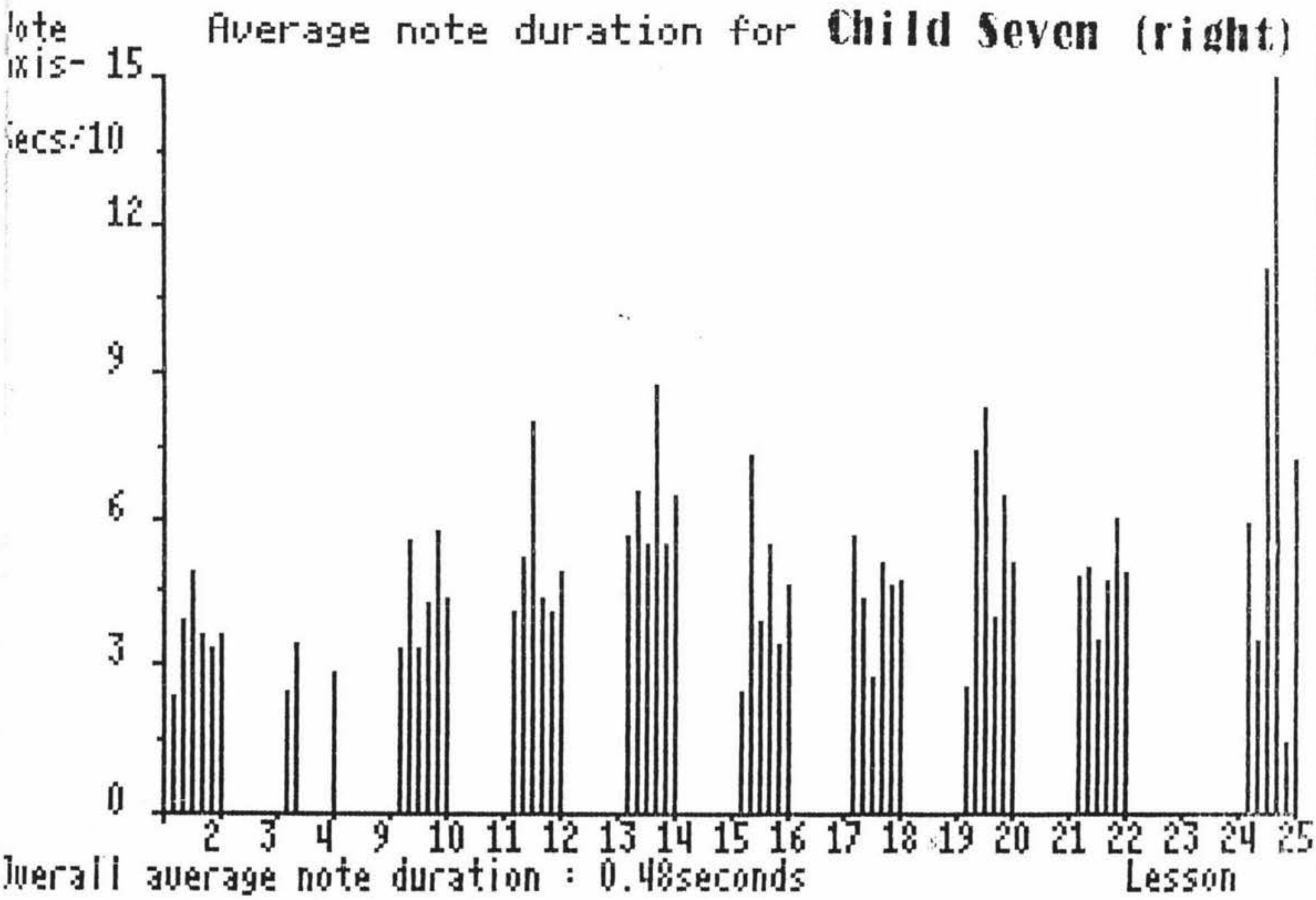
Deviation from beat for Child Seven (left) (ii)
Secs/10
10
8
6
4
2
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Overall average deviation : 0.35 seconds
Lesson



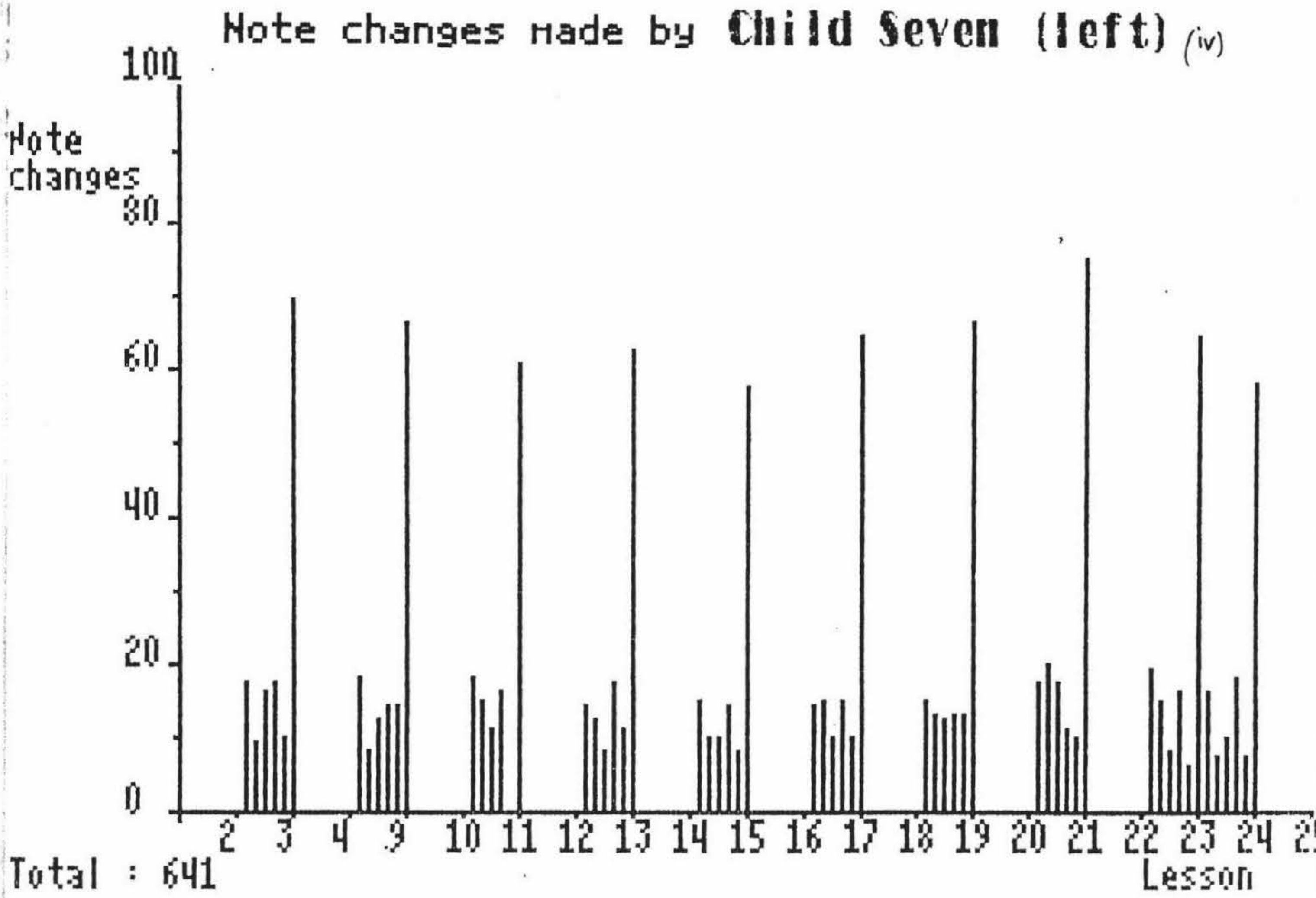
Deviation from beat for Child Seven (right)
Secs/10
10
8
6
4
2
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Overall average deviation : 0.35 seconds
Lesson

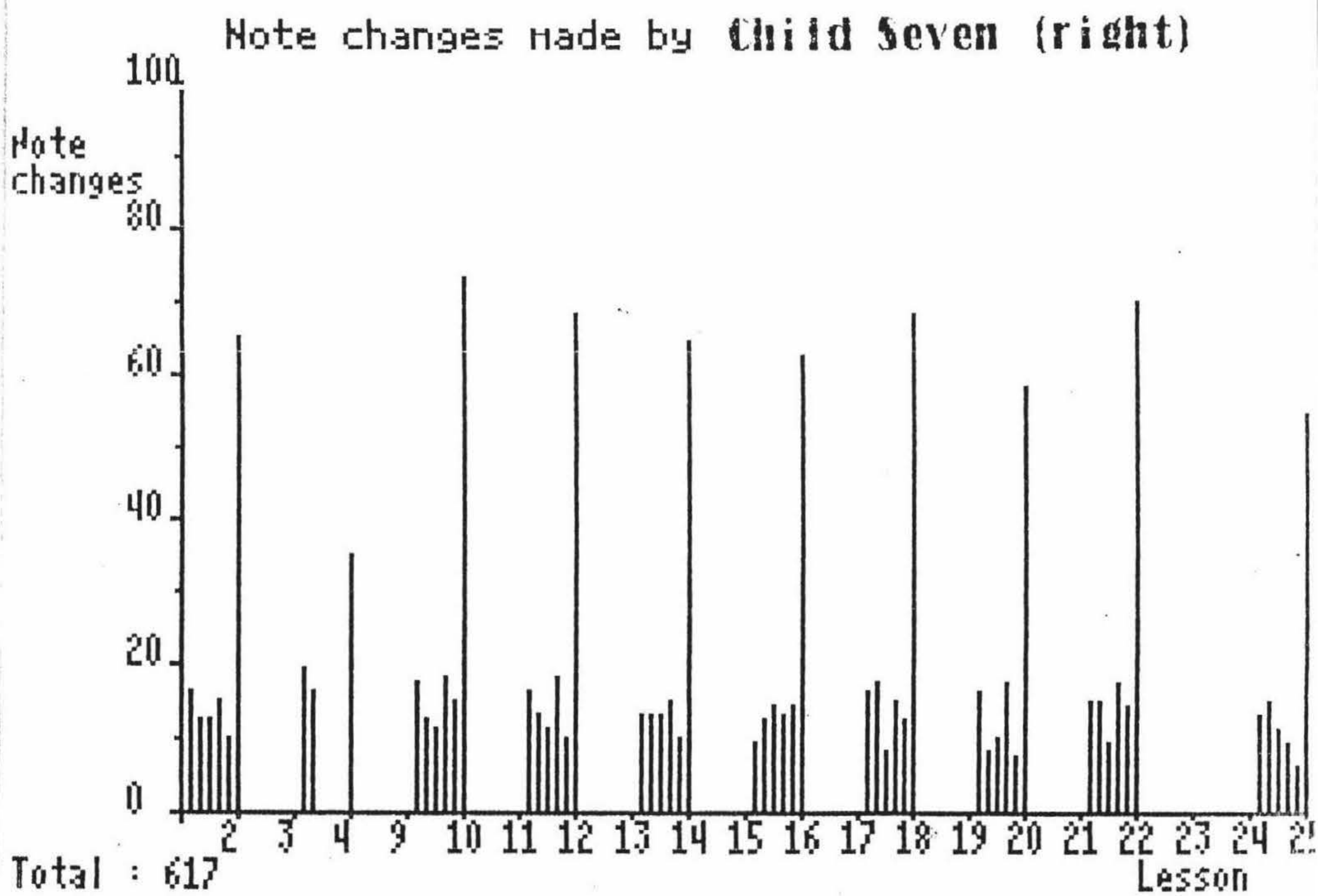


Note axis- Secs/10
Average note duration for Child Seven (left)
15
12
9
6
3
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Overall average note duration : 0.55seconds
Lesson

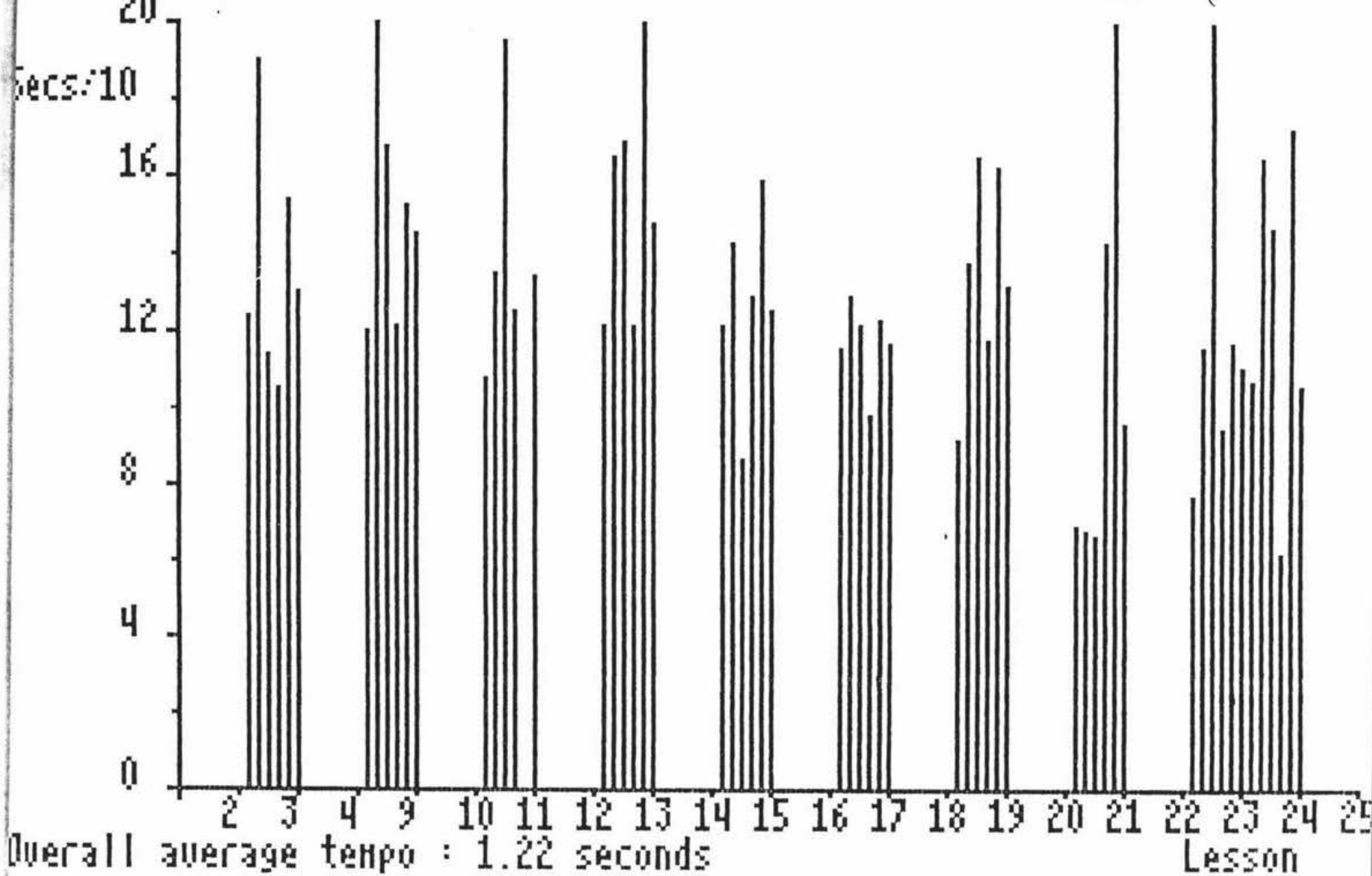


Note axis- Secs/10
Average note duration for Child Seven (right)
15
12
9
6
3
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Overall average note duration : 0.48seconds
Lesson

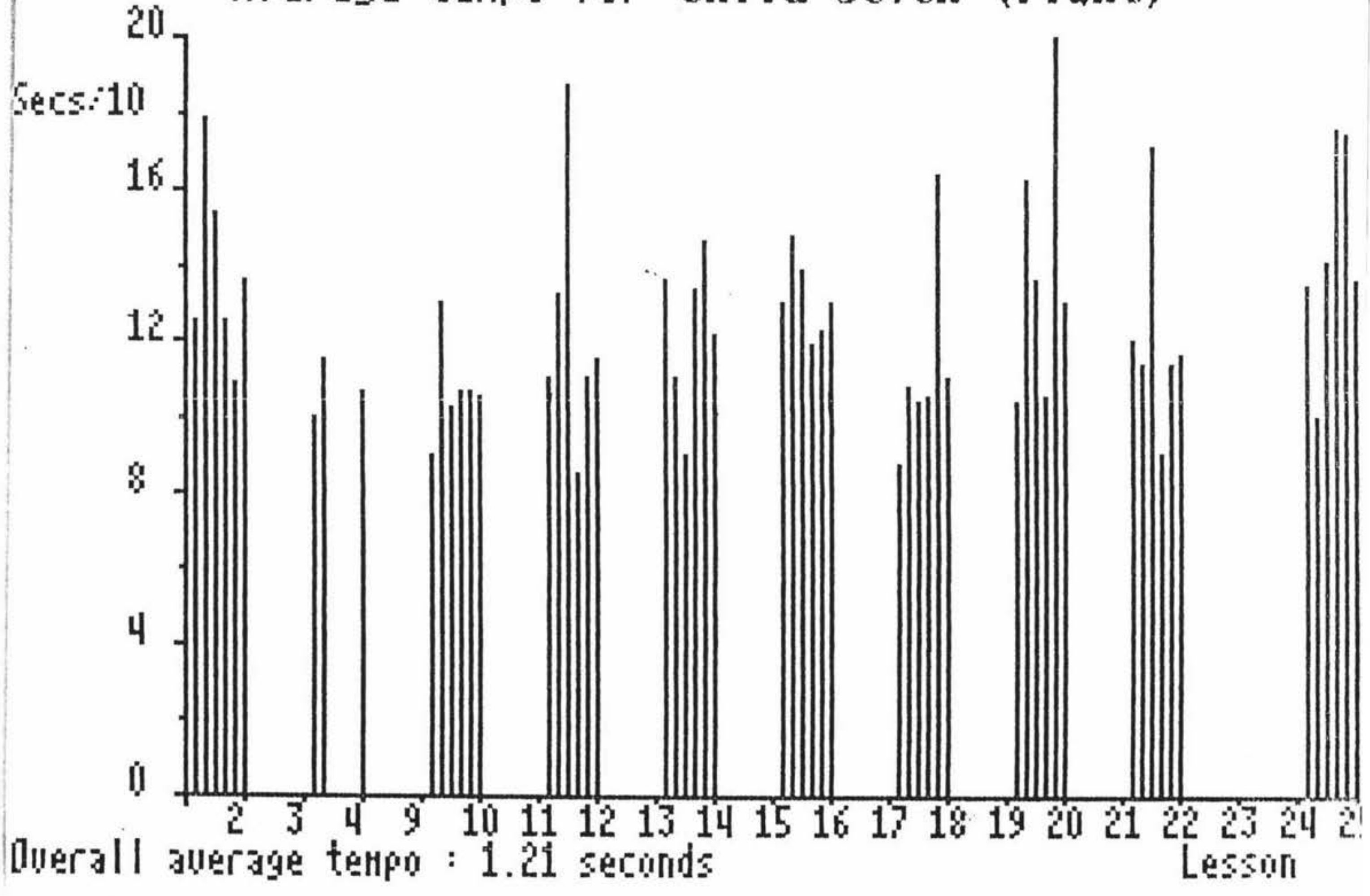

Note changes made by Child Seven (left) (iv)
Note changes
100
80
60
40
20
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Total : 641
Lesson

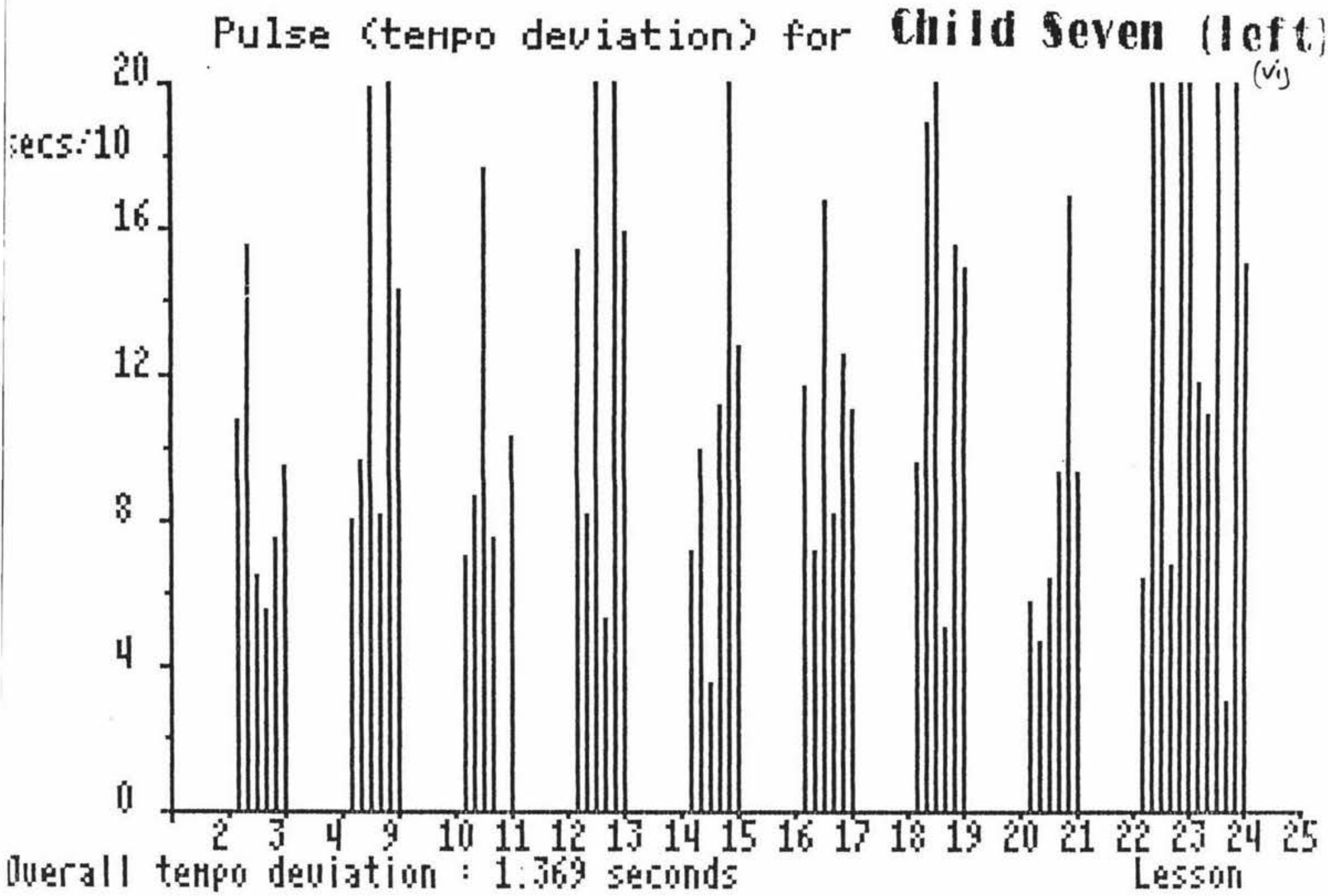

Note changes made by Child Seven (right)
Note changes
100
80
60
40
20
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Total : 617
Lesson

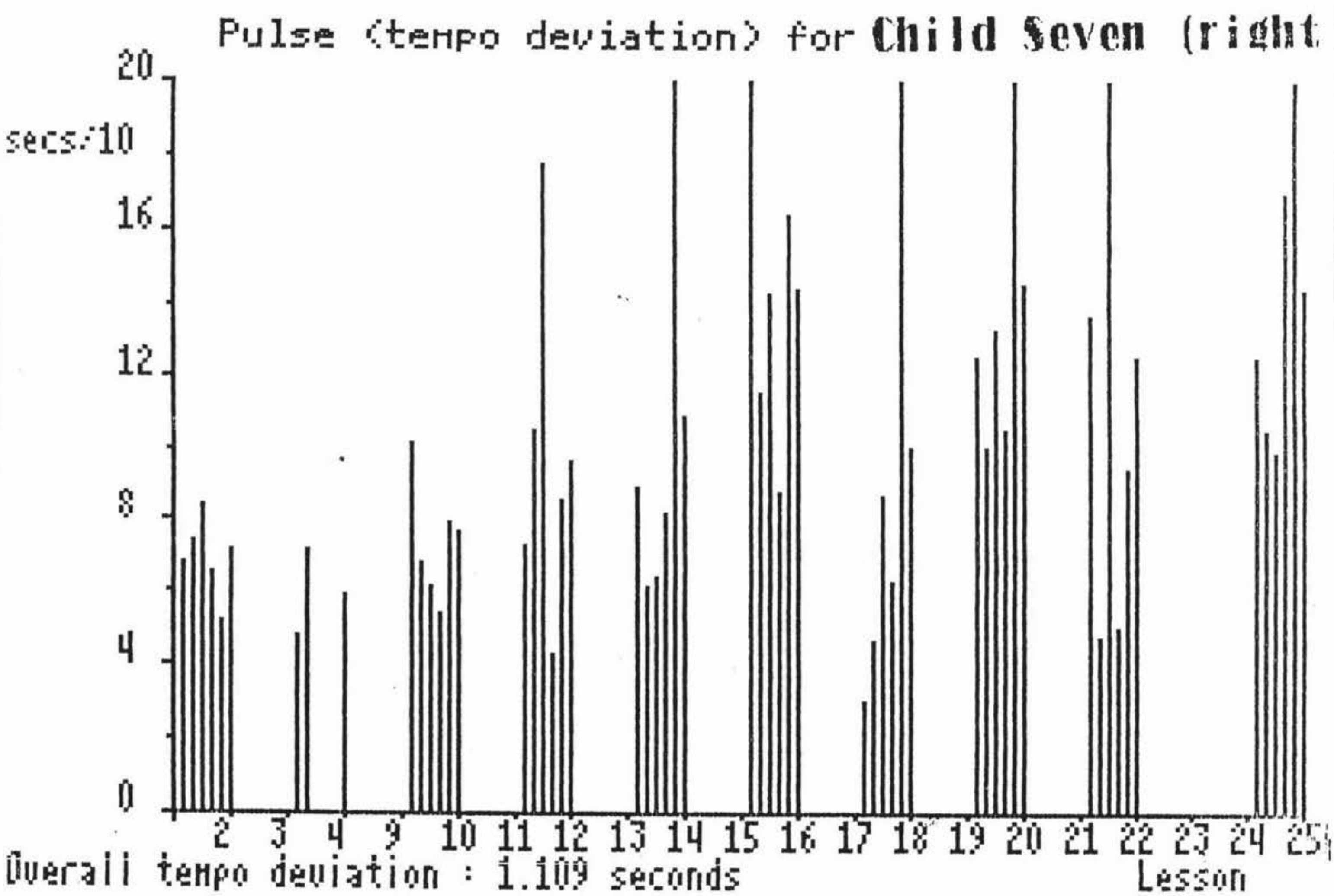
Average tempo for **Child Seven (left)** (v)



Average tempo for **Child Seven (right)**

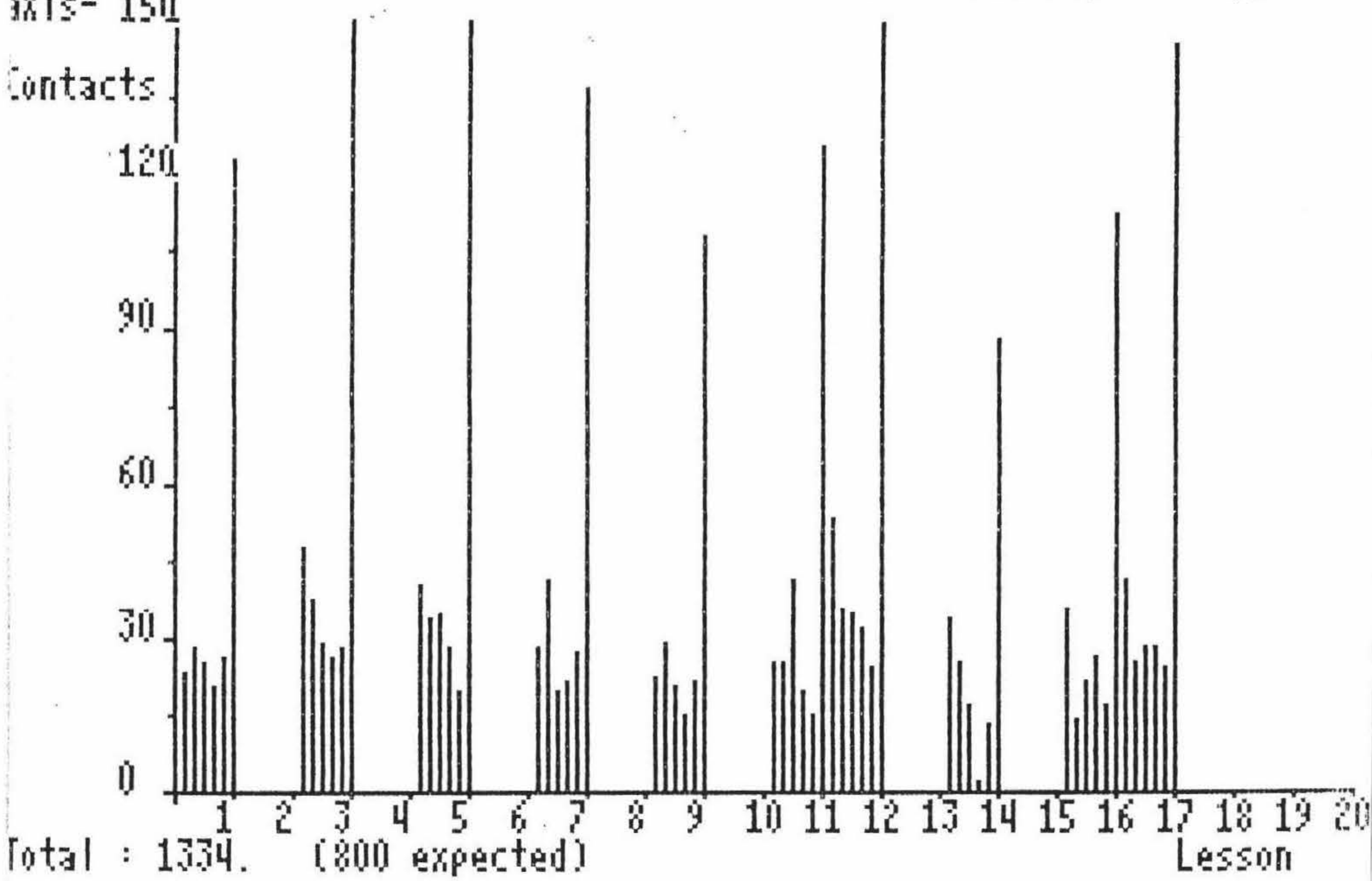



Pulse (tempo deviation) for Child Seven (left)
(vi)
secs/10
20
16
12
8
4
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Overall tempo deviation : 1.369 seconds
Lesson


Pulse (tempo deviation) for Child Seven (right
secs/10
20
16
12
8
4
0
2 3 4 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Overall tempo deviation : 1.109 seconds
Lesson

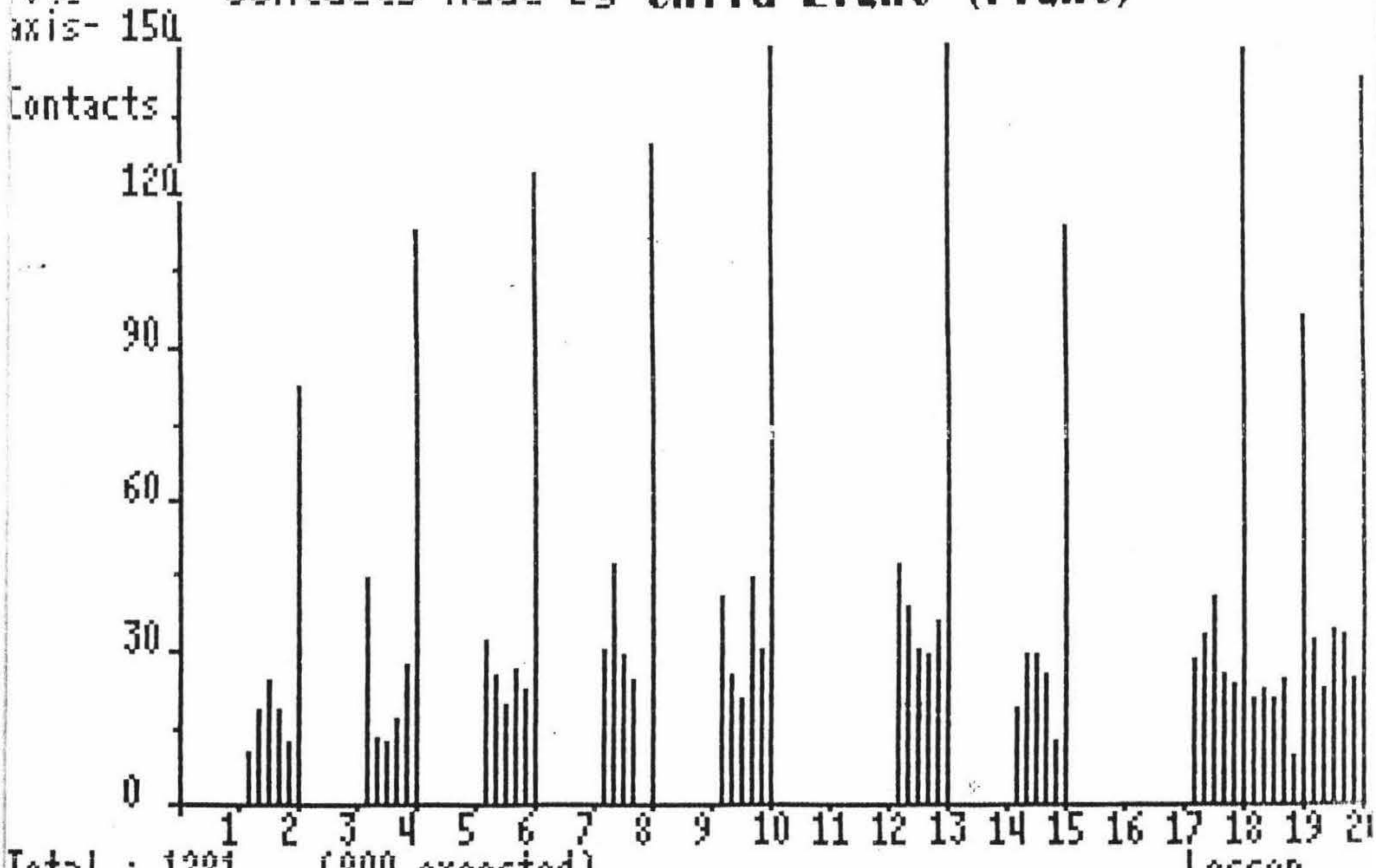
(i)

Contacts made by **Child Eight (left)**

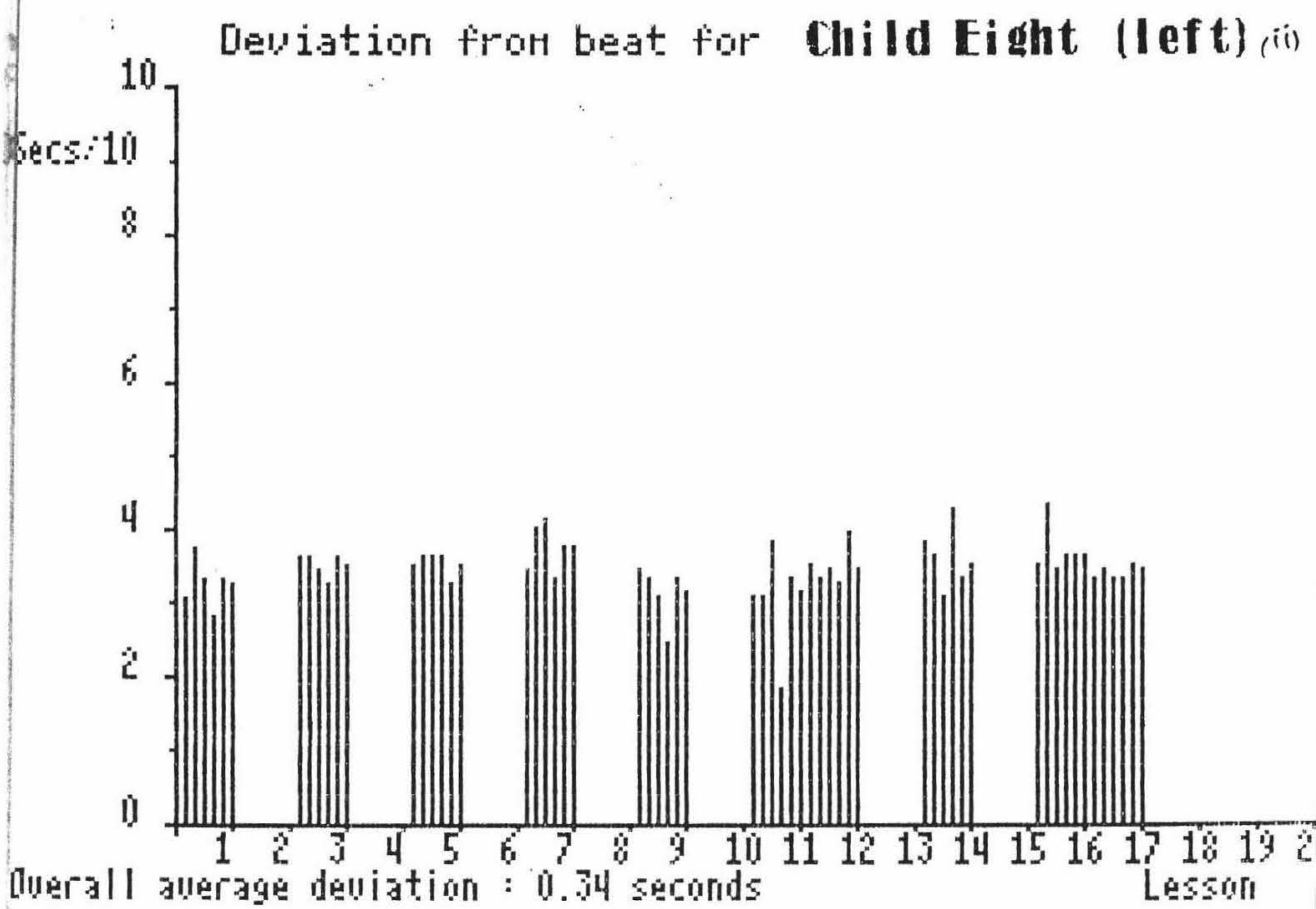


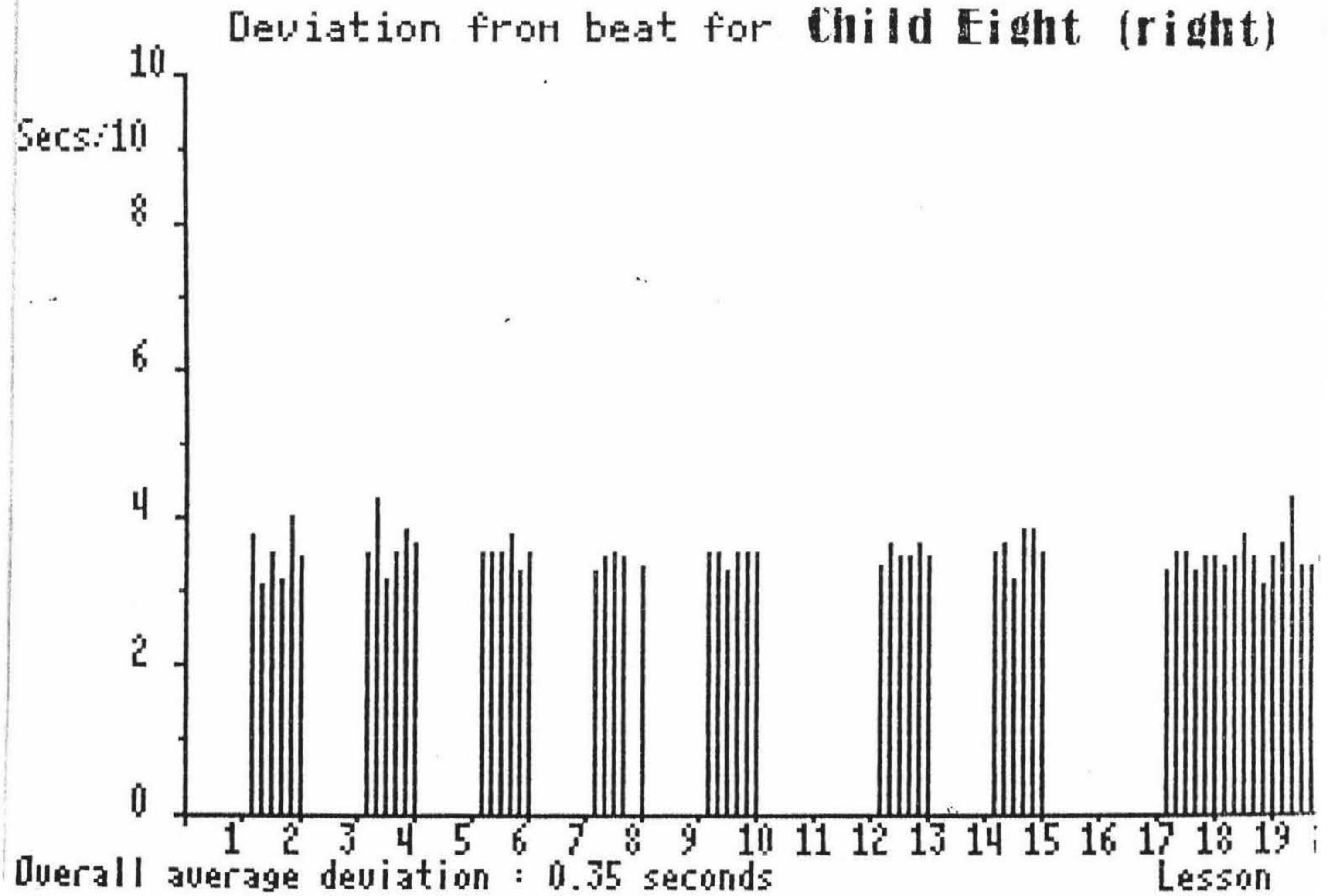
Total : 1334. (800 expected)

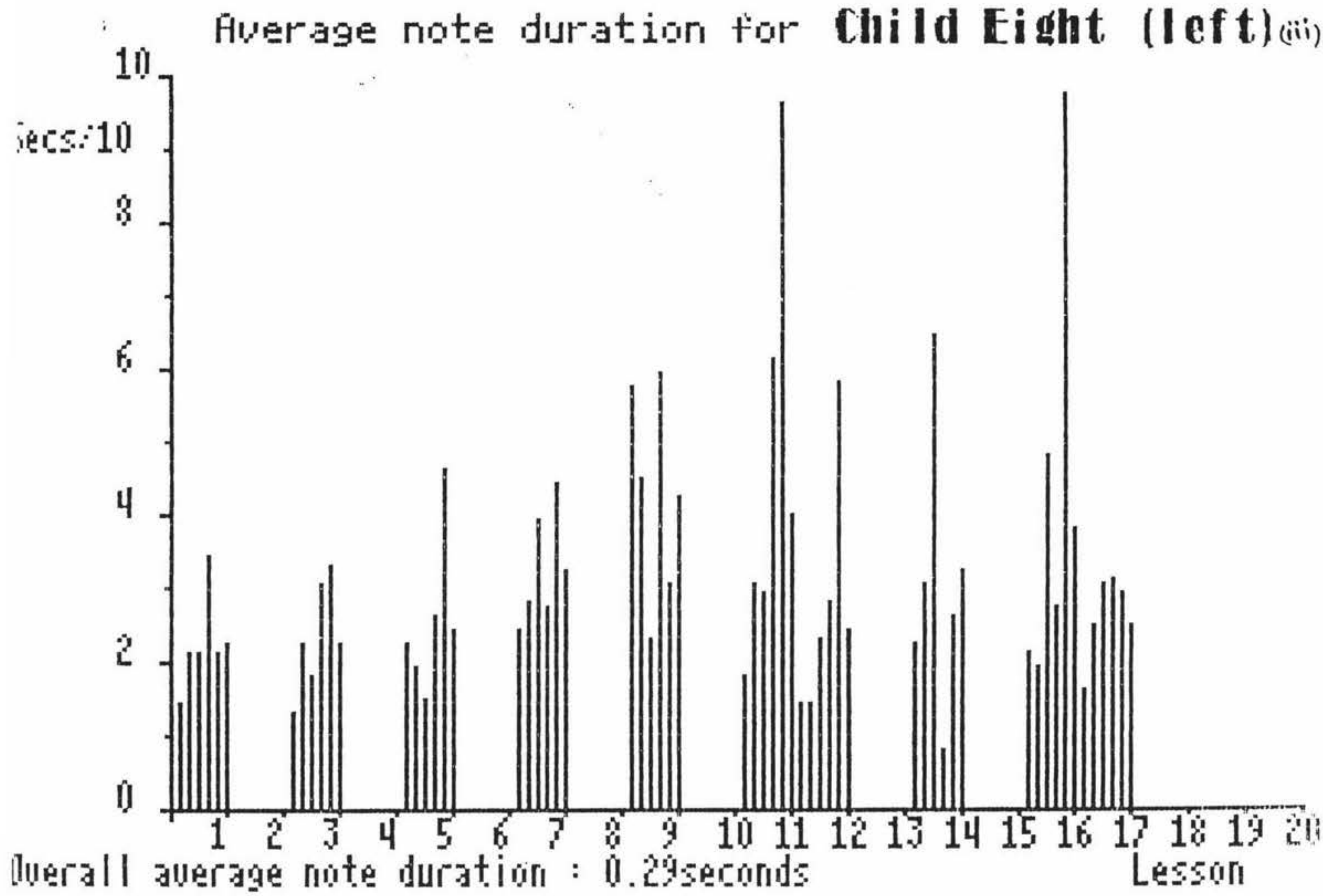
Contacts made by **Child Eight (right)**

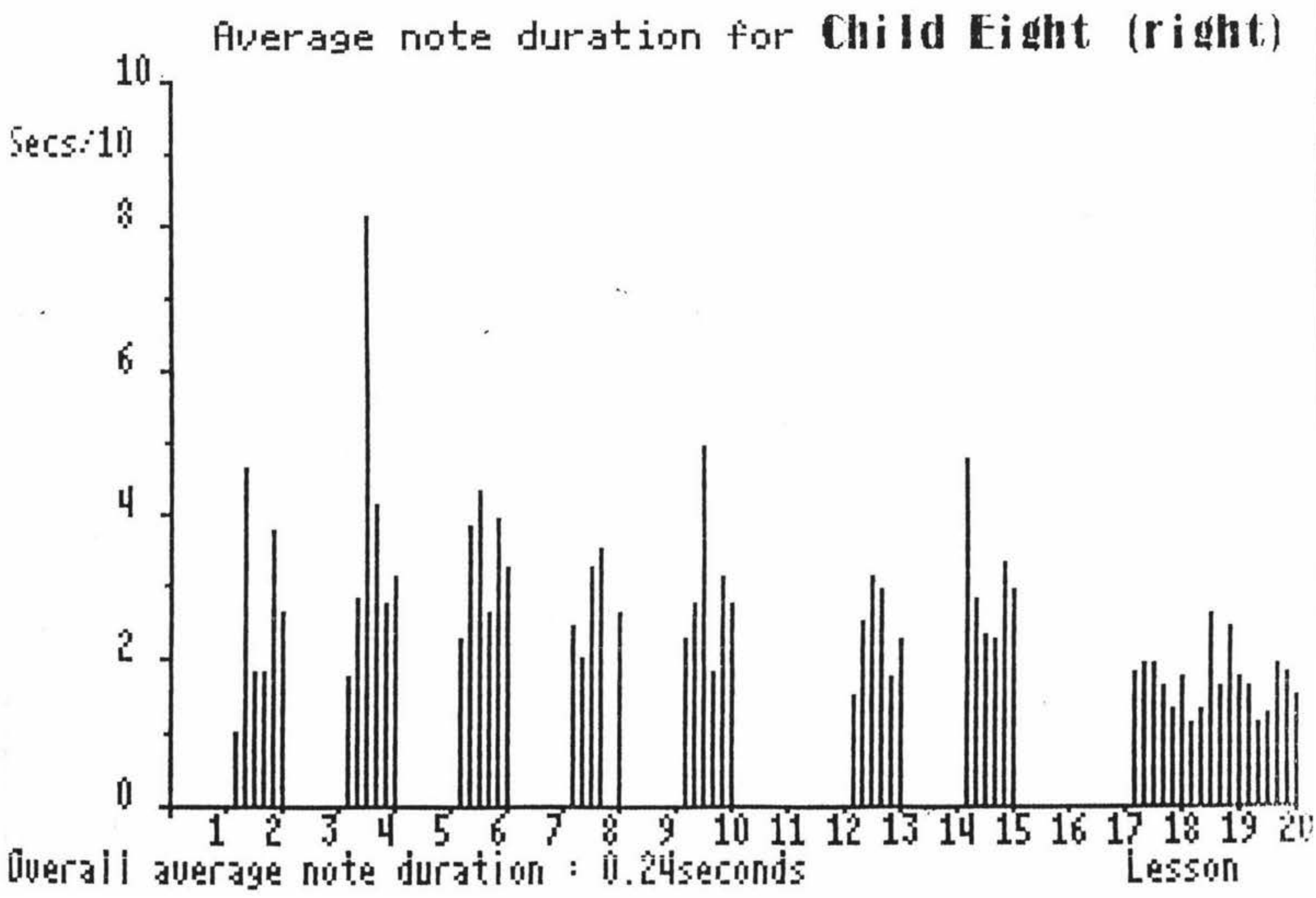


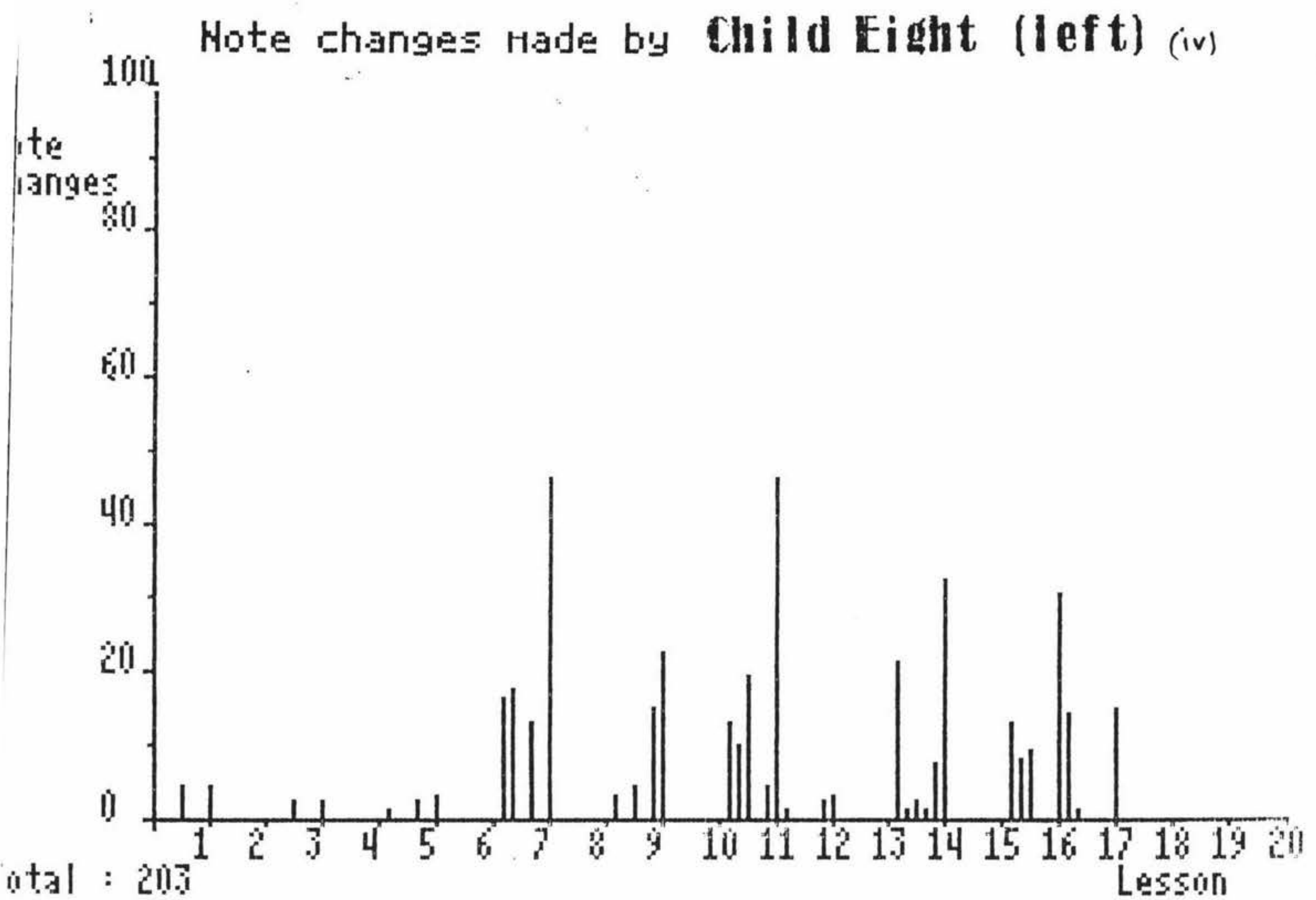
Total : 1281 (800 expected)

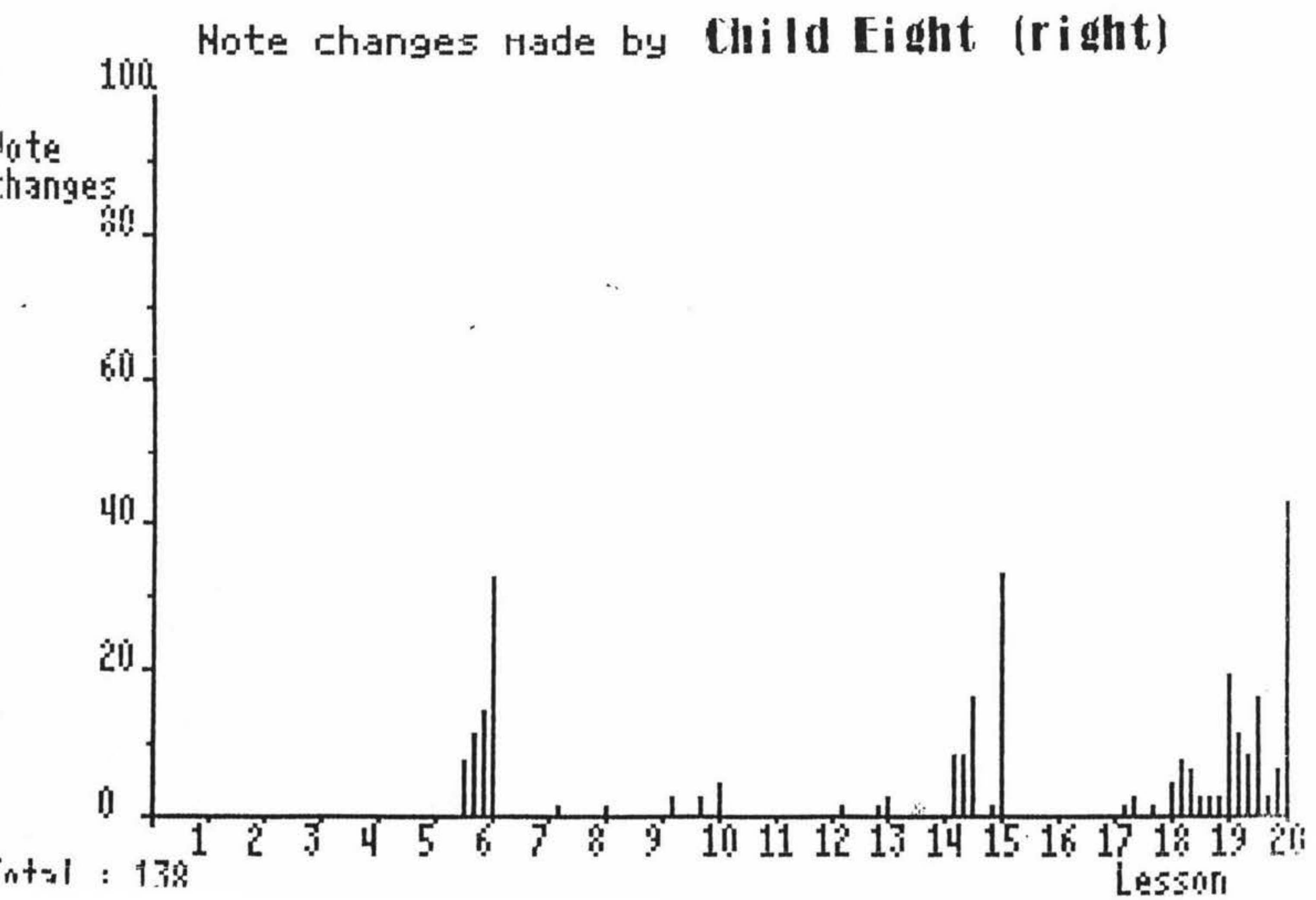

Deviation from beat for Child Eight (left) (i)
10
Secs/10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 2
Overall average deviation : 0.34 seconds
Lesson


Deviation from beat for Child Eight (right)
10
Secs/10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Overall average deviation : 0.35 seconds
Lesson

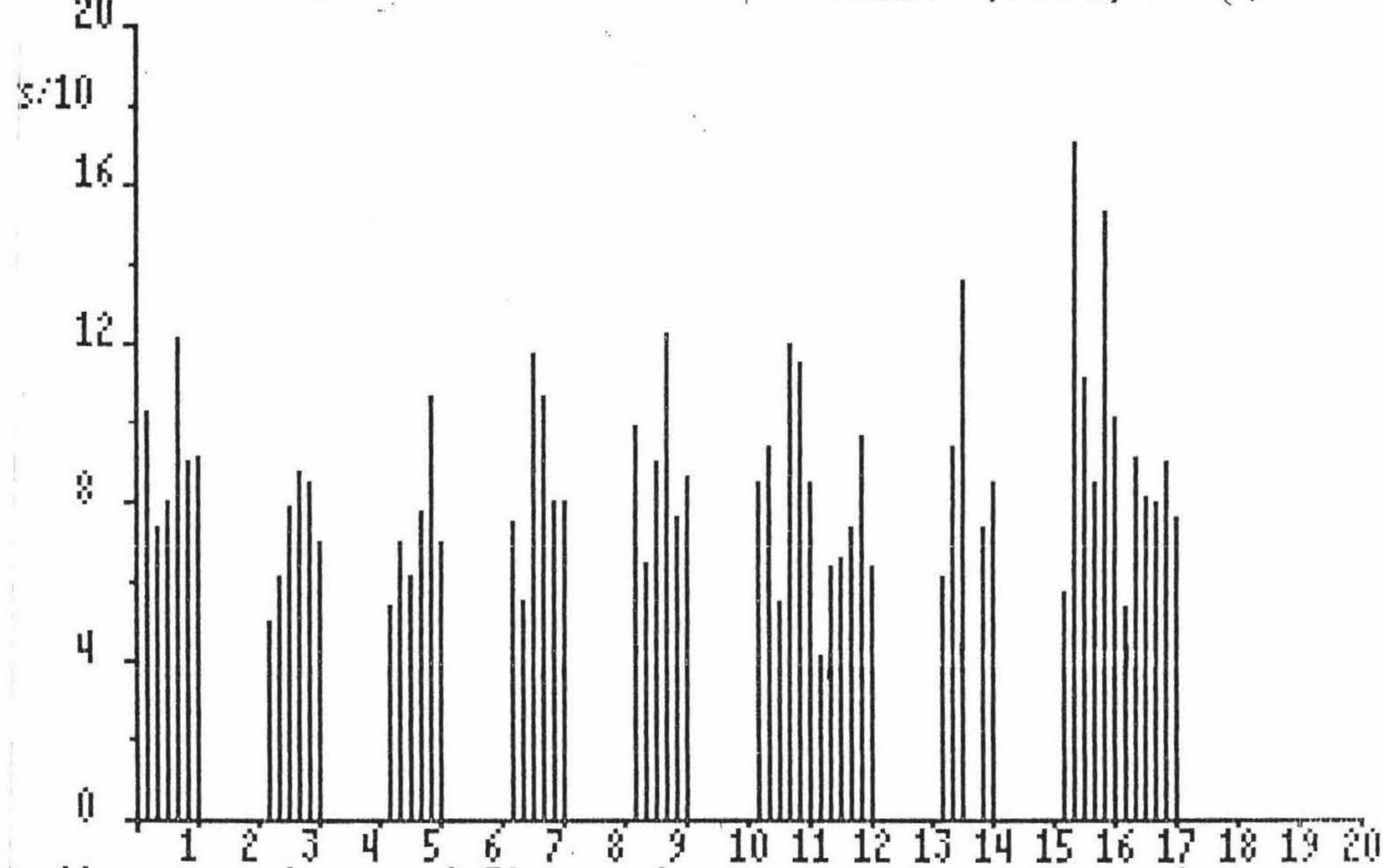

Average note duration for Child Eight (left) (iii)
Secs/10
0
2
4
6
8
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Lesson
Overall average note duration : 0.29seconds


Average note duration for Child Eight (right)
Secs/10
0
2
4
6
8
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Lesson
Overall average note duration : 0.24seconds


Note changes made by Child Eight (left) (iv)
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Total : 203
Lesson

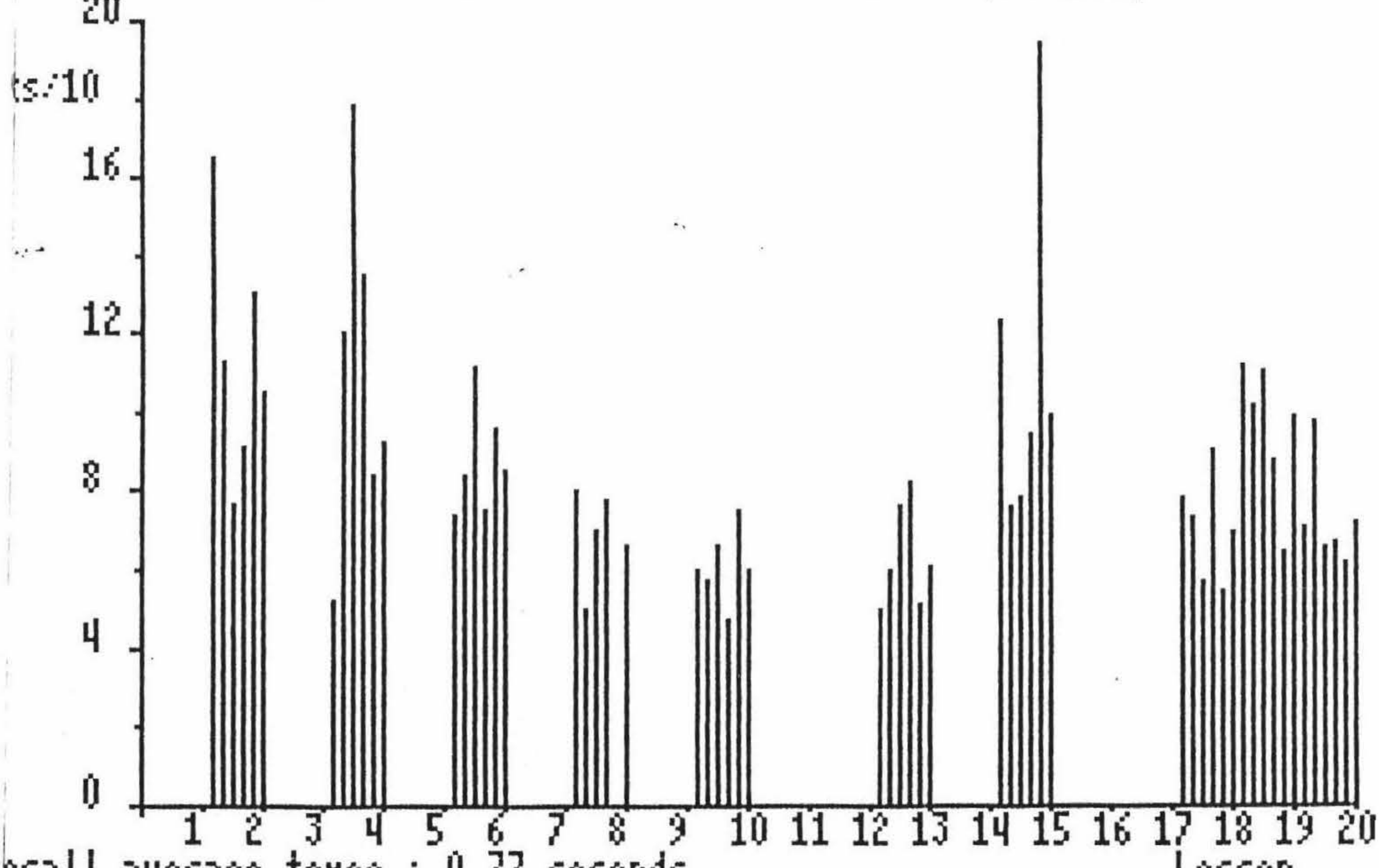

Note changes made by Child Eight (right)
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Total : 138
Lesson

Average tempo for **Child Eight (left)** (v)

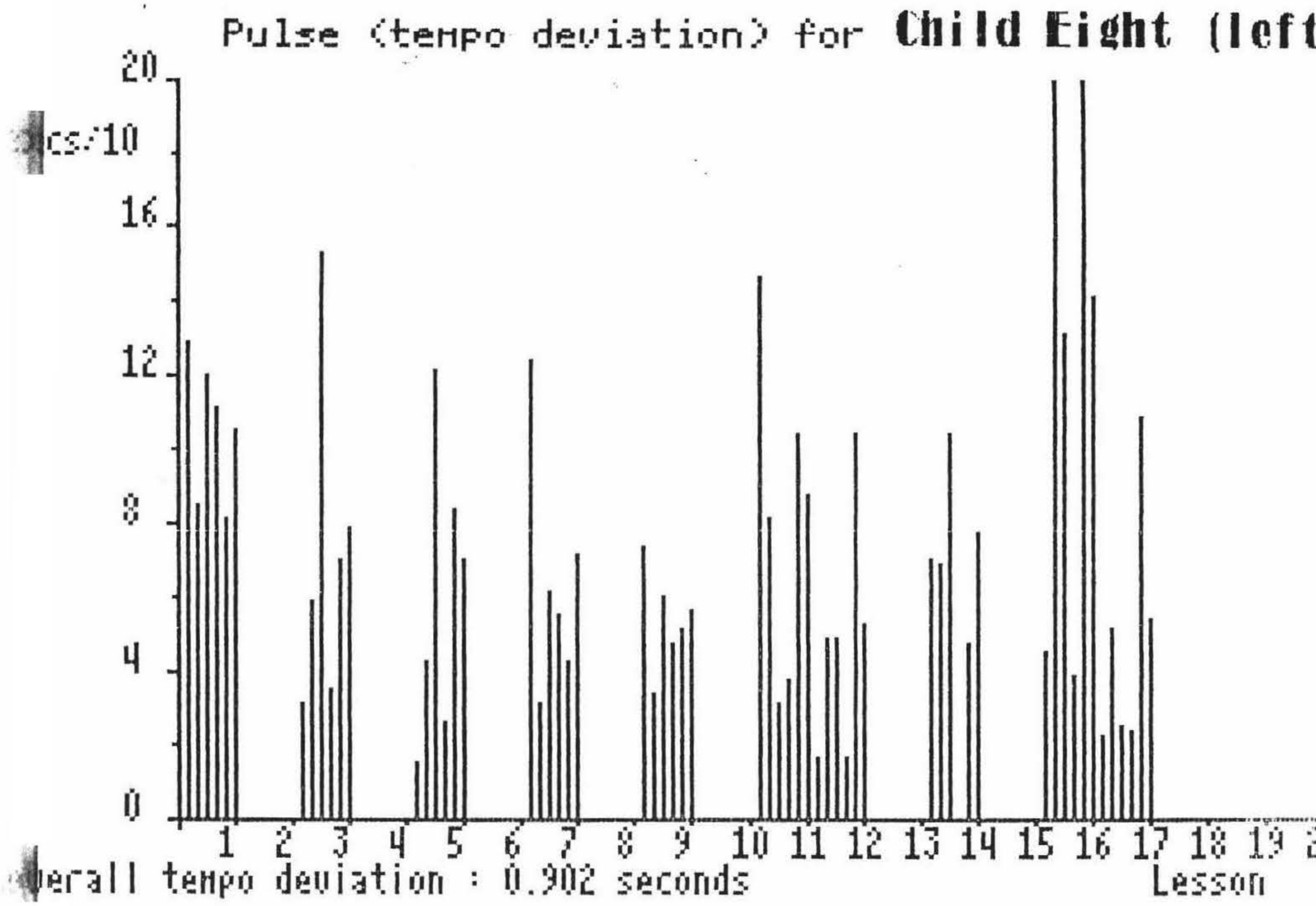


erall average tempo : 0.79 seconds

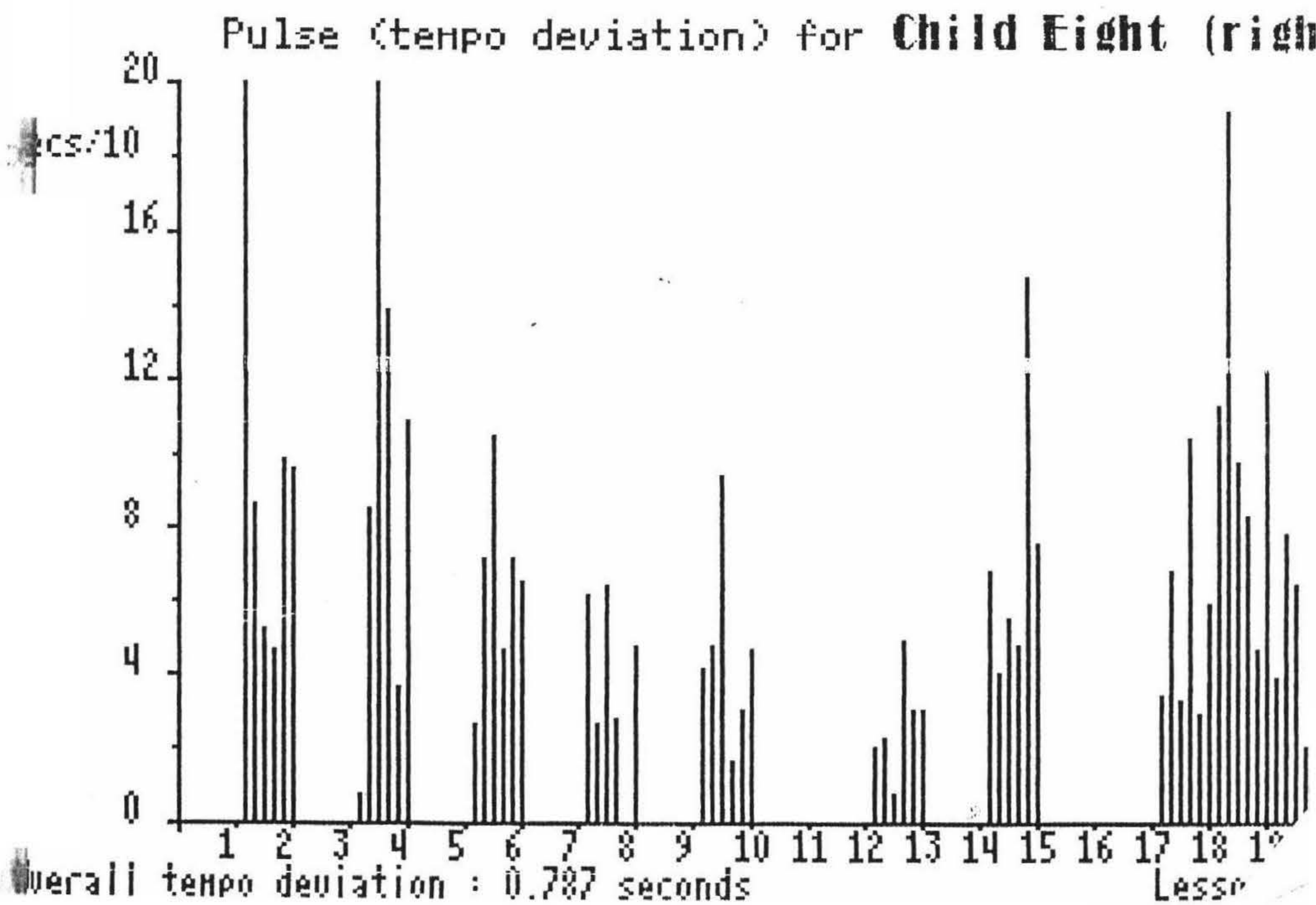
Average tempo for **Child Eight (right)**



erall average tempo : 0.77 seconds



Pulse (tempo deviation) for Child Eight (left
20
cs/10
16
12
8
4
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Overall tempo deviation : 0.902 seconds
Lesson



Pulse (tempo deviation) for Child Eight (righ
20
cs/10
16
12
8
4
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Overall tempo deviation : 0.787 seconds

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