MUSIC COGNITION IN INFANCY: INFANTS' PREFERENCES AND LONG-TERM MEMORY FOR COMPLEX MUSIC

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Abstract

The purpose of this study was to investigate infants' preferences and long-term memory for two contrasting complex pieces of music, that is, *Prelude* and *Forlane* from *Le Tombeau de Couperin* by Maurice Ravel (1875-1937). Seventy 8.5-month-old infants were randomly assigned to one of four experiments conducted on the *Headturn Preference Procedure*. The first experiment examined infants' preferences for Prelude and Forlane in piano timbre. The second experiment assessed infants' preferences for *Prelude* and *Forlane* in orchestra timbre. Infants' preferences for the Forlane in piano and orchestra timbres were investigated in the third experiment. The last experiment aimed at infants' long-term memory for complex music. Thirty infants were exposed to either the *Prelude* or the *Forlane* three times a day for ten consecutive days. Two weeks following the exposure, infants were tested on the HPP. It was predicted that these infants would prefer to listen to the familiar piece from the exposure over the unfamiliar one. Results suggested that 8.5-month-olds could tell apart two complex pieces of music in orchestra timbre and could discriminate between the piano and the orchestra timbres. Contrary to the belief that infants are ill equipped to process complex music, this study found that infants could encode and remember complex pieces of music for at least two weeks.

Because infants rely on their caretakers to provide musical experiences for them, maternal beliefs and uses of music were also investigated. Mothers of participating infants were interviewed on musical background, listening preferences and musical behaviors and beliefs with their infants. The analysis of interview data yielded the following main results: (1) Singing was the primary musical activity of mothers and babies; (2) Maternal occupation and previous musical experiences affected their musical behaviors with their babies; (3) Most mothers held the belief that there is appropriate music for babies to listen to although there was no consensus as to what is appropriate music. Such beliefs reflect a conflict between maternal beliefs regarding infants' music cognition and the actual music-related perceptual and cognitive abilities of infants. Attempting to attenuate this conflict, suggestions for music educators, parents and researchers were proposed.

Résumé

Cette étude concerne les préférences musicales des soixante-dix enfants en bas âge et leur mémoire musicale à long terme. Elle prend pour corpus le *Prélude* et la *Forlane* du *Tombeau de Couperin*, de Maurice Ravel (1875-1937), en version pour piano ou orchestrale. Quatre experiénces ont alors été appliqués en utilisant le test de *Headturn Preference Procedure*. Exp. 1 et Exp. 2 présentaient les deux pièces (version pour piano et version pour orchestre, respectivement) et vérifiaient les préférences des sujets pour l' une d' elles. Exp. 3 vérifiait leur préférence pour la Forlane, version piano ou orchestrale. Exp. 4 concernait la mémoire à long terme des enfants vis-à-vis des compositions musicales complexes. Trente enfants âgés de 8.5 mois ont été exposés soit au Prélude, soit à la Forlane trois fois par jour pendant dix jours consécutifs. Deux semaines après, on leur a fait passer le test de *Headturn Preference Procedure*, en vue de vérifier l' hypothèse qu' ils seraient plus attentifs à la pièce entendue auparavant qu'à celle qui leur était inconnue. D' après les résultats des tests, les enfants de 8.5 mois réussissent non seulement à distinguer deux pièces d' un même auteur, mais aussi différentes versions d' une même pièce. Ils sont capables aussi de coder des pièces de musique complexe, e de les retenir pour une période de deux semaines ou plus, contrairement à une croyance répandue.

Une série d' interviews faites auprès des mères de ces enfants a permis de vérifier (1) qu' elles identifient le chant comme la principale activité musicale qui les relie à leur enfant; (2) que leur comportement musical est affecté par le type de profession qu'elles exercent, et par leur education musicale préalable; (3) qu' elles croient qu' il existe un type de musique pour enfants, encore qu' il n' y ait pas d' accord sur sa nature. De telles opinions dénoncent un décalage entre les capacités perceptuelles qu' on attribue naïvement aux enfants en bas âge et celles qu' on découvre au cours de la recherche expérimentale. Quelques suggestions qui pourraient atténuer ce décalage sont adressées aux enseignants, parents et chercheurs.

Resumo

O objetivo deste estudo foi o de investigar as preferências e a memória musical a longo prazo dos bebês para duas peças musicalmente complexas, *Prelude* e *Forlane* da suíte *Le Tombeau de Couperin* de Maurice Ravel (1875-1937). Setenta bebês de 8.5 meses de idade participaram de uma entre quatro experiências realizadas com o auxílio do Headturn Preference Procedure. A primeira experiência examinou as preferências dos bebês para *Prelude* e *Forlane* tocadas por um piano. A segunda experiência investigou as preferências dos bebês para *Prelude* e *Forlane* tocadas por uma orquestra. As preferências dos bebês para *Forlane* em timbres contrastantes, isto é, piano ou orquestra foram avaliadas na terceira experiência. A última experiência interessou-se pela questão da memória musical a longo prazo para música complexa. Trinta bebês ouviram ou *Prelude* ou *Forlane* três vezes ao dia, por dez dias consecutivos. Os bebês foram trazidos ao laboratório da universidade duas semanas após o período de exposição musical. Os resultados das experiências sugerem que os bebês de 8.5 meses conseguem diferenciar duas peças complexas tocadas em timbre orquestral, e que discriminam entre os timbres do piano e da orquestra. Contrariamente à idéia de que os bebês são mal-equipados para processar música complexa, este estudo sugere que os bebês podem aprender e reter músicas complexas na memória a longo prazo por pelo menos duas semanas.

Uma vez que os bebês dependem de seus reponsáveis para obterem experiências musicais, as mães dos bebês participantes responderam perguntas sobre usos da música com seus bebês, experiências musicais anteriores e preferência musical. Os resultados principais que emergiram das entrevistas foram os seguintes: (1) Cantar era a atividade musical favorita das mamães e bebês; (2) A ocupação da mães e suas experiências musicais anteriores influenciaram no uso da música com seus bebês; (3) A maioria das mães disse acreditar na existência de "música apropriada para bebês", embora não houve consenso na definição deste tipo de música. A idéia de música apropriada revela um conflito entre as habilidades músico-cognitivas dos seus bebês e o julgamento que as mães fazem das mesmas. São oferecidas sugestões para educadores, pais e pesquisadores.

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Note

In accordance with the regulations of the Faculty of Graduate and Postdoctoral Studies of McGill University, preliminary results from this study were presented previously at scientific meetings, namely:

- International Conference on Infant Studies in Toronto, Ontario, Canada (April, 2002);
- 57th Biennial in-service Meeting of the Music Educators National Conference in Nashville, Tennessee, USA (April, 2002);
- 143rd Meeting of the Acoustical Society of America in Pittsburgh, Pennsylvania, USA (June, 2002).

A review of literature on infants' music perception and cognition, with partial contents of chapter II, was published by the author and appears in the British periodical *Early Child Development and Care* (2002).

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Research with babies can be a rather difficult task. I was very fortunate to encounter support when many said "nah". I am indebted to my co-supervisor Dr. Linda Polka for providing me with access to her lab facility, for helping with the research design, and for sharing all her expertise on babies. This project would have never taken place without her unending support. A heartfelt thanks goes to Dr. Celeste Johnston from the School of Nursing for providing me with much encouragement for conducting a study with babies. Additional thanks are due to Dr. Peter Jusczyk, who made valuable comments and suggestions during the elaboration of the design of this study.

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To all of you: *MUITO OBRIGADA*.

Dedication

" Você,
precisa aprender inglês,
Precisa aprender o que eu sei, e o que eu não sei mais
Baby, I love you."

"You,
need to learn English
Need to learn what I know and don't know
Baby, I love you."

(Caetano Veloso – Baby)

To Mary Helena and Rodolfo ("minha mãe & meu pai"), to whom I was a baby once, with my love, my respect and my gratitude.

To Nonna Tina, with love and admiration.

To all babies, known and unknown. Just thinking about them is enough to make me believe there is hope for social change.

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Chapter I

Introduction

References to the uses of music with infants and young children date as far back as antiquity (West, 2000). In his work "Laws", the Greek philosopher Plato described the process in which a restless infant was lulled to sleep by means of music and rocking. Ptolemy, Aristides, Asclepius and Boethius also discussed the relationship between music and the soul, and the ways in which different melodies were responsible for the stimulation or sedation of the ill and the healthy child or adult (see West, 2000). Many years later, in the 17th Century, New England Puritan women were advised to sing the "Cradle Hymn" to lull their babies to sleep (Reese, 2000). These are some of the many examples that exist in the literature regarding the uses of music in infant caretaking contexts (for examples refer to Horden, 2000).

Observational data from several studies (Blacking, 1967; Forrai, 1997; Kelley & Sutton-Smith, 1987; Moog, 1968) have provided strong evidence of human infants' abilities to learn music. Through observations of Venda children in Africa, John Blacking (1967/1995) noticed that babies learned many songs while being nursed. Sakata (1987), who studied the musical behaviors of the Hazara women in pre-Taliban Afghanistan found music to be a powerful means of cultural transmission between mothers and their infants. The same was said about the function of Tamil mothers' infant-directed chant (Balakrishnan, 1980). Anecdotal data also supports the idea that babies are capable of learning music before they can actually speak. Shinichi

Suzuki (1983), the founder of the famous violin method, described his astonishment with a baby's reaction to familiar music:

> *"Just in front of me sat Mrs. Kiuchi, holding a baby in her arms. I inquired its age and was told that the infant, named Hiromi, was just five months old. Hiromi's sister, Atsumi, six years old, was practicing at that time the Vivaldi A-minor concerto, as well as listening to the record everyday. So Hiromi grew up hearing this music daily from the very beginning. I was anxious to know what effect this had on a five-month-old baby, so I announced that I would like to play something and stood up with my violin. When everybody was quiet, I started playing a minuet by Bach. While I played, my eyes did not leave Hiromi's face. The five-month-old already knew the sound of the violin well, and her eyes shone while she listened to this piece that she was hearing for the first time. A little while later I switched from the minuet to the Vivaldi A-minor concerto-music that was played and heard continuously in her home. I had no sooner started the piece when an amazing thing happened. Hiromi's expression suddenly changed. She smiled, laughed, and turned her happy face to her mother, who held her in her arms. "See-that's my music," she unmistakably wanted to tell her mother. Soon again, her face turned in my direction, and she moved her body up and down in rhythm. This baby, just five months old, had shown that she knew the melody of the Vivaldi A-minor concerto." (Nurtured by love, pp. 7).*

The role of parents was notable in this and all the abovementioned observations of early music learning. This comes as no surprise since parents hold an important role in their children's music education. Not only are they responsible for providing musical experiences for their children, but they also shape the musical environment in the home. Because infants learn a great deal from their environment; from what they hear, see, smell, touch and taste (see Campbell, 2000; Meltzoff, 1998; Small, 1998), the home music environment is likely to influence their musical development (Kelley & Sutton-Smith, 1987). Parents are then the mediators of their babies' musical experiences.

The way parents use music with their babies is both personal, that is, varies across families but is also highly influenced by their culture. Schoenstein (2002) has discussed extensively in the book *Toilet trained for Yale* how the media has helped create a frenzy of push-parenting behaviors, including musical ones. In the past few years, a great deal of attention has been given to the uses of music and its effects on early child development. Much information has circulated regarding the importance of music in the lives of infants and young children. Through the dissemination of research that still needed further replication like the so-called "Mozart-effect", the popular press helped spread some unconfirmed or even misleading ideas regarding the benefits of music exposure on infant brain development (for a discussion see Abrams et al., 1998; Duke, 2001). Such ideas obviously have affected the attitudes of many parents, teachers and children towards music.

Moreover, this ever-growing interest in early musical abilities yielded an increase in music resources geared towards the infant-young children population. In the past few years, many music books and toys (e.g., music blocks, mobiles) were designed with young learners in mind. Programs such as *Kindermusik, Musikgarten* and *Music Together* have been developed to musically educate parents and babies in North America (see Denney, 2000; Denton, 2000; Levinowitz & Guilmartin, 2000). Videotapes, cassettes and CDs of classical music, world lullabies and children's songs containing mainly simple music are readily available in regular stores. Although the quality of these resources varies considerably, a common element amidst them is an implicit belief that there is appropriate music for babies. Such beliefs sustain the idea that babies are naturally inclined to like and benefit from simple music. Moreover, they imply that infants are ill equipped to process complex music and that this type of music is inappropriate for them. Unfortunately, these beliefs are transmitted in full to parents who often endorse them without questioning their veracity. An example of parental confusion regarding musical appropriateness in the case of infants was described by Custodero (2002, personal communication):

> *"A voice on the other end of the phone sounds worried. It's a first-time mother, an African American graduate of Union Theological Seminar, on maternity leave from university teaching. "I saw your name on the back of this [classical music] CD and knew I could trust someone from Teachers College. My husband [a professor at the University of Chicago] is playing James Brown for our baby and I'm concerned that it might not be the right thing to do. Will it hurt her?" After a short conversation, she is convinced that dancing to favorite music and looking lovingly into the eyes of a child does not pose a threat to her daughter's intellectual development."*

Beliefs of appropriate music for babies are seen through parental reports (Ilari, 2002) and through the repertoire found in all sorts of musical materials designated for babies (see appendix S). Music teachers of infants are often quite traditional in their selection of repertoire for their classes (e.g., Kindermusik, see Denney, 2000). The music content of educational materials is perhaps the cause of such traditional approach employed by teachers. A careful examination of the repertoire found in several resources for babies (i.e., CDs, videotapes, music education books) reveals an implicit belief of the infant as a limited listener. This is especially true for resources that include music of the classical genre. In a survey of 60 infant-related musical resources (refer to appendix S), only a handful included examples of contemporary music. Most surveyed CDs of classical music included primarily pieces from the

Baroque and Classical periods. Furthermore, the majority of CDs had pieces of music that were highly repetitive, with structured forms, clear distinctions between melodies and accompaniments, simple harmonies and chord progressions. Such choice of repertoire is perhaps grounded on an "old" notion of the infant as a poor listener, or, in the words of John Locke (1690, cited in Berk, 1999): a *tabula rasa*.

Despite the fact that music has accompanied the growth of many infants across time, it was only recently that the study of music in infancy became systematic and took the infant's perspective. Borrowing from the language acquisition literature and methodology, researchers have attempted to understand how infants make sense of the music that surrounds them. The last few decades have seen an increase in research on infants' music perception and cognition (see Trehub, Bull & Thorpe, 1984; Trehub & Trainor, 1993; Zentner & Kagan, 1998). With the development and further refinement of measurement tools, researchers have challenged the assumption that infants are passive listeners with limited perceptual and cognitive skills for auditory events. There is now evidence to suggest that infants are sophisticated listeners who process music in many adult-like ways (Schellenberg & Trehub, 1996; Trehub & Trainor, 1993).

Paradoxically, researchers have shown to be quite traditional in their approach to repertoire when it comes to infant perception research. The musical stimuli used in most studies conducted with infant listeners have normally been computer-generated, controlled artificial melodies (Ferland & Mendelsohn, 1989; Trehub, Bull & Thorpe, 1984), lullabies (Trainor, 1996), simple folk songs (Trainor, Wu & Tsang, 2001; Zentner & Kagan, 1998), and early Mozart sonatas (Jusczyk & Krumhansl, 1994;

Saffran, Loman & Robertson, 2000). As noted earlier, an implicit assumption underlying this choice of stimuli is that the musical processing abilities of infants are limited to repetitive music with simple intervals, contours, rhythms and structured forms. Moreover, it has been recently suggested that complex music might be inappropriate for young children due to their limited abilities to process music (Dalla Bella, Peretz, I., Rousseau, L & Gosselin, N., 2001). Studies that investigate how infants process and encode more complex music, that is, music with extended harmonies, unusual rhythmic patterns, complex forms and melodies are needed to address the issue of processing limitations.

Purpose of the study

The purpose of this study was twofold. The first purpose was to examine infants' preferences for and discrimination of two distinct pieces of complex music played in single and multiple timbres (i.e., piano and orchestra respectively). The second purpose was to investigate whether infants could remember a complex piece of music, heard previously, after a two-week delay (see Jusczyk & Hohne, 1997; Saffran, Robertson & Loman, 2000). Because infants rely on caretakers to provide musical experiences for them, maternal musical beliefs and uses of music with the participating infants were also investigated. Mothers' beliefs and uses of music with their infants were studied in an attempt to further understand and complement the infant perceptual data.

Research Questions

This study attempted to answer several questions regarding the behaviors of infants and their mothers. Questions regarding their behaviors were investigated using a specific behavioral technique described in the methodology chapter of this thesis. Mothers' musical beliefs and behaviors were obtained through interview data. Specific questions of interest to this study were:

Infants

(1) Do infants show preferences for two contrasting complex pieces of music played in piano timbre?

(2) Do infants show preferences for two contrasting complex pieces of music played in orchestral timbre?

(3) Do infants show preferences for the same complex piece of music played in two contrasting timbres (i.e., piano and orchestra)?

(4) Can infants discriminate between two contrasting complex pieces of music played in piano timbre?

(5) Can infants discriminate between two contrasting complex pieces of music played in orchestra timbre?

(6) Can infants discriminate between piano and orchestra versions of the same piece of music?

(7) Do infants show recognition of a familiar piece of music that was heard previously after a two-week delay?

(8) Can infants extract different excerpts of a complex piece of music and categorize them within the context of a single piece?

(9) Is complex music more difficult than simple music for infants to process?

Mothers

(1) Does maternal occupation affect mothers' musical behaviors with their infants?

(2) Does maternal experience affect mothers' musical behaviors with their infants?

(3) Does maternal previous musical experience affect their musical behaviors with their infants?

(4) Does the existence of a musician in the family affect mothers' musical behaviors with their babies?

(5) Do previous ensemble experiences affect mothers' overall musical behaviors with and without their infants?

(6) Does maternal music listening practices affect their musical behaviors with infants?

(7) Do mothers' listening preferences affect their beliefs and uses of music with their babies?

(8) Do mothers who spend more time with their babies use more music than mothers who spend less time with their babies?

(9) Are mothers the primary caretakers of their infants?

(10) Can mothers describe episodes in which they were surprised by their infant's memory?

(11) Do mothers sing and/or play music for their infants?

(12) Which types of music do mothers choose to sing or play for their infants?

(13) Do mothers believe in appropriate music for babies? What sorts of music do they judge appropriate and inappropriate for their babies to listen to?

(14) Do mothers agree that there is a specific, best time for musical activities to take place within their babies' routines?

(15) Overall, are mothers' beliefs and uses of music with their infants similar across families?

Terminology

The following working definitions were used in this thesis:

At-term infants – Infants born between 36 and 38 full weeks gestation age.

Auditory Thresholds – A "hearing limit": a statistically determined point in which a response to a particular auditory stimulus changes.

Complex music – Music with a large amount of information conveyed simultaneously, violating tonal and or/rhythmic expectation patterns. For the purpose of this thesis, complex music was defined in comparison to music that is traditionally presented to babies such as lullabies, playsongs, and simple baroque and classical pieces by Bach and Mozart.

Developmental disability – A disability that impedes or slows down a child's natural development process. Asperger and Down syndrome were the only two developmental disabilities represented in the sample of the experiments of this study.

Discrimination – The ability to differentiate or tell two stimuli apart.

Dishabituation – The opposite of habituation. Regain of attention in response to a novel stimulus.

Ecological validity – The ability to generalize findings obtained in lab-controlled studies to everyday life contexts.

Enculturative learning – A term used by Campbell (2000) to define intuitive forms of learning that occur through the child's observation and experience with the world.

Forgetting – The inability to retrieve information that was previously stored in one's memory.

Habituation – The decrease in attention to a stimulus due to familiarity.

Head-turn preference procedure (HPP) – A behavioral method used to study infant preferences for one stimulus over another. While some preferences may be of interest in themselves, others are indicative of discrimination, categorization and/or memory. This method is used to measure infant attentive listening to different auditory stimuli.

Infantile amnesia – the inability to recall events that occurred during the first two to three years of life.

Innate behaviors –Behaviors that are present at birth.

Intuitive parenting – Behaviors that parents are not taught; that are inherent to parenting.

Keepers – Infants who met the study criteria.

Long-term memory – The ability to recall events that took place a long time ago, measured in hours, days, weeks and even months. Consistent with previous studies, two weeks was considered long-term for infants in this study.

Melodic contour – The shape created by the direction of pitches in a melody.

Memory – The ability to recall information that is stored in one's mind.

Mental representation – An internal representation of an absent stimulus or past event.

Multipari women – Women who have given birth to more than one child.

Non-keepers – Those subjects that for many different reasons (e.g., fussiness, dropout etc) did not meet the pre-established criteria to be in a final sample of the study.

Operant learning – A form of learning in which a subject is reinforced each time he or she responds to a task in a particular way. By reinforcing responses, the subject gradually learns a behavioral contingency.

Preference – Listening longer to one particular stimulus over another.

Premature infants – Infants born on or before 35 weeks gestation age, or weighing less than 5 ½ pounds.

Primipari women – Women with a single child.

Remembering cues – A related cue or portion of a stimulus (e.g., the melody or the rhythmic structure of a musical work) that, when presented, could facilitate memory retrieval.

Retention period – The period following musical exposure. During this period, infants did not listen to either the assigned or the foil piece, but were free to listen to all other musical pieces.

Short-term memory – Memory for things or events that took place a short while ago, normally measured in seconds or minutes.

Chapter II

Review of literature

The study of infant cognition is quite recent (Clifton, 2001). Between the 1930s and 40s there was a substantial body of knowledge on infants' sensory capacities. The dissemination of Piaget's (1952) theory of sensorimotor development, Sokolov's (1963) work on habituation, and Fantz's (1961) writings on infant looking preferences had a major impact on the development of infant research in North America in the 1960s (all cited in Clifton, 2001). However, it was not until the 1970s that the study of infant auditory development blossomed. This delay was not caused by a lack of interest in infant auditory perception. Rather, methodological constraints prevented researchers from conducting studies on auditory development with human infants (Werner & Marean, 1996).

Before the 1970s, knowledge of infant cognition was obtained mainly by means of diaries and anecdotal data (Wyly, 1998). The development of behavioral research tools gave place to a systematic study of infant auditory perception. A seminal study of speech perception conducted by Eimas, Siqueland, Jusczyk & Vigorito (1971) gave origin to a series of exciting studies on infant auditory perception using the high-amplitude sucking method (Clifton, 2001). A few years later, Moore, Thompson & Thompson (1975 cited in Kuhl, 1987) presented the research community with a visual reinforcement head turn procedure, which was based on a research tool developed in 1947 called "peep show audiometry" (Werker, Polka & Pegg, 1997). This procedure was later modified and perfected by Eilers and colleagues (1977), and by Schneider and Trehub (1985), to study infant perception of speech and non-speech sounds (Clifton, 2001). The head-turn preference procedure was introduced to the research community a few years back (see Kemler-Nelson et al, 1995). And more recently, researchers have introduced neuro-imaging techniques to further understand infant auditory cognition (e.g., Trainor & Schmidt, 2001). All together, these methods have allowed researchers to uncover much information on human auditory development, and to change the concept of the infant, from "tabula rasa" to competent listener (Clifton, 2001).

Three behavioral methods suitable for studying infant auditory perception

Despite the advances in research tools, to date only a limited number of behavioral methods are suitable for investigating auditory thresholds in infants. These methods rely on some natural behaviors of the preverbal infant such as gazing towards a sound source and operant learning. The high amplitude sucking procedure (HAS), the conditioned head turn method (CHT), and the headturn preference procedure (HPP) have proven to be reliable and have been used by several developmental research labs throughout the world. Because these methods will be mentioned throughout this volume, a brief description of each method is given below, with comments on the strengths and weaknesses of each one. The HPP is discussed at length in the methodology section of this thesis.

The high-amplitude sucking method (HAS) is a habituation-based procedure that consists of measuring infants' non-nutritive sucking rates in the presence of particular sound stimuli (Jusczyk, 1985; Kuhl, 1987). Habituation is a concept based on the premises that attention increases with the presentation of a novel stimulus, and decreases as the latter becomes familiar. This attention decrease is called habituation (see Berk, 1997; Malcuit, Pomerleau & Lamarre, 1988). In the HAS procedure, infants suck on a blind nipple (i.e., not attached to a bottle of milk, formula or other) that is attached to a pressure transducer. When the infant sucks the nipple, he or she produces pressure changes inside the nipple that are monitored with a standard pressure transducer. Pressure for each sound stimulus is measured by sound waves. Comparisons are drawn from the sucking rates and habituation times for each stimulus.

In the standard HAS procedure the infant sits on a reclining seat with a loudspeaker placed to one side. Prior to the presentation of sound stimuli, each infant sucks on the nipple for a few minutes so that the experimenter can determine a baseline amplitude criterion for each individual infant (Jusczyk, 1985; Werker et al., 1998). Immediately after the baseline level is established, sound stimuli are presented. Once the initial sucking rate drops to a preset criterion (i.e., usually a 25% decline for 2 consecutive minutes), habituation has occurred. Infants in the experimental group are then presented with a new stimulus. A change in the sucking rates of infants in this group is expected, that is, if they detect a change in the stimulus. Infants in the control group are not presented with a new stimulus. Therefore, no changes in their sucking rates are expected (Werker et al., 1998). In some alternative HAS set-ups, infants learn to control their sucking in order to activate different tape recorders playing contrasting sounds (De Casper & Fifer, 1980). In most HAS set-ups, high-amplitude sucks are recorded by the computer, added and compared across groups.

Some advantages of the HAS are the possibility of studying perceptual issues related to innateness and the lack of need for training infants to suck. Some disadvantages include the high dropout rates (e.g., around 50%), age limitation (i.e., best suited for babies between 0 and 3 months of age), and the fact that only group results can be obtained (Werker et al, 1998). Nevertheless, the HAS is a reliable measurement of auditory thresholds in neonates and young infants.

Another procedure, the conditioned headturn (CHT) is considered to be one of the most versatile procedures for assessing infant perception of speech (Werker, Polka & Pegg, 1997) and music (Trehub, Bull & Thorpe, 1984). In this operant learning procedure, infants hear a sound or a short series of sounds repeatedly and are taught to make a head turn when they hear a sound change. Correct head turns are reinforced by toys that light up and move. Incorrect head turns are not reinforced. Testing in the CHT usually includes a training or conditioning phase in which all trials are sound change trials. Once the infant learns the contingency and reaches a predetermined criterion in the training phase (i.e., normally three consecutive correct head turns), the testing phase begins. During the testing phase, infants are presented with change and control trials (i.e., no sound change) presented at random. Correct head turns are calculated for each infant and collapsed across groups.

Some advantages of the CHT are the possibility of presenting several trials to a same infant and the possibility of analyzing both individual and group results. Some limitations of the CHT include the fact that the procedure is best suited for short duration stimuli and the relatively high dropout rates (e.g., up to 50%), due to the difficulty that some infants have in learning the contingency (Werker et al., 1998). In spite of these limitations, several labs around the world have used the CHT successfully. As a matter of fact, the CHT has proved useful in the identification of infants with hearing losses and potential developmental delays in hearing (Werker, Polka & Pegg, 1997). Not surprisingly, most behavioral studies on infant music perception and cognition have been conducted on the CHT.

The Headturn preference procedure is another behavioral method used to study infants' preferences for different auditory stimuli (e.g., Kemler Nelson et al., 1995). In this procedure, infants are attracted by a blinking light and are taught to make a head turn in that direction. When the infant turns its head, a sound is played and will continue on until the infant turns away from the light for more than 2 seconds. Looking times are recorded for each trial. Normally, testing sessions include 12-16 trials that last a total of 5-10 minutes. Preference is calculated by averaging the length of the infants' looking time to the different kinds of stimuli over the test-trial series. Strengths of the HPP are the low attrition rate; lower than in other procedures such as the CHT and the HAS (Kemler-Nelson et al, 1995), and the possibility of using long duration stimuli. The rather limited age of cooperative participants (i.e., 5- to 10-month olds) is perhaps the major pitfall associated with the HPP (Kemler-Nelson et al., 1995).

Even if these methods have proved to be reliable for the study of infant auditory development, there are some criticisms associated with them. As Werker and colleagues (1998) suggested, these methods are reliable for determining infant discrimination. Yet, they do not indicate exactly "what" the infant has perceived. In other words, it is difficult to tell whether the infant recognized or identified the stimuli in the same way the adult did/would have done, or whether there was some special element in the stimuli that influenced the infant's performance. Because the infant obviously does not speak about its perceptions, a carefully planned and controlled study design is vital for the successful application of these methods. Fortunately, much research has been conducted in the past few years, yielding a solid body of knowledge on infant perception of speech and music sounds. These are reviewed in the forthcoming section, with special emphasis on studies addressing musical development during the first year of life.

Musical beginnings: From the fetus to the newborn

The intrauterine acoustic environment

Infants are capable listeners from an early age. It is around the third trimester of pregnancy that fetuses awaken to a variety of sounds. Although the human ear appears at about 3 weeks gestation age (Woodward et al, 1992 cited in Woodward, Guidozzi, Hofmeyr, Jong, Anthony & Woods, 1992), it only starts functioning at a later time in development. It is between 26 and 29 weeks gestation age that the fetus' brain develops more rapidly and the hearing apparatus starts to function (Snow, 1998). During this period the fetus becomes more reactive to sounds and starts moving in response to external auditory stimuli in the form of speech and music (Abrams et al., 1998). Internal and external sounds turn the womb into an acoustically stimulating environment for the unborn child.

The acoustic environment that surrounds the fetus is rich in sounds and not silent and still as previously thought. Using a variety of research techniques including measurements of auditory evoked potentials, neurochemical responses (i.e., glucose intake), and naturalistic observations of fetal movement in the presence of auditory stimulation, much information regarding the intrauterine acoustic environment has been obtained (for a review see Lecanuet, 1996). Ethical reasons might explain why neurological studies on fetal hearing found in the literature have dealt solely with non-human subjects (Lecanuet, 1996). Studies conducted with human subjects have, for the most part, utilized observational and behavioral methods.

Through the insertion of small microphones in the vagina and cervix of pregnant and non-pregnant women and sheep (e.g., Abrams & Gerhardt, 1997; Lecanuet, 1996), researchers found the womb to be noisy (i.e., 72 to 96dB sound pressure levels) and rich in low-frequency sounds that exist in conjunction with varied respiratory, cardiovascular, intestinal and placental sounds (Lecanuet, 1998; Woodward et al., 1992). Speech samples heard in uterus are often intelligible despite the fact that many sounds are muffled and high frequencies are attenuated (Abrams & Gerhardt, 1997; Abrams et al, 1998; Querleu et al, 1988 cited in Lecanuet, 1998). Additionally, the articulation of female voices heard in uterus is more attenuated than the articulation of male voices. Notwithstanding, the transmission of the maternal voice to the fetus is still favored over another external voice (Querleu et al, 1988 cited in Lecanuet, 1998).

According to some studies, music is also transmitted to the fetus. Olds (1986) reported that unborn babies not only hear music in the womb, but also exhibit heartbeat changes in response to different tempi of musical pieces. Whereas slow and quiet music elicited a relaxed heartbeat, fast music accelerated the hearts of the studied fetuses. The differential responses to slow and fast musical pieces are a demonstration that the fetus hears and responds to music in the womb.

Woodward and colleagues (1992 cited in Woodward, Guidozzi, Hofmeyr, Jong, Anthony & Woods, 1992) also studied the transmission of music by recording sounds heard in uterus. In their study, a group of pregnant women heard pure tones, a singing voice and recorded music while miniature microphones placed near the uterus recorded intrauterine sounds. The results confirmed a greater attenuation of high frequency tones over low frequency ones and the muffling of the human voice. In addition, intrauterine recordings of music played externally indicated that musical articulations (e.g., attacks) were muffled, although the equalization of high, middle and low frequencies was maintained. The overall character of the musical piece played externally was also kept intact.

In sum, these studies suggest that the womb presents the fetus with a considerable amount of diversified auditory information. These sounds are not only heard, but are likely stored in long-term memory during the last trimester of pregnancy.

Postnatal consequences of prenatal auditory learning

As soon as the hearing apparatus starts to function, some attributes of auditory memory seem to appear. It is during the third and last trimester of pregnancy that fetuses become capable of storing auditory information in long-term memory. Several pieces of research have confirmed the existence of prenatal auditory learning experiences (for a review see Lecanuet, 1998). DeCasper & Fifer (1980) showed that 3-days old infants recognize and prefer to listen to the maternal voice over that of another woman.

In another study, DeCasper & Spence (1986) asked sixteen pregnant women to read a 4-phrase children's poem aloud to their unborn children during the last six weeks of their pregnancies. Soon after birth, infants were presented with the familiar poem and an unfamiliar one, in a modified version of the High-Amplitude Sucking Technique (HAS). Each poem was coordinated with a particular sucking mode (i.e., weak and intense). Infants were expected to control their sucking in order to hear either the familiar or the unfamiliar poem. Interestingly, infants in the study sucked in a particular way, in order to listen to the familiar poem that was learned prenatally more often than to the unfamiliar one. This was a classical demonstration of prenatal auditory learning. Ever since these studies were brought to public attention additional evidence of prenatal auditory learning has been presented by several research labs (see DeCasper, Lecanuet, Busnel, Granier-Deferre, Maugeais, 1994).

Evidence of prenatal music learning also exists. In a series of experiments Hepper (1991) examined prenatal music learning by contrasting heart rate, movement and behavioral states of infants prenatally exposed to a soap opera tune and of non-exposed infants. Fifteen expecting women were recruited and instructed to watch the soap opera at least once a day, for the duration of their pregnancy. An additional fifteen pregnant women, who did not watch the soap opera, served as a control group. Newborns were tested 2 to 4 days after birth. Infants in the exposure group exhibited a significant decrease in heart rate, movement and behavioral state after listening to the familiar music. This did not occur with infants in the control group. In addition, no significant differences in heart rate, movement and behavioral state were found for a second experimental group of infants, who were tested at 21 days, and for a third experimental group, who heard the familiar piece played backwards when tested between 2 and 4 days postnatal age. Hepper concluded that prenatal music learning experiences might be tune-specific and can disappear with time.

Using a similar methodology, Wilkin (1995) contrasted the fetal heart rate changes and movements of 34 fetuses. Approximately half of these fetuses were exposed daily to a specially prepared audio tape consisting of white noise, a Beethoven piano sonata, a Kyrie from a Palestrina Mass, and an instrumental rock piece by Emmerson Lake and Palmer. Measurements of heart rate and observations of movement were taken at 32 and 38 weeks gestation age, and also at 6 weeks postnatal age. The results indicated that at 38 weeks, fetuses in the exposure group exhibited greater heart deceleration when listening to the familiar tape than non-exposed fetuses. In addition, infants, who were exposed to music during pregnancy, appeared to be more receptive, alert, and exhibited more movement in response to music than their non-exposed peers.

Lamont (2001) also studied the long-term effects of prenatal musical exposure. She asked twelve pregnant ladies to pick their favorite song and listen to it everyday, for the duration of their pregnancies. Women were free to choose songs in any styles (e.g., classical, world, reggae and pop genres). Infants were tested in a modified version of the Headturn preference procedure when they were between 13 and 16 months postnatal age. The test consisted of measuring and contrasting infant attention to the familiar song and to a foil unfamiliar song, matched for key, mode, tempo, timbre and genre. Eleven out of twelve infants attended longer to the familiar song. A control group of non-exposed infants was also tested and showed no preferences for any of the songs. Lamont also tested infants for their ability to detect changes in tempo and genre. In a second test, she presented the same twelve infants with the familiar song (e.g., Mozart) paired with an unfamiliar song, which was completely different in tempo and genre (e.g., UB40 pop song). Regardless of their familiarity with the songs, infants showed a significant preference for pieces that were faster, louder and of the pop genre. Nonetheless, some criticisms can be made to this study. By testing infants twice using the same stimulus (i.e., the familiar piece of music), there was a lack of control for test learning and habituation, which might have biased infant responses. The results, however, seem to reinforce the idea that prenatal music learning does exist, with perhaps longer-term effects than previously thought.

Taken together, the aforementioned studies provide some evidence of the existence of prenatal auditory learning experiences. Once the hearing apparatus starts to function, the unborn child begins to learn about its surrounding acoustical environment. Notwithstanding, both the specific characteristics and durability of such learning experiences remain unknown and are yet to be determined.

The newborn listener (0-2 months)

Some evidence exists to suggest that infants come into the world with many remarkable auditory perceptual abilities (Snow, 1998). At birth, infants are sensitive to several sound properties including frequency and intensity. From the third trimester of pregnancy to the third month of postnatal life, fetuses and infants have shown to discriminate low pitch sounds better than high pitch ones (see Lecanuet, Graniere-Deferre, Jacquet & DeCasper, 2000). According to Werner & Vandenbos (1993) this pattern reverses between the third and the sixth month of postnatal age, so that by 6 months infants exhibit an adult-like sensitivity to high pitch. In terms of intensity, newborns have shown to perceive solely those sounds that are 40-50 dB more intense than those perceived by the normal hearing adult. At three months of age, infants' absolute detection threshold improves, and is generally only 10 to 15 dB higher than that of a normal hearing adult (Werner & Vandenbos, 1993). Such threshold levels remain virtually unchanged during the preschool years. It is only around age 6 that the child's absolute detection threshold will be more adult-like for frequencies over 2000 Hz (Trehub, Schneider & Morrongiello, 1988 cited in Werner & Vandebos, 1993). Furthermore, a child's absolute detection threshold for lower frequencies is only adult-like at around 10 years of age (Nozza, Rossman & Bond, 1991 cited in Werner & Vandenbos, 1993).

Orientation to sound sources occurs within minutes after birth. According to Muir, Humphrey & Humphrey (1994), such behavior, which is slow in the neonatal days, decreases in both frequency and magnitude and often disappears between the first and the third months of life. Interestingly, when infants are between 4- and 5-months old their orientation behaviors toward sound sources reappear, now more agile, flexible and controlled (for a review see Trehub & Trainor, 1990).

Neonates also have shown to be sensitive to certain sound properties such as the rhythm of words in speech. Sansavini, Bertoncini & Giovanelli (1997) demonstrated that 2-4-days old Italian infants could discriminate between different stress patterns (i.e., accents) in multisyllabic Italian words. In a series of three experiments using the HAS procedure, infants were presented with pairs of disyllabic, trisyllabic and two lists of 8 disyllabic words that were orthographically identical but had different stress patterns (e.g., /'mama/ and /ma'ma/). These very young infants could detect stress patterns in pairs or lists of disyllabic words, and in trisyllabic words. These results suggest that newborns not only perceive different stress patterns in both disyllabic and trisyllabic words, but also are able to categorize words based on their stress patterns.

In fact, newborns and very young infants show discrimination and preferences for auditory stimuli at an early age. Several studies have shown that newborns discriminate and prefer to listen to their native language over a foreign language. Mehler and colleagues (1988) conducted a series of studies to investigate native language discrimination in four-day-old French infants. The task consisted of listening to speech passages in French and/or Russian. Forty infants were randomly assigned to four experimental conditions: Russian only, French only, French-Russian, Russian-French. All infants were tested on the high-amplitude technique, and sucked at higher rates when French and not Russian stimuli were presented. These results lead to the conclusion that newborn infants discriminate between their native language and a foreign one.

Using a similar procedure, Moon, Cooper & Fifer (1993) examined the preferences of two-days old infants for their native language versus a foreign language. Sixteen infants of monolingual Spanish mothers and monolingual English mothers were tested on speech samples in English and Spanish. Infants showed stronger sucks to their native language than to the foreign one, which confirms previous findings regarding infant discrimination and preference for its native language.

The quality of the speaking voice, or timbre, is also an important source of infant auditory preference. The maternal voice is by far the most preferred timbre of young infants. As mentioned earlier, DeCasper & Fifer (1980) used the high amplitude sucking method to show that 3-day-old infants prefer to listen to their mothers' voice over that of another woman. In this classical study, ten American infants heard the voices of their mothers and that of another woman reciting a child's story (i.e., Dr. Seuss' *To think that I saw it in Mulberry Street*), while sucking on a pacifier. If the infant sucked at a high rate, he would hear his mother's voice. On the other hand, slow rates in sucking produced the sound of another woman's voice. Infants sucked hard so to activate and hear their mothers' voices as opposed to the voice of a strange woman, demonstrating both recognition and preference for the maternal voice.

Looking to replicate DeCasper & Fifer's (1980) findings, Spence & Freeman (1996) designed a series of experiments to examine newborn preferences for the maternal voice in two modes: low-pass filtered and whispered. In a first experiment, preference for the maternal versus a non-maternal low-pass filtered voice was assessed using the high amplitude sucking technique. Results suggested that one-day old infants sucked hard to activate their mothers' voices, even when the latter was low-pass filtered. Although linguistic cues were removed with the filtering, infants were able to rely on prosodic characteristics of speech to recognize the maternal voice. Three subsequent experiments were conducted to investigate preferences for the maternal and the non-maternal whispered voices. Overall, infants could detect and discriminate between whispered voices but did not prefer the maternal whispered voice, perhaps due to the fact that acoustic features responsible for recognition of voices were not present in the whispered voice. Hence, acoustic features of speech such as prosody (i.e., melody of speech) seem to play an important role in infant recognition and preference for voices.

Most of the information available to date on newborn auditory perception was conducted within the domain of language acquisition. Because speech is a prominent form of communication that exists between humans including caretakers and their preverbal infants (Trehub, Trainor & Unyk, 1993), much effort has been put into the study of how infants perceive and acquire language. As Trehub, Unyk & Trainor (1993) suggested, the justification for studying musical development is not as clear because of our lack of understanding of music's role in society. Therefore, it was only in the last few decades or so that researchers started devoting their time to the study of the musical development. Unfortunately, however, only a reduced number of studies have been conducted with neonates.

In order to understand whether passive music listening produced any effects on newborns' weight loss, crying and physical movements, Owens (1979) exposed 30 babies to a tape consisting of three recorded lullabies (i.e., all with a total duration of approximately 5 minutes long), for three consecutive days. Each baby heard the tape 12 times per day, in intervals of 2 hours. An additional 53 babies did not listen to any lullabies and served as a control group. No significant differences were found between the two groups for all three behaviors, although most exposed babies reduced their physical movements when the music was playing.

A similar listening response was found by Tims (1978), who measured and contrasted 8-week-old infants' visual fixation behaviors in response to three types of stimuli: quieting, stimulating and continuous-electronic music. Although visual fixation was longer for quieting music, infants were less motorically active when listening to music than in the absence of it. These results suggest that music might be a powerful tool of pacification in the form of movement reduction in neonates and young infants (for a discussion see Michel, 1973).

Unfortunately, no further studies concerned with the music perception of full-term, normally developing newborns' were found. This is regrettable because the neonate is an "ideal" subject for investigations concerned with the origins of music perceptual behaviors (Trehub & Trainor, 1993). The neonate's rather reduced musical exposure accounts for an unbiased perception of musical features. Yet, neonates up to the age of 6 months are still in drowsy or disorganized states (see DeNora, 2000), and can be difficult to work with (Trehub & Trainor, 1993). Although fascinating, the study of neonatal auditory perception is laborious, time-consuming, and usually associated with a very high subject dropout rate (for a discussion and examples see Kovacs-Mazza, 1996; Kuhl, 1987). These issues partly explain why most studies on infant music perception and cognition have been conducted with older infants, that is, between 6- and 11-months of age.

Music listening during the first year of life

Methodological issues have favored the study of music perception and cognition in 6- to 11-months old babies. During this exciting period of development, babies become proficient in controlling motor skills such as head-turns (Muir, Humphrey & Humphrey, 1994), and can easily engage in tasks that require sitting still on the mother's lap. However, at the end of the first year of life, babies gradually lose interest for certain attention tasks (Werker et al., 1998). Once they learn to walk, keeping them in a lap-sitting task is often difficult (Werker et al., 1998). These factors explain why researchers have turned their questions to the aforementioned age group.

The use of the conditioned headturn procedure as the primary data collection method has also favored a specific approach to infant music perception studies. In this approach, researchers rely on the premises that a thorough understanding of processing abilities in music requires a detailed study of the perception of isolated features such as pitch, melodic contour, scales, rhythm, tempo, mode (for examples consult Olsho, 1984; Thorpe, Trehub, Morrongiello & Bull, 1988; Trehub, Bull & Thorpe, 1984). Although these features appear simultaneously and seldom in isolation within the context of music, there is a rationale for studying them separately. By studying infant perception of individual features, researchers can understand infants' responses to each one of them, and work towards building a model of musical development. The fact that much research on infant cognition has been conducted in psychology and not music education labs also favors the study of infant discrimination of isolated musical features. As Trehub (1990) proposes, the study of certain musical features such as pitch and contour proves important in domains other than music (e.g., language acquisition), which justifies the broad interest for them.

Altogether, studies on musical development, language acquisition and developmental psychoacoustics have helped to build a solid body of knowledge on infant musical development (Dunham, 1990). For the purpose of clarification, studies are grouped here according to their emphasis on the perception of individual dimensions of musical sounds such as pitch, intensity, duration and timbre. Quantitatively speaking, a large number of studies have been conducted on infant discrimination of pitch dimensions, followed by the perception of dimensions of rhythm. This does not come as surprise because pitch and rhythm are considered to be "the two primary dimensions of music" (Krumhansl, 1999; pg. 159). By contrast, the literature on infant perception of musical timbres is relatively small, and intensity is probably the least studied musical dimension.

Pitch perception

Pitch is an acoustic property that allows the listener to identify highness or lowness in a sound (Benward, 1985). While pitch is a general term, the term *tone* is used to define pitches with a definite frequency. In music, tones are called notes and are arbitrarily determined by a set of rules. The Western music system for example, is based on the chromatic scale, or, a series of twelve notes equally separated by units called semitones, which are equally spaced in a log-frequency scale. Although many studies imply pitch perception to be a synonym to note perception, this association is not always valid. Therefore, it is important to make the distinction between these three concepts when reviewing the literature. For the purpose of clarification, the following working definitions are employed in this study:

1- Pitch is used here to define sounds with no specific frequency information;
2- Tone is used in studies with specific frequencies of sounds that do not correspond to those in the chromatic scale and;
3- Note describes tones with frequencies that correspond to those of the chromatic scale in the Western tonal system, as seen in table 1 below.

Table 1

Frequency of musical notes in the chromatic scale

Note name	C (Middle C)	C#	D	D#	E	F	F#	G	G#	A	A#	B
Frequency (Hz)	262	277	294	310	330	349	370	392	415	440	466	494

As noted earlier, infants show perceptual biases for high-pitches at around 6 months postnatal age. In one study, Olsho (1984) compared the ability of 18 infants from 5 to 8 months postnatal age and adults to distinguish between high and low pitches. The task consisted in the presentation of a series of tones between 250 and 8000Hz in either ascending or descending order. Using the conditioned head-turn, infants were taught to make a head-turn whenever they heard a sound change. While adult performance was equivalent for both low and high pitches, infants performed better than their adult counterparts when the discrimination involved high pitches.

A bias for processing high pitch was also demonstrated in a preference study conducted by Trainor & Zacharias (1998). They presented two groups of sixteen 6-month-olds with two pairs of an identical infant-directed song sung in both low and high pitch by a same female singer. Infants listened longer to the higher pitched than to the lower pitched versions of the song. To check whether preference for the higher-pitched versions of the songs was not due to the singers' natural propensity to sing in a high-pitch, a second experiment was conducted. The stimuli for this experiment consisted of "Twinkle Twinkle Little Star" renditions recorded by two contraltos and by two sopranos. Once again, infants showed a significant preference for the high-pitched over the low-pitched versions of the songs.

Using a habituation-dishabituation procedure, Demany & Armand (1984) designed a series of experiments to study infant perception of two attributes of pitch: tone height and tone chroma (i.e., a common pitch quality between tones that are separated by one or more octaves). Three groups of 3-month-old infants were presented with a control descending sequence of three pure tones. Once habituation occurred, each group received one different new sequence of three pure tones. In each one of the new sequences, the first tone was identical as in the control sequence, and the two remaining pitches were one seventh, one octave or one ninth below the original sequence. The contour of all new sequences was kept identical to the control sequence. Infants performed better in detecting changes in sequences that were transposed one seventh and one ninth below the control sequence. Transpositions of an octave were not as easy for infants to detect. In a second experiment, Demany and Armand presented 2 groups of infants with a control sequence of six pure tones. Once infants habituated to the sequence, a novel sequence was presented with an identical first pitch and subsequent new pitches played an octave below the pitches in the original control sequence. These sequences also presented violation of contour. Infants dishabituated once the new sequence was presented, which lead the researchers to conclude that infants are sensitive to both properties of pitch: tone height and chroma.

Perception of intonation and melodic contour

Infants not only are sensitive to isolated pitches, but also are attentive to pitch contour, that is, the direction of pitches in a sequence. Sensitivity to contour is important in the perception of both music and speech, clearly two forms of human communication through sounds (Chen-Hafteck, 1997). To differentiate speech contours from music contours, two different terms will be used throughout this thesis: intonation and melodic contour, respectively. Studies that have addressed melodic contour in indirect ways such as those concerned with infant-directed singing are included in a later section.

Intonation

The way parents and caretakers speak to their infants is very distinct from other forms of speech (e.g., adult directed speech), and is known as "motherese", "baby talk" or infant-directed speech (Fernald, 1985; Fernald & Kuhl, 1987; Trainor, Austin & Desjardins, 2000;). Motherese is generally higher in pitch, slower in tempo, linguistically simpler, more rhythmic, and is more exaggerated than adult-directed speech (Fernald, 1985, 1989; Trehub, Trainor & Unyk, 1993). Interestingly, motherese exists in many cultures (see Papousek, Papousek & Symmes, 1991), and also in signed language (Masataka, 1992). Some scholars refer to motherese as "musical speech" because they believe the prosody of speech to be the most prominent and important feature (Fernald, 1989; Trainor, Clark, Huntley & Adams, 1997). According to these scholars, the prosody of speech carries the message that parents communicate to their infants (Fernald, 1989). Different pitch contours found in motherese ascribe different meanings and elicit different responses from infants (Fernald, 1985). Bell-shaped contours (down-up-down) for example, are generally used to capture infant attention (Fernald, 1989), while sustained and falling contours (down-down) are often used to calm and soothe infants (Papousek et al., 1991).

Fernald (1989) demonstrated that the prosody found in motherese speech communicates intent to infants. Vocalizations of 5 mothers to their 10- to14-month-old infants were recorded in five contrasting conditions: attention-bid, prohibition, approval, comfort, and game. Renditions of adult-directed speech in the same five conditions were also recorded. Vocalizations were matched for condition and voices, and low-pass filtered to ensure that all segmental content was removed. A group of eighty adult listeners was asked to categorize each speech sample according to communicative intent, and to indicate which speech sample within each pair was infant-directed. Participants judged communicative intent more accurately in infant-directed than in adult-directed speech samples. In sum: Prosodic information found in speech was taken to be more relevant in the communication of intent to infants than to adults.

Intent, however, is not the single element communicated through motherese. Trainor, Austin & Desjardins (2000) asked 23 mothers to record the sentence "Hey, honey, come over here" in four versions according to the following emotional scenarios: love, comfort, surprise and fear. While motherese samples were directed to the infant and recorded in its presence, adult-directed samples were directed to the researcher and recorded in the absence of the infant. Six adult listeners rated each sample for its emotional content and addressee. Raters were able to tell infant-directed versions from adult-directed ones, and could identify the correct emotion for both versions above chance levels. Acoustical analysis revealed few overall differences in pitch range, tempo and rhythm in both motherese and adult-directed samples, although mean pitch was higher for infant-directed than adult-directed renditions. Nevertheless, some differences were found for emotional content of speech. Infant-directed speech samples of love and comfort were usually slower and lower in pitch than samples of other emotions in adult-directed speech. These results led to the conclusion that the primary difference between infant-directed speech and adult-directed speech is the expression of emotion.

The interest for studying intonation contours and other features of motherese lies on the fact that infants show a clear preference for this type of speech at a rather young age (Fernald, 1985; Pegg, Werker & McLeod, 1992). Such preference suggests that intonation contours found in motherese serve some communication function. Intent and emotions are communicated thoroughly through intonation contours found in the adult speech to the infant (Fernald & Kuhl, 1987; Papousek, Papousek & Symmes, 1991). Some scholars also suggest that the exaggerated intonation contours found in motherese might serve as an aid to language learning (for a discussion see Hirsh-Pasek, K., Nelson, D.G., Jusczyk, P.W., Cassidy, K.W., Drus, B. & Kennedy, L., 1987). These multiple functions attributed to motherese leave little room for doubts on the importance of intonation contours in infant-caretaker relationships and auditory learning.

Melodic contour

Analogous to intonation contours of speech, melodic contours found in infant-directed-songs also play a role in the discrimination of musical genres (e.g., lullabies and playsongs), and influence infant behavioral states (Rock, Trainor & Addison, 1999). Moreover, the study of melodic contour is justified in itself because of the obvious link between contour and melody. One could define melody as a combination of short melodic contours, sometimes called melodic motives in music. Some studies addressed melodic contour perception in infants.

Trehub, Bull & Thorpe (1984) presented ninety-two 8- to 11-months old infants with five 6-tone melodies in the following conditions: original, transposed, contour preserved with some pitch changes, octave change with contour preserved, and octave change with contour violation. Infants could not discriminate the transposed and contour-preserved versions of the melody, but had no difficulties in detecting contour-violated versions of the original melody. This failure to respond to transposed and contour-preserved versions led the research team to conclude that infants process musical information on the basis of global properties such as melodic contour and frequency range.

Using a novelty-preference habituation procedure, Ferland & Mendelson (1989) examined 10-month-old infants' ability to categorize musical sequences on the basis of melodic contour. To address this issue, two tasks were designed: one concerned with discrimination and a second one focusing on preference. In task 1, thirty-two infants were familiarized with ascending or descending 5-note melodies and then presented with same-contour melodies that had a similar or different frequency range, accordingly to the condition they were assigned to. Results suggested that infants relied on notes, contour shape or both to detect changes to melodies that maintained the original contour. In task 2, thirty-two infants were familiarized with one type of contour and tested on the reverse contour type. An overall novelty preference was found, which served as evidence of infants' categorization of melodies on the basis of their contour.

Because the aforementioned studies on melodic contour perception presented alterations of many notes if not of the entire melody, it was not clear whether infants could attend to absolute cues, and discriminate a single note change in a familiar melody. Attempting to answer this question, Trehub, Thorpe & Morrongiello (1985) investigated whether infants could detect a single note change in a six-note previously heard melody. A group of 6- to 8-month-olds was tested in the conditioned head-turn procedure for identification of note changes in previously heard melodies. The test consisted of listening to a basic six-note melody in the key of C major and to six transformations of the familiar melody. In each transformation of the basic melody, the altered note was in a different position within the melody. Contour was violated in some but not all transformations. Infants could readily detect single note changes in any position within the familiar melody. Although these findings seem somewhat contradictory to those found by Trehub, Bull & Thorpe (1984), they can be interpreted as a result of task facilitation. While in the Trehub, Bull & Thorpe (1984) three or more notes were changed in each transformation of the melody, in this study the overall character of the melody was kept constant. Hence, the task was made easier in this study than in the Trehub, Bull & Thorpe (1984) study. The research team concluded that infants could respond to absolute cues depending on the nature of the stimuli and the demands of the task.

While findings from the studies mentioned above are almost unanimous in what refers to a more global than absolute processing of melodic information in infancy, some related questions remained unexplained. Did babies in some of the aforementioned studies perform well above chance because although contour was not violated, some note changes did not conform to an established key (see Trehub, Thorpe & Morrongiello, 1985)? Sensitivity to melodic contour can at times be related to the perception and implicit knowledge of intervals, key-relationships, scales and tonality. In order to understand infant melodic perception embedded in the Western music tonal system, a new series of studies was conducted. These studies emphasized infant discrimination of intervals, which are elemental to the perception of scales.

Perception of Western Music Tonal Structure

Two scales that are commonly used by Western composers are the major and the minor scales. While the function of each note receives the same name (e.g., tonic, subdominant, dominant, etc) in both scales, the intervallic distance measured in tones (T) and semitones (½T) between successive pitches are not identical for all notes in the scales. Intervallic relationships between notes of the Western major and minor scales are as follows:

- Major scale: T – T – ½T - T – T – T -½T
- Minor scale: T – ½T - T – T – ½T – T - T

Intervallic relationships found in scales are important in Western music because they are seminal to concepts such as consonance, dissonance, key relationships, and harmony.

Trehub, Cohen, Thorpe & Morrongiello (1986) investigated whether babies could notice a semitone change in 5-note melodies that either did or did not conform to Western scales. A group of forty 9- to 11-month-olds was presented with either a major or an augmented background five-note arpeggio. With the aid of the conditioned headturn procedure, babies were taught to make a head-turn in response to a note change to the background arpeggio. Five transformations of the background arpeggio were presented during the test phase. Each one of these five transformations corresponded to a note change in each position of the arpeggio. Babies performed equivalently and detected changes to both major and augmented arpeggios.

However, different results were found when comparisons were drawn between infant performance of major, minor and augmented arpeggios. Cohen, Thorpe & Trehub (1987) examined the abilities of 7- to 10-month-old infants in detecting semitone changes to the third note of major, minor and augmented arpeggios. Infants detected semitone changes to the arpeggios built on the major and minor, but not on the augmented arpeggios. According to the research team, an inference that can be made from this study is that some melodies might be easier to process than others due to their intervallic relationships.

Trehub, Thorpe & Trainor (1990) investigated infants' detection of a change to the fourth note of three contrasting five-note melodies called good Western, bad Western and bad non-Western. While the good Western melody was well formed, with all pitches conforming to the C major scale, the bad Western melody did not conform to any particular scale and had three tritones. The bad non-Western melody consisted of 5 frequencies that did not belong to the chromatic scale, with intervallic relationships that were smaller than the semitone. Thirty 8.5 months-old infants were randomly assigned to one type of melody. At test, infants were taught to make a head-turn when they heard an alteration (i.e., 5 different transpositions) to the original melody. The average proportion of head-turns for both control and change trials was above chance levels for the good Western melody, and at chance levels for the two bad melodies. The research team suggested that well-formed melodies might elicit enhanced melodic processing in infants.

In order to deepen the understanding of early melodic processing, Trainor & Trehub (1992) questioned whether conformance to the rules of the tonal system would affect infants' perception of melodies. In addressing this question, they presented 8-month-old babies (N=48) with a standard 10-note C major melody, in which all notes that conformed to the rules of the Western tonal system. Babies were assigned randomly to one of two conditions: (1) diatonic or within key change, and (2) non-diatonic or out-of-key change. Using the CHT, babies were taught to make a head-turn when they detected a change to the sixth note of the standard melody. Note changes were either within key (a B natural in place of a G natural) or out-of-key (an A flat in place of the G natural). Infants detected both within key and out-of-key changes to the standard melody equally well. Contrastingly, a group of adults tested on the same stimuli detected out-of- key changes better than within key changes to the standard melody. The contrasting performance of infants and adults was interpreted as a byproduct of music exposure and acculturation. Infants' equivalent performance for the two types of change suggests that the nondiatonic change becomes more discrepant with exposure to Western music. Adults normally have more exposure to Western music than infants. This might explain why they showed an increased difficulty in the detection of within-key rather than out-of-key changes in previously heard melodies than their infant counterparts.

Studies conducted using non-Western musical materials have found somewhat similar results. These studies prove important because they shed light on issues of innateness and enculturation. Lynch and colleagues (1990) used the conditioned-head turn procedure to compare the abilities of 6-month-olds and adults to detect small mistunings to one tone (i.e., intervals smaller than a semitone) in short melodies based on the major, the minor and the Javanese pelog scales. While infants in the study performed above chance levels when detecting mistunings in all scales, their adult counterparts performed above chance levels only when detecting mistunings in the major and minor scales. Adult performance for melodies based on the Javanese pelog scales was comparatively poorer than for the melodies build on the major and minor scale. This finding suggests that exposure to Western music influences one's perception of music.

In a follow-up study, Lynch & Eilers (1992) contrasted the ability of 30 adults, ten 6-month-old and ten 12-month-old infants to detect mistunings in melodies based on the major, the augmented (i.e., a scale used in modern Jazz improvisation that is highly chromatic) and the Javanese pelog scale. Twelve-month-olds and adults performed significantly better in the discrimination of mistunings of melodies based on the major scales, as opposed to melodies based on the augmented or the Javanese pelog scales. Contrastingly, 6-month-old infants performed equivalently when detecting mistunings in melodies based on the major and augmented scales. Their performance was superior on melodies built around the latter two scales than on those melodies that were based on the Javanese pelog scale. Performance on the Javanese pelog scale was only marginal. It is possible that, by enlarging the sample size, some of these results would have been slightly altered. Yet, a comparison between the performance of younger and older babies suggests that learning of some intervallic rules of the Western tonal system are taking place during the first year of life.

Interestingly, some intervals found in the Western tonal system are said to be more salient than others. The interval of the perfect fifth is especially important in Western music as it determines key relationships and coherence in music (for a discussion see Sloboda, 1985). To confirm the importance of key relationships, Trainor & Trehub (1993a) contrasted infants (n=44) and adults' (n=84) abilities to discriminate changes in the middle note of 5-note major and augmented arpeggios, transposed to related and unrelated keys. Transpositions to related keys were based on the circle of fifths, considering the first pitch as the tonic of each arpeggio. Infants showed enhanced performance when detecting changes to notes of triads that were transposed to related rather than unrelated keys. This was especially true for augmented triads. Contrastingly, adults showed superior performance for major triads that were transposed to related keys. Adult performance in augmented triads was poorer for related as opposed to unrelated keys. This study lends further support to the notion that enculturation plays a role in musical development.

Trainor (1997) revisited the question of enhanced performance for the perfect-fifth interval. She tested infants between 6- and 8-months of age (M=7.13 months) and adults on their abilities to discriminate intervallic changes between a perfect-fifth interval and other intervals (e.g., tritone, major seventh, octave, minor sixth and major ninth). Note changes occurred in the two possible orders: from the perfect fifth or perfect-octave to other intervals and vice-versa. Both infants and adults demonstrated enhanced performance when detecting changes from the perfect fifth and the octave to other intervals, than to the same intervals in reverse order. In conjunction with previous findings, these results were interpreted as evidence of early predispositions to discriminate changes to simple-ratio (i.e., the perfect-fifth and the octave) intervals. Since melodic intervals often suggest implied harmonies, the abovementioned results have clear implications for infants' perception of harmony.

<u>Harmonic Perception</u>

Harmony is often defined as a vertical dimension of music (Benward, 1985). The basic unit of harmony is the chord. A chord exists when two or more different tones are played simultaneously. In Western music theory, intervallic relationships between tones in a chord not only determine chord types (e.g., major, minor, augmented, diminished), but also indicate the functions of each chord within the musical work. Although considered to be one of the most difficult musical features for children to learn (for a discussion refer to Costa-Giomi, 1994; 1995), some studies have examined harmonic perception in infants.

While some studies have focused on infant perception of sensory consonance, other studies have examined musical consonance. What distinguishes sensory consonance from musical consonance is one's exposure to music of a particular system or culture (Schellenberg & Trainor, 1996). In other words, musical consonance relates to a sensation gained from the exposure to the set of rules found in the musical system of one's culture (i.e., enculturation). By contrast, sensory consonance is independent from exposure to such rules and relates solely to the physical properties (i.e., intervals) of sounds. Studies concerned with both sensory and musical consonance are of relevance to the study of musical development, and are therefore included in this section.

Schellenberg & Trainor (1996) contrasted infant and adult discrimination of consonant and dissonant harmonic intervals. Twenty-eight adults and 15 infant listeners heard repetitions of a baseline interval of a perfect fourth, perfect fifth or a tritone. During trials, subjects were presented with change (i.e., an interval different than the baseline) or no-change (i.e., an interval identical to the baseline) trials and had to make judgments either by pressing a button in the computer or making a head-turn towards a loudspeaker. Results indicated that both adults and infants were better in detecting changes from a consonant to a dissonant interval, than from one consonant interval to another. Consonant intervals were treated as similar, regardless of their interval width.

In another study, Schellenberg and Trehub (1996) studied infants' ability to detect changes in consonant (i.e., simple-ratios) and dissonant (i.e., complex-ratios) harmonic intervals. Their hypothesis was that infants would be better in detecting changes to consonant intervals due to some human innate predispositions to process simpler rather than complex musical intervals. Two experiments were designed to examine 6- and 9-month-old infants' detection of changes to the high-note of melodic or harmonic intervals of a perfect fourth, perfect fifth and tritone. Infants (N=90) showed superior performance in detecting changes to simple intervals (e.g., the perfect fourth and the perfect fifth) than to complex ones (e.g., the tritone). These results were taken to be a demonstration of infants' implicit knowledge of consonance.

Infant biases for processing consonant chords over dissonant ones have also been shown in studies of embedded musical features. Zentner & Kagan (1998) investigated 4-month-olds' (N=25) perception of consonant and dissonant versions of melodies of Central European folk songs. While the consonant versions were composed in parallel major and minor thirds, dissonant versions were built on parallel minor second intervals. The results suggested a preference for the consonant over the dissonant versions of the same songs. When the consonant versions of the songs were played, infants attended significantly longer to the loudspeaker and were less motorically active. According to the researchers, this study is a demonstration of infants' innate biases for processing consonance.

Similarly, other studies have demonstrated infant preferences for consonant over dissonant triads. Crowder, Reznick & Rosenkratz (1991) used a modified version of the Head-turn preference procedure to examine the listening preferences of fourteen 6-month-old infants for major/minor and dissonant/consonant chords. No preferences were found for either the major or the minor chords, although a significant preference was found for the consonant chord. Even if the sample of this study was relatively small, results were consistent with other investigations on the same issue.

Trainor & Heinmiller (1998) designed two experiments to study infant perception of isolated consonant and dissonant chords, and for these two types of chords within the context of real music, that is, in a simple Mozart minuet. Two groups of 6-month-old babies were tested on the Head-turn preference procedure. Infants (N=26) attended longer to both consonant chords and consonant versions of the Mozart minuet than to the dissonant ones. It should be noted, however, that the versions of the Mozart minuets were very dissimilar from one another. Whereas the original version kept the original musical and interpretative features, the transformed version was made dissonant throughout. Such contrast in the song versions may have influenced infants' preference for the consonant over the dissonant version of the song.

Altogether, these studies present strong evidence of biases for processing consonance in early life. Such biases suggest a biological basis for the processing of musical intervals, which can be explained in terms of the hardwiring of the auditory system (Trehub, 2000). Interestingly, these findings are in synchrony with the simple, repetitive and harmonically uncomplicated infant-directed music repertoire (e.g., lullabies and playsongs) found in many cultures of the Western world (see Trehub & Schellenberg, 1995).

Perception of timbre

Timbre can be defined as "the quality of a sound that distinguishes it from other sounds of the same pitch and loudness" (Mathews, 2001; p. 86). Researchers in psychoacoustics argue that timbre is a complex sound feature due to its large amount of quantifiable attributes (Mathews, 2001). This might explain why a comparatively lower number of studies have focused on timbre than on pitch or rhythm (for a discussion see Krumhansl, 1999). Even if timbre is said to be a musical feature that children perceive at a rather young age (McDonald & Simons, 1989), only a handful of studies have focused on infant perception of timbre. Not surprisingly, the literature favors the study of infant perception of the human voice.

<u>The human voice</u>

Since the maternal voice is one of the first sounds that infants hear repeatedly from a rather early age, several studies have focused on infant discrimination and preference for it. There is some solid evidence to suggest that the maternal voice is by far the preferred timbre of infants. This was demonstrated by Standley & Madsen (1990), who presented a group of 2- to 8-months old babies with 3 contrasting stimuli: the maternal voice, the voice of an unknown woman and a piece of music. In an operant listening task, babies showed their preference for different auditory stimuli by moving their legs so to activate different tape recorders. The maternal voice was the most preferred stimulus, especially in the case of young babies. Contrastingly, older babies showed an equivalent preference for both the mother's and the other woman's voice.

As noted, infants remember voices heard in the womb (DeCasper & Fifer, 1980). Evidence of voice learning after birth also exists. Jusczyk, Hohne, Jusczyk &

Redanz, (1993) showed that 9-month-olds (n=16) could remember the voice of an unknown speaker that was heard repeatedly after a two-week delay. The ability to remember and differentiate familiar voices from unfamiliar ones is often said to be vital for survival and for various aspects of the child's growth, including social and cognitive development. Interestingly, this ability is already present during the first year of life.

Musical instruments

Studies concerned with the perception of timbre of musical instruments by young infants are scarce. Michel (1973) conducted several experiments to understand infant responses to timbre. Using a reflex conditioning method (i.e., eye blinking), Michel demonstrated that the discrimination of two pitches in contrasting timbres is already in place when the infant is between two and three months postnatal age. Such ability is said to improve so that, a few weeks later in development, infants can tell apart two notes differing in pitch but in identical timbre.

Trehub, Endman & Thorpe (1990) questioned whether young infants could discriminate between contrasting complex tones on the basis of timbre. The stimulus consisted of computer generated complex tones with a spectral structure that corresponded to that of the [a] sound in four varying conditions: frequency, duration, intensity and control. Tested on the CHT procedure, infants (N=40) showed enhanced performance in the discrimination of complex tones on the basis of timbre when frequency, duration and intensity varied.

Using non-artificial sounds, Pick and colleagues (1994) presented thirty 7- to 9-month-olds with pairs of videos each showing one musician playing a different musical instrument. The videos were in synchrony. The infants also heard a soundtrack that was in synchrony with both videos, but specific to only one of them. Regardless of their lack of familiarity with the instruments, infants could associate the sight and sound of some instruments (e.g., viola, cello and trombone). By contrast, infants had a hard time associating the sight and sounds of the flute and the clarinet. These asymmetries in infants' abilities to associate sights and sounds of instruments were interpreted in relationship to the use of arm movements of players. While arm movements were clearly visible in the viola, cello and trombone, they were perhaps subtler in the cases of both the flute and the clarinet. These results suggested that the discrimination of timbre in bimodal (i.e., visual and auditory) tasks relies on the physical characteristics of each instrument.

Even though timbre is said to be a musical feature that children perceive at a young age (McDonald & Simons, 1989), no studies that investigated infants' discrimination of timbres of musical instruments were found. To date no information is available as to whether the ability to perceive subtleties in timbres of, for example, the violin and the cello played in the same register is present in early infancy, or is dependent on auditory development and musical training. Such information is important because it tackles issues related to sensory perception and innateness.

Duration: Perceiving temporal events

The perception of temporal events occurs early in life. Infants come into the world prepared to identify and differentiate the temporal subtleties of the world that surrounds them (Stern, 2000). As a matter of fact, learning of temporal events occurs in uterus. According to Dunham (1990), temporal information, which appears to remain intact in the womb, is available to the fetus from the third trimester of pregnancy on. Evidence of prenatal rhythmic perception is often thought to be more anecdotal than empirical. Because of the difficulty in studying the auditory perceptual abilities of fetuses, studies on the rhythmic perception of the latter are rare (for a discussion see Dunham, 1990). Substantiation of postnatal temporal discrimination, however, has been more definitive. Newborn babies have shown the ability to discriminate between contrasting temporal patterns at 6 days postnatal age (Millot, Filiatre & Montagner, 1987 cited in Dunham, 1990). Discrimination of contrasting temporal patterns has also been shown in 2- and 4- month-old babies (Baruch & Drake, 1997).

Rhythm is often defined as a pattern of uneven durations (Benward, 1985, p.5). The perception of rhythm is characterized by a subjective grouping of separate events that facilitates cognitive processing (Bregman, 1990). Evidence of grouping has been demonstrated by several means including through analysis of children and adults' invented notations of songs (for a review see Ilari, 2002a), and behavioral data obtained in studies conducted with adults (for a review see Deutsch, 1999), and infant listeners (Thorpe & Trehub, 1989).

Demany, McKenzie & Vurpillot (1977) used a habituation procedure to demonstrate that 2- and 3-month-olds readily discriminate between contrasting rhythmic patterns by chunking separate units into small groups. Using a similar procedure, Chang & Trehub (1977) showed that 5-month-olds could readily discriminate between two contrasting rhythmic patterns (OOOO OO) and (OO OOOO). In another study, Trehub & Thorpe (1989) presented eighty infants with repetitions of one standard rhythmic cell consisting of three or four tones. At test, infants were presented with rhythmic cells that derived from the original standard one, but had variations in tempo and frequency. Infants performed equivalently well for three- and four-tone patterns, despite variations in tempo and frequency. These studies provided some convincing evidence that young infants can discriminate between contrasting rhythmic patterns.

Two studies by Thorpe, Trehub, Morrongiello & Bull (1988) and Thorpe & Trehub (1989) assessed infants' ability to detect small changes in a six-tone rhythmic pattern. Six- to nine-month-old infants were exposed to a baseline rhythmic pattern consisting of 2 groups of different pitches (XXXOOO) and then to two violated patterns, in which pauses were inserted within (XXXO OO) or between (XXX OOO) groups. Infants could detect the alterations in the patterns that had violations within but not in those with violations between groups. These results suggested that babies chunked the units of the baseline pattern into two separate groups (XXX and OOO).

Grouping of rhythmic patterns involves at least two concepts: duration illusion and auditory stream segregation (for a discussion see Thorpe & Trehub, 1989). While the duration illusion is characterized by the lack of perception of pauses inserted between-groups, auditory stream segregation is based on the idea that short patterns of sounds are grouped according to similarities in pitch, timbre or other sound properties (Thorpe & Trehub, 1989). Like adult non-musicians, infants have shown to group rhythmic figures by similarity (Demany, 1982; Demany, McKenzie & Vurpillot, 1977; Thorpe & Trehub, 1989) or by temporal proximity of elements (Trehub & Thorpe, 1989).

In terms of the perception of meter in early infancy, little information is currently available. Bergeson (2001) studied infants' perception of duple and triple meter. Sixty-four infants were assigned to one out of two melody conditions: duple or triple meter. At test, infants were taught to make a headturn when they detected a semitone change in a previously heard melody. Results suggested a superior performance for duple over triple meter. Bergeson interpreted these results as a consequence of an innate propensity to process duple meter. Although such conclusion is perhaps premature, results from this study are indicative of early abilities to discriminate between contrasting meters. Such abilities are vital for infants to characterize and tell music with contrasting meters and styles apart.

On that note, infant perception of contrasting musical styles (e.g., lullabies and playsongs) has been studied at length. Contrasting styles, rhythms and tempi are said to be important in the regulation of infants' attention (Dunham, 1990) and affect (Pouthas, 1996). This is evident if one takes into account the fact that infants show different reactions when listening to slow versus fast music in the form of lullabies and playsongs (Rock, Trainor & Addison, 1999). As Pouthas (1996) suggested, the world that surrounds the infant is one of temporal organization with a large variety of biological, motor and environmental rhythms. Nevertheless, the impact of such learning on more complex temporal learning in later stages of development is yet to be determined.

Attending to "real" music

A thorough analysis of the stimuli used in infant research reveals a lack of studies on the perception of real music, that is, music as it is heard in the radio, in CDs, or concerts. As noted, researchers have traditionally adopted the approach of isolating musical features so to understand how infants respond to individual features, normally in the form of artificial (i.e., computer-generated controlled) sound patterns. Such approach to the study of infant cognition is justified when methodological considerations are made. Ever since Trehub, Bull & Thorpe (1984) validated the CHT (conditioned headturn procedure) as a reliable tool for music research; its use became rather systematic. Because the CHT is best suited for short duration stimuli (Werker, Polka & Pegg, 1997), it matched well with inquiries into infant musical pattern perception. The tendency to study isolated patterns has persisted in infant music research. Few behavioral studies have been conducted using alternative methods.

In the past few years, however, other methods have been validated (see Kemler-Nelson et al., 1995). As an example, the HPP has allowed researchers to make inquiries into infants' preferences for music by measuring responses to long musical excerpts as opposed to short patterns. This method allowed researchers to study long duration stimuli, notably excerpts of real music. Some problems, however, have been associated with the use of real music in research studies; notably the lack of knowledge of the specific features that were perceived by the infant listeners. Notwithstanding, these studies have made important contributions to the current knowledge of infants' music cognition as they used stimuli that are arguably more ecologically valid. Studies that use real music are particularly relevant to the field of music education as they relate directly to everyday life practices of many teachers, therapists and practitioners in the field. These studies are described ahead.

Perception of musical form and structure

Infants' segmentation of speech sounds has been studied in several language acquisition labs (e.g., Jusczyk, 1999; Polka, Sundara & Blue, 2002). Yet, only a few studies have addressed infants' segmentation of music, that is, their perception of musical form and structure. Methodological constraints and the difficulty of interpreting results have possibly prevented researchers from engaging into the complexities of studying babies' segmentation of musical phrases and motifs. The main problem relates to the identification of precise features that account for infant segmentation of music.

Krumhansl & Jusczyk (1990) exposed twenty-four 4- and 6-month-old infants to natural and unnatural musical excerpts taken from 16 Mozart minuets (i.e., excerpts with pauses inserted at the end and in the middle of a musical phrase, respectively), and measured their attentive listening for each type of excerpt. As it occurs with speech (see Jusczyk et al., 1992), infants in this study attended significantly longer to naturally segmented than to unnaturally segmented excerpts of music. In a subsequent study, Jusczyk & Krumhansl (1993) further examined infants' (N=120) preferences for naturally and unnaturally segmented musical phrases using several manipulations of the stimuli including reversed excerpts (i.e., played backwards). They found that infants not only preferred the naturally segmented excerpts, but also were attentive to musical phrase structures, using descending contours and changes in pitch duration (i.e., slowing down) as indications of endings in musical phrases. The specific features that infants were attending to are currently unknown.

Similarly, Nazzi, Kemler-Nelson, Jusczyk & Jusczyk (2000) found that 6-month-olds could tell well-formed speech passages from ill-formed ones, based on their prosodic structure. The research team investigated whether a similar claim could be made for musical passages. They presented 36 babies with well-formed and ill-formed musical passages and measured attentive listening. Well-formed and ill-formed musical passages were constructed based on speech samples and did not conform to musical rules of the Western tonal system. Although the difference in listening time for each passage was small, babies listened slightly longer to the well formed than to the ill-formed musical passages. The non-conformity to rules of the Western tonal system might have accounted for the comparatively smaller effect in the musical than in the speech passages.

Melen & Wachsmann (2001) studied the categorization of musical motifs during infancy and found that twenty 6- to 10-month-old infants could abstract a musical motif that was presented repeatedly and detect its derivates if contour and rhythmic features were kept constant. Because the two pieces that served as stimuli were different in too many dimensions (e.g., rhythm, accompaniment patterns, style, key and time signature), it was not possible to identify the exact musical features to which infants were attending. Results from this and the aforementioned studies suggest that categorization of music on the basis of motifs may be occurring during the first year of life.

Uses of music in everyday life of infants and their caretakers

Throughout the world, parents and caretakers have used music in different contexts, to soothe their infants and send them to sleep (Field, 1999; Trehub, Unyk & Trainor, 1993b), or to arouse and entertain them (Trehub & Schellenberg, 1995). The literature suggests lullaby and play songs as the most common styles that are employed with infants (Trehub & Schellenberg, 1995). Interestingly, the way parents sing to their infants is distinct from any other performance and is called IDS (infant directed singing). This singing style is characterized by the use of high pitches, slow tempo, and an expressive singing quality (Trehub et al., 1997). Types of songs (Unyk, Trehub, Trainor & Schellenberg, 1992), the different contexts in which these songs are being used (Rock, Trainor & Addison, 1999), infant gender (Trehub, Hill, Kamenetsky, 1997), and parental role (Trehub et al., 1997) are likely to influence parents and caretakers' singing modes.

The infant's presence or absence also affects the expressiveness of caretaker-singers. Trainor, Clark, Huntley & Adams (1997) designed a study to determine the acoustic features that account for babies' preferences for infant-directed singing. The analysis of acoustic features of lullabies and playsongs recorded in naturalistic contexts revealed significant differences between infant-directed and non-infant-directed renditions of songs. Infant-directed versions of both lullabies and playsongs were sung in higher pitch, more exaggerated stress patterns and with longer pauses between phrases than the comparison non-infant-directed versions.

Trehub and colleagues (1997) also investigated the singing modes of mothers and fathers, and found significant differences in singing frequency and choice of songs. Mothers in their study reported singing to their infants more often than fathers. In addition, mothers sang simpler, more stereotyped, child-directed songs while fathers sang more complex songs, often invented and not necessarily child-oriented. In spite of these differences in song choices, both mothers and fathers showed a similar expressiveness to their singing when the infant was present, consistent with the previous finding that parents and caretakers sing differently in the presence or absence of their infants (Trainor, 1996; Trehub, Unyk & Trainor, 1993b).

Infant-directed music influences the communication and interaction between infants and their parents and caretakers (Trainor, 1996). In fact, the literature on infant-directed speech suggests that the prosody or melody of speech is not only vital in the communication of affect between caretakers and infants (Trainor, Austin & Desjardins, 2000), but has clear implications for the development of attachment in infants (Rock, Trainor & Addison, 1999). On a more physiological basis, maternal singing also has been shown to regulate infants' arousal states by decreasing their cortisol levels (Shenfield, Trehub & Nakata, 2002).

The use of infant-directed music is not limited to the parent/caretaker – infant routine though. Music has been used successfully in therapeutic, clinical and palliative care, and has aided in the treatment of anxiety and stress reduction in the hospitalized including high-risk mothers (Winslow, 1986), children, and adolescents (Kennely, 2000; Klein & Winkelstein, 1996). Studies have shown that musical interventions with premature babies in Neonatal Intensive Care Units have helped stabilize oxygen saturation levels (Moore & Standley, 1996), reduced initial weight loss (Caine, 1991), reduced stress (Caine, 1991; Lorch et al., 1994), and benefited days of discharge (Caine, 1991; Coleman et al., 1997; Standley, 1998). Furthermore, music in the NICU has aided in the development of non-nutritive sucking behaviors of premature infants by means of contingent reinforcement to routine non-nutritive sucking procedures such as the PAL – Pacifier Activated Lullabies (for more details see Standley, 1999; Standley, 2001). Music has also helped reduce a common maladaptive behavior in young infants known as infantile colic (Larson & Alyson, 1990). Although further research in the area is still needed, there is some evidence to suggest that music might be a powerful reinforcement tool in therapeutic contexts. Hence, this review of literature seems to suggest that infants are not only sensitive to musical properties such as pitch, contour, rhythm or others, but may benefit from musical experiences in varied care-taking contexts.

Memory for music

Memory is a key concept to this thesis. For this reason, studies on musical memory were reviewed in this section. The concept of memory is usually associated with processes of encoding, storage and retrieval of ideas, which are essential to learning (see Kauffman, 1990). Putting it simply, memory involves holding a thought in one's mind and remembering it (Chaplin, 1968). Scholars have long debated over the existence of different types of memory. The terminology has changed enormously throughout the years (see Schneider, 2000). Yet, some concepts such as short-term and long-term memory have stood the test of time. These two memory systems are present and vital for several aspects of music making including music education, culture preservation, and the development of musical preferences and taste.

Short-term memory is the name used to define one's ability to remember immediate events or things (see Levitin, 1999). Both consciousness and awareness are present in short-term memories, which are not durable. By contrast, long-term memory allows one to remember events or things that took place far back in time. Some scholars argue that even if long-term memories are not always easily accessible, they imply a sense of knowing that the memory "is in there" (Levitin, 1999). Moreover, long-term memory is claimed to be important as it helps preserve the musical culture of many societies, including non-literate ones (Dowling, 1978). In regards to the content of long-term memory, there are some theories that suggest two ways in which information can be represented (see Rovee-Collier, Hayne & Colombo, 2001; Schneider, 2000):

- Explicit or declarative memory relates to one's ability to recall names, places dates and events. There are two sub-types of explicit memory: episodic and semantic. While episodic memory refers to experiences and events, semantic memory relates to the knowledge of language and concepts. Both episodic and semantic memories can be consciously retrieved.

- Implicit or procedural memory relates to several nonconscious abilities, including learned habits, skills and several forms of operant learning and classical conditioning.

Recent studies have shown that infants display explicit memory (Schneider, 2000). Most of these studies have been conducted within the visual domain (e.g., Rovee-Collier, 1996; Schneider, 2000). What this research has shown is that visual long-term memory in infancy is context-dependent (Amabile & Rovee-Collier, 1991; Shields & Rovee-Collier, 1992). In other words, babies seem to remember visual events seen previously if the latter are presented in the same original context (for an example see Fagen, Prigot, Carroll, Pioli, Stein & Franco, 1997). These studies have also shown that infants' long-term memory depend on a combination of several factors such as stimulus and task complexity relative to age and familiarization time. These factors are part of the multifactor model of infant preferences for novel and familiar stimuli (Hunter & Ames, 1988), discussed ahead.

The multifactor model of infant preferences for novel and familiar stimuli

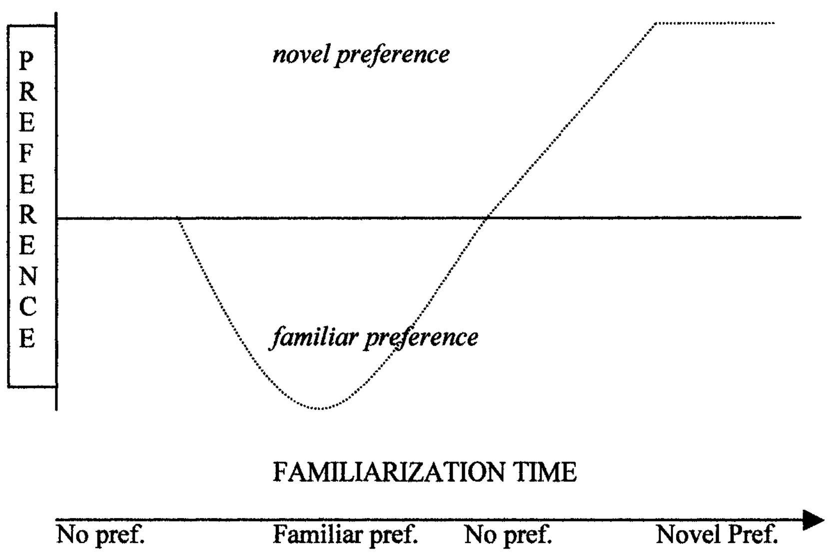
Studies on infant discrimination and memory for both visual and auditory events are often grounded on a multifactor model of infant preferences for novel and familiar stimuli (see Hunter & Ames, 1988). This model is rooted on the work of optimal-level theorists such as Berlyne (1960 cited in Hunter & Ames, 1988), who suggested a variety of stimulus dimensions as influential in exploratory behavior. Surprise, incongruity, complexity and novelty are some of these dimensions. The present model focuses mainly on novelty, which is defined here " in terms of a time continuum along which an object which was once novel becomes familiar" (Saayman, Ames & Moffett, 1964, p. 190, cited in Hunter & Ames, 1988).

This model suggests that infant preferences for novel and familiar stimuli shift according to the combination of three variables: familiarization time, age and task difficulty. Through long periods of familiarization infants' tend to habituate to a stimulus, which leads their preferences to shift from no-preferences, to familiar and finally to novel. According to Hunter, Ames & Koopman (1983), when familiarization is very short infants will show a familiarity preference indicating that they are still exploring the stimulus. By contrast, long familiarization times are likely to yield novel preferences, which are clear indicators of habituation. The nature of the task also affects infants' preferences. A difficult task requires more exploration and thus attention from infants, whereas a simple task leads to faster habituation. In addition, depending on the complexity of the task, young infants might need longer familiarization periods than their older peers in order to learn the task and habituate. Figure 1 shows a graphic representation of infant preferences for novel and familiar stimuli. The shape of the curve may change slightly according to infant age and task difficulty.

Figure 1

Infant preferences for novel and familiar stimuli – A model

(Borrowed from Hunter & Ames, 1988)



This model has proven to be reliable and has been used in several pieces of research, notably in studies on or related to infant short-term memory. In applying this model to infant long-term memory, researchers need to ensure that infants habituated to the stimuli (i.e., that infants went through all "phases" of the model). In addition, in assessing long-term memory researchers must consider the amount of delay between familiarization and testing, notably because such delays include a new variable: forgetting. Research in the visual domain suggests that after short delays between familiarization and testing, and in the absence of remembering cues, infants usually show a novelty preference. By contrast, after long-delays between familiarization and testing babies normally show familiar preferences (see Courage & Howe, 2001; Trainor, Wu & Tsang, 2001). Such trends might also hold for the auditory domain (see Jusczyk & Hohne, 1997; Saffran, Loman & Robertson, 2000; and Trainor, Wu, Tsang & Plantinga, 2002).

In sum, infant preferences for novel and familiar stimuli depend on the interaction between three variables: familiarization time, age and task difficulty. Without delays between familiarization and testing, long familiarization is likely to produce novel preferences, and short familiarization tends to yield familiar preferences. However, when delays between familiarization and testing are added, the issue of forgetting affects infants' performance. Thus, when no "remembering" cues are presented (i.e., a melody from a familiar song), long delays between familiarization and testing yield familiar preferences, while short delays are likely to produce novel preferences. These factors are taken into account in the most studies conducted on infants' long-term memory for auditory events, which are reviewed in the next section.

Studies conducted with infant listeners

Short-term memory for music in infancy, childhood and adulthood has been addressed quite extensively, even if indirectly. As an example, the majority of studies on infants' perception of music have relied on babies' abilities to detect sound changes (for examples see Demany & Armand, 1984, Thorpe & Trehub, 1989; Trainor & Trehub, 1993; Trehub, Bull & Thorpe, 1984). Such abilities imply the existence of short-term memory. Recent research presents evidence that infants' short-term memory for music is far more sophisticated than previously thought. Palmer, Jungers & Jusczyk (2001) exposed adults (n=104) and 10-month-olds (n=16) to two performances of 5-note melodies in contrasting meters and keys. After a brief retention interval, listeners heard the familiar performance and unfamiliar performances of the same music. Both infants and adults listened longer to the familiar performances than to the unfamiliar ones, which lead the researcher team to conclude that listeners can encode expressive features of melodies, regardless of their age and musical experience. Other studies have demonstrated that musical structure, the existence of lyrics, musical acculturation and melodic contour are some other features that affect children and adults' short-term memory for music (Bartlett, 1980; Feierabend, Saunders, Holahan & Getnick, 1998; Gerard & Auxiette, 1988; Zenatti, 1985).

Nevertheless, studies concerned with long-term memory of music are still scarce, notably in the case of infant participants. The past few years however, saw an increase in interest on the topic. The reduced number of studies that addressed long-term retention of musical information during infancy that are reviewed here, relied on evidence presented at an earlier time by research conducted in the speech domain. For this reason, studies on infants' memory for speech are also reviewed in this section.

Some studies suggest that babies can remember familiar words. Mandel, Jusczyk & Pisoni (1995) used the Headturn preference procedure to demonstrate that 4.5-month-olds recognized and listened longer to their own names than to other names from a list. Halle & Boyson-Bardies (1994) compared infants' listening preferences for familiar and unfamiliar words. They presented 11- and 12-month-olds with lists of familiar and rare words matched in phonetic structure, and measured their attentive listening. Babies showed a preference for the familiar words and such preference was much stronger for 12- than for 11-month-old babies.

Using a rather laborious study design, Jusczyk & Hohne (1997) studied 8.5-months old infants' long-term memory for spoken words. They exposed babies to short children's stories for ten consecutive days. After a two-week retention period, babies were tested on the Headturn preference procedure. At test, they heard words taken from the familiar stories mixed with foil words. Foil words were matched with the story words for their phonetic characteristics and frequency of appearance. Results showed that babies attended longer to the familiar than to the unfamiliar words. A control group of babies, who were not exposed to the stories, was also tested and showed no preferences. The same design was used by Jusczyk (personal communication, 2000) to demonstrate that 8.5-months old babies could remember specific jazz performances after a two-week delay.

Based on Jusczyk & Hohne's (1997) design, Saffran, Robertson and Loman (2001) questioned whether similar results could be found with musical stimuli. They familiarized infants with slow movements of Mozart sonatas for 14 consecutive days and found that 8.5 month-olds retained that information in memory after a two-week delay period. Interestingly, a novelty preference was found when infants were presented with excerpts taken from the middle of the pieces. Familiarity preference was found only when babies heard excerpts taken from the beginning of the pieces.

The authors attributed these results to musical context; that is, to the idea that middle sections are not as easily encoded as beginning sections of musical works.

Trainor and colleagues (2001; 2002) also investigated infants' long-term memory for music. They exposed 6-month-old infants to a 30-second simple and unfamiliar English folk tune played in piano timbre for one week. Babies were tested at delays of one day, one, two and three weeks. Novelty preferences were found for the piano pieces at delays of 1 day and 1 week. No preferences were found at 2 weeks and a familiarity preference was shown at 3 weeks. Interestingly, however, infants did not show recognition for the tune when it was played in harp timbre, or in a slower tempo. Yet, infants showed recognition of the familiar piece when the latter was transposed to another key during the test. These findings suggest that infants encode the timbre and the tempo of the pieces of music that are presented to them, but that the representation of pitch in long-term memory is relative and based on contour.

All together, the abovementioned studies suggest that infants can learn and encode music in long-term memory. Likewise, studies conducted with children and adult listeners revealed that long-term memory for music might be directly linked to musical complexity (Pechmann, 1998; Russell, 1982; 1987), melodic and rhythmic salience (Hebert & Peretz, 1997), presence or absence of lyrics (Feierabend, Saunders, Holahan & Getnick, 1998), and the amount of exposure or familiarity with a piece (Gardiner & Radomski, 1998). Because the study of infant long-term musical memories is quite recent, the extent to which adults' and infants' long-term memories resemble is still unknown. In order to understand how infants encode and represent music in long-term memory, further research addressing issues such as the effects of age and musical complexity are still needed. Such studies would not only add to the body of knowledge on infants' long-term auditory memories, but would also contribute to the development of effective curriculum for music educators, therapists and other practitioners in the field of early childhood education and care.

Music perception and cognition in the first year of life: A summary

This chapter reviewed the literature on infants' music perception and cognition. A solid body of knowledge exists to suggest that infants process music in many similar ways as adults. Although cross-cultural comparisons are still scarce, some evidence exists to suggest that babies come into the world with some well-developed abilities to process musical patterns. This does not mean that music learning is not taking place during the first year of life, though. Some studies have shown that young infants in the Western world quickly learn the rules of its tonal system, becoming increasingly proficient in detecting good patterns and "little mistakes" in them.

Young babies also respond to some music associated behavioral contingencies such as quieting down at the sound of a lullaby or becoming cheerful when a play-song is heard. Because the habit of singing to infants exists across cultures, one can assume that the world that surrounds the infant is one rich in music-like sounds: from the intonation contours found in the affective maternal speech to the actual music that is heard in the household. The perception of music during early infancy is then embedded in important social relationships of everyday life.

However, little is known about the ways in which infants encode and represent the music that they hear in long-term memory. To date only a few studies have examined infants' memory for music. Additional studies would contribute to the understanding of music storage and retrieval processes that take place during the early months of life, and how the latter may affect children's later musical development and taste.

Chapter III

Study Design and Methodology

Data Collection

Data for the present study was collected between March and October, 2001. Infant testing took place at the Infant Speech Perception Lab in the McGill School of Communication Sciences and Disorders.

Sample

One hundred and six infants (56 boys, 50 girls) were recruited in Montreal by means of posters and informal invitations at community centers, daycares, and infant-mother swimming and music classes. The final sample was composed of 70 infants (38 boys, 32 girls) with a mean age of 8 months and 2 weeks at test (range 7 months, 3 weeks – 8 months, 3 weeks). All infants were born at term, normal, healthy and free of colds and ear infections for the duration of the study. The sample was representative of a large variety of social economical and ethnic groups, and constituted primarily by children born from primipari women. Parental consent was obtained prior to the commencement of the study. Data from an additional 36 infants were not included in the final sample due to equipment failure (n=3), fussiness or crying at test (n=2), parental interference (n=1), experimenter error (n=3), age (n=7), developmental disability (n=1), lack of information on retention period (n=1), and too-low (n=5) or too-high retention period (n=1). In addition, 12 families dropped out of the study before the actual lab test due to ear infections or colds in their infants at the time of testing (n=2), bad weather conditions for driving to the laboratory (n=2), parental fatigue (n=2), unexpected travel (n=1), and other personal reasons (n=5).

Infants were tested at 8.5 months old postnatal age because previous studies (Jusczyk & Hohne, 1997; Saffran, Loman & Robertson, 2000) have shown that at this age infants can remember auditory stimuli in the form of words and music after a two-week delay. In addition, infants at this age are said to be fairly cooperative in lap-sitting tasks (for a discussion see Werker et al., 1998). Participating infant-parent dyads received a CD of classical music and a diploma (appendices K and L) for their participation. A letter with the results of the study was mailed to each participating family in May, 2002 (appendices O and P).

Stimuli

In selecting the stimuli for this study, a 20th century musical work was deemed suitable. Two main reasons explain such a choice. The first reason refers to the lack of studies on young children's, and thus, babies' preferences for contemporary music (for a discussion see Costa-Giomi & Pennycook, 1996). The second reason relates to recent suggestions regarding the inadequateness of contemporary works for young listeners. In discussing the results of their own study concerned with young children's judgments of happy and sad music, Dalla-Bella, Peretz, Rousseau & Gosselin (2001) stated:

"The music presented was of the classical genre and included excerpts up to 20th century composers (e.g., Ravel). Such material is adequate for adults, but perhaps less so for young children." (p. B-9).

This statement reinforced the motivation to use a contemporary work in this study. Thus, it was important to investigate whether the belief that 20th century music is perhaps inappropriate for young children would be sustained in the case of infants.

Due to their musical forms, harmonies, rhythms, and/or textures among others, some 20th century works are often said to be more complex than, for example, some works of the classical period (e.g., Mozart or Haydn). However, it should be noted that no single definition of complex music exists. As the literature suggests, musical complexity is relative and dependent on many factors such as the use of musical features (i.e., harmonic structure, use of rhythmic patterns, etc.) in a work (see Price, 1986), the style of a piece, the listener's musical experience and familiarity with a work (Hargreaves, 1984). For this reason, complex music was defined and chosen here according to these factors, always in relationship to simple music that is commonly presented to young listeners with little musical experience (i.e., infants).

The stimuli consisted, then, of two pieces that form part of the work "Le tombeau de Couperin" by Maurice Ravel (1875-1937). In comparison to music that is normally presented to infants such as lullabies, playsongs and early Mozart sonatas, this 20th century work can be considered complex. Under much influence of the French literary Symbolism, Ravel was interested in the creation of sound colors and textures. For this reason, the work favors the use of ambiguous chords and sonorities over a traditional resolution of chords. Tonal and modal harmonies grant the work with some ambiguities, which makes listening to this work a challenging task for the naïve listener used to listening mainly to simple and repetitive music (i.e., lullabies, playsongs, early Mozart sonatas).

A work that was probably unfamiliar to infants and their parents, *Le tombeau de Couperin* was originally composed for piano and later orchestrated by the composer himself. The Prelude and the Forlane were purposely chosen for their contrasting styles, similar meter and e-minor tonal centers. The following versions, shown on table 2, were selected for this study.

Table 2

Selected Recordings

	PIANO VERSION	**ORCHESTRAL VERSION**
CD title	Ravel Piano Works	Ravel Orchestral Music
Interpreter	Pascal Roge	Royal Concertgebouw Orchestra conducted by Bernard Haitink
Duration of the Prelude	2'55	2'57
Duration of the Forlane	5'12	5'38
Recording Year	1973	1973
Label	London - Decca	Philips
CD reference number	440 836-2	438 745-2

Of the approximately 20 versions analyzed these two were selected because the duration of the movements and overall piece were quasi-identical. In other words, the tempi were almost the same in these versions.

Musical Analysis

Ravel was often labeled as a neoclassical composer, and his music shows influences from different styles including the Baroque, the Classical period and Jazz. Le tombeau de Couperin is no exception. Completed in 1917 the work is a sort of "musical obituary" (i.e., each piece was dedicated to someone who died in World War I), a tribute to composer François Couperin (1668-1733) and to 18th Century French music. Even if the work retained some important stylistic features of 18th Century French music (i.e., suite form, ornamentation), it was essentially "dressed in 20^{th} Century clothing" (Bricard, 1993, p. 9).

Both Prelude and Forlane have a complex harmonic structure in which modal textures are presented or implied. Formally speaking, both pieces are highly repetitive. Although neither piece follows a pre-established form (e.g., ABA, ABACA, etc), the repetition of motifs throughout the pieces (e.g., the triplet motif in the Prelude and the dotted rhythmic motif in the Forlane) provides the listener with a sense of unity. In other words, recurring motifs and themes generate form and unity. The rhythmic patterns that underlie the recurring motifs provide important unity cues to the listener, since melodies are often interwoven with the accompaniment.

The Prelude

During the Baroque period, a prelude was traditionally used as an introductory piece to a large instrumental work, usually a piano or organ suite (Slonimsky, 1989). Ravel wrote the Prelude to introduce listeners to *Le tombeau de Couperin*. The prelude here is in 12/16 meter and centers around the key of e-minor, with frequent uses of modal and pentatonic scales. A perpetual motion of triplets with fast ornaments attached to the notes, a lean texture and a particular sound color are said to establish a connection to the music of François Couperin (see Bricard, 1993). Because the harmony of the piece is partially responsible for the designation "complex", a detailed harmonic analysis was done. Table 3 shows a sample harmonic analysis of the first 36 measures of the work.

Table 3

Sample harmonic analysis of the Prelude

MEASURES	KEY OR MODE	SCALE USED	COMMENTS
1 and 3	E Aeolian	e-minor pentatonic E G A B D	Use of e-minor pentatonic.
2 and 4	E Aeolian	a-minor pentatonic A C D E G	Use of a-minor pentatonic.
5 - 6	E Aeolian	E Aeolian mode E F# G A B C D	The melody states the Aeolian mode.
7 - 9	E Dorian	E Dorian mode E F# G A B C# D	The C# is introduced stating the Dorian mode.
10 - 13	E minor	e-melodic minor E F# G A B C# D#	The leading tone D# is introduced with the emphasis on the V chord. There is also a change to the melodic minor mode.
14 - 15	-------	--------	Descending chromatic bass line from V chord to I chord that implies E Lochrian mode. Mix of 3rds progressions, parallel chords indicate that chord function is secondary to sonority.
16 - 17	E Phrygian	E Phrygian E F G A B C D	The F chord (bII) and the Bm7(b5) (V) imply the Phrygian mode. The G# and F# are inflections that refer to other modes.
18 - 19	-------	--------	Bass line descends chromatically from IV chord. The inner voice also descends chromatically.
20 - 21	-------	--------	Chromatic bass line descends suggesting Eb Lydian, E Lochrian and back to E Aeolian.
22 - 23	C Lydian	C Lydian C D E F# G A B	There is no modulation, but an emphasis on the 6th degree. The C Lydian mode has the same notes as E Aeolian.
24 - 25	G Lydian	G Lydian G A B C# D E F#	Emphasis on the 3rd degree of the scale (relative major). C# is introduced, suggesting the Lydian mode.
26 – 28	E Aeolian	E Aeolian E F# G A B C D	Modal progression VII-VI-V-VII-I
29	-------	-------	Use of secondary dominants to modulate to G Major (relative major of e-minor).
30 - 36	G Major	G Ionian G A B C D E F#	--------

The Forlane

A Forlane is a traditional Italian folk dance from the 17th Century. The Forlane found in *Le tombeau de Couperin* is in 6/8 meter and centered in the key of e minor. Once again, Ravel creates tonal ambiguities through the use of modal scales with inflections on notes from other modes, and the use of a compressed version of the chromatic scale in the left-hand chords in several measures of the work. Other examples of a rather untraditional approach to harmonic progressions are included in Table 4, which encompasses the analysis of the first 28 measures of the Forlane.

Table 4

Sample harmonic analysis of the Forlane

Measure numbers	Key or mode	Scale used	Comments
1	E minor	E Dorian E F#GABC#D	Inflections on A#, D# and G# suggest other modes. Ravel elaborates on the tonic by avoiding cadences. Instead, he uses a major 3rd progression to the G# major chord with a b13.
2	---------	-------------	Appoggiatura: keeping previous chord and introducing the bass of the new chord. An upwards-step movement resolves the appoggiatura.
3	---------	-------------	Major 3rd progression in the bass A-(C#)-E#.
4	---------	-------------	Ravel arrives at this measure through a parallel chord movement and then uses a II-V progression to return to the tonic. (Jazz influence).
5-8	E minor	E Dorian E F#GABC#D	Same elaboration of tonic chord, by using circles of 3rds and the parallel chords used in measures 1-4.
9	E minor	E Dorian EF#GABC#D	Inflections on A#, D# and G# suggest other modes. In particular, the G# chord functions as the dominant of the VI degree (C#m).
10	C# minor	C# harmonic minor C#D#EF#G#A#B#	Emphasis on the 6th degree of the E Dorian mode (C#). Use of the VII7 chord to bring the listener back to the II chord of the E Dorian mode.
11-12	F# minor	f# minor pentatonic	The VII7 chord is used once again to bring the listener back to the II chord of the E Dorian mode.
13-16	E major	E Ionian EF#G#ABC#D#	The tonic chord is now major (mode mix) for the purpose of color change and not modulation. Use of a progression of 3rds at the end of measure 16.
17-18	G# mixolydian	G# Mixolydian G#A#B#C#D#E#F#	The A-natural is used as an inflection (flat 9). The V chord is a half-diminished, reinforcing the modal sensation.
19-20	E Phrygian	E Phrygian EFGABCD	The Ab appears as a split 3rd.
21-24	----------	-----------------	Again, chord function is secondary to tone color. Inflections on bII and II chords give the listener a sense of ambiguity (Phrygian and Dorian) modes.
25-28	E minor	E Dorian EF#GABC#D	Recapitulation of the piece. Same elaboration of tonic by circles of 3rds and parallel chords used in measures 1-4.

In sum, Prelude and Forlane are typical examples of 20th century neoclassical music, in which allusions to traditional form, ornamentation and structure are made, but with a new harmonic and melodic treatment. Such characteristics make these pieces complex for the infant listener, accustomed to hearing mainly to lullabies, playsongs and early Mozart works.

Procedures

Two data collection procedures were used in the present investigation. Infant perception data were collected through testing in the Headturn preference procedure. Maternal data was obtained by means of structured interviews and listening diaries.

Structured interviews and listening diaries

All participating mothers were interviewed on their musical background, previous musical training, parental experience, musical preference, singing/listening habits, and beliefs regarding musical appropriateness in the case of infants (appendices I and J). The rationale for having these interviews was to obtain information on the musical environment surrounding each participating infant. Such information could prove useful in the interpretation of behavioral findings and, perhaps, help identify factors that might have affected infants' preferences and long-term memory for music.

The data collection method used was the structured interview procedure, in which questions are set beforehand in a particular order. Each interview lasted between 20-30 minutes and was conducted either in the university lab or at the mother's house. All mothers in the sample were interviewed by a female researcher, because women usually are more at ease talking to female researchers than to male researchers (for a discussion see Finch, 1993). Interviews were conducted in English (n= 33), French (n=45), Portuguese (n=12), and Spanish (n=5).

Despite the fact that 106 infants were recruited for this study, interviews were conducted solely with 100 mothers. Two main reasons explain this numerical difference. First, there were two mothers of twin babies who participated in the study who were interviewed only once. Secondly, four additional interviews were not conducted because the mothers did not have time for the interview during the home visit and subsequently dropped out of the study.

In addition to being interviewed, mothers of infants who took part in the long-memory portion of the study (i.e., experiment 4) also received a copy of the "baby listening diary" (appendices L and M). These mothers were asked to annotate the date and time when listening occurred, the number of times the infant heard the piece each day, who accompanied the infant during the listening, activities and mood of the infant during the listening. Such information was useful to control for amount of listening and retention period when analyzing behavioral data. A total of 40 diaries were retrieved and analyzed for their content.

Infant Data Collection Procedure: The Headturn Preference Procedure (HPP)

All infants were tested on the Headturn preference procedure, a behavioral data collection tool that measures preferences for one kind of auditory stimulus over another. In some HPP studies, the purposes are to study the preferences themselves (e.g., Trainor & Zacharias, 1998). In other studies, preferences are taken as an index of infant discrimination (Kemler-Nelson et al, 1995), segmentation (Jusczyk & Krumhansl, 1993) or memory (Saffran, Loman & Robertson, 2000).

This study used preference as an index of preference, discrimination and memory. As traditionally done, infant discrimination was implied when a significant preference for one auditory stimulus over another was found. However, it is important to note that no clear conclusions can be made when no significant preferences are found.

Strengths and weakness of the HPP

The HPP is a reliable data collection tool that allows for the presentation of long-duration stimuli (for a discussion see Kemler-Nelson et al, 1995). Testing in the procedure is not only shorter than in other behavioral procedures such as the Conditioned headturn procedure (CHT) or the High amplitude sucking technique (HAS), but also requires only one experimenter. These factors were key to the selection of the testing procedure for this study.

As with any other infant testing procedure, the HPP has both strengths and limitations. In spite of its weaknesses, the HPP has proven to be a reliable and useful tool for the investigation of infants' perception of auditory events (Kemler Nelson et al., 1995). Because it has been used successfully in several developmental labs throughout the world (for examples see Jusczyk & Hohne, 1997; Saffran, Robertson & Loman, 2000; Trainor, 1996), the HPP was chosen as the primary data collection tool for this study.

One of the strengths of the HPP is the low attrition rate, often lower than in other procedures such as the conditioned head-turn (see Werker et al., 1998) and the High-amplitude sucking method (Kemler-Nelson et al, 1995). Normally, the attrition rate in the HPP is only 15 to 20%, and rarely higher than 40% (Kemler-Nelson et al., 1995). Another strength of the HPP is the possibility of using longer duration stimuli. This proves vital for music researchers interested in studying infants' perception of musical excerpts as opposed to short melodic or rhythmic patterns. Additionally, unlike in the CHT where stimuli are presented only to one side of the infant, the HPP has stimuli presented to both sides of the infant. This controls for lateral asymmetries in infant music perception (see Balaban, Anderson & Wisniewski, 1998).

Notwithstanding, the HPP has some limitations. Findings from the HPP can at times be difficult to interpret because the procedure does not indicate exactly "what" the infant heard. Furthermore, the stimuli for studies using the HPP need to be carefully chosen, well balanced, controlled and age-specific. Otherwise, the infant habituates quickly or loses interest for both the task and the stimuli, becomes restless, fussy and possibly drops out of the study.

HPP set-up description

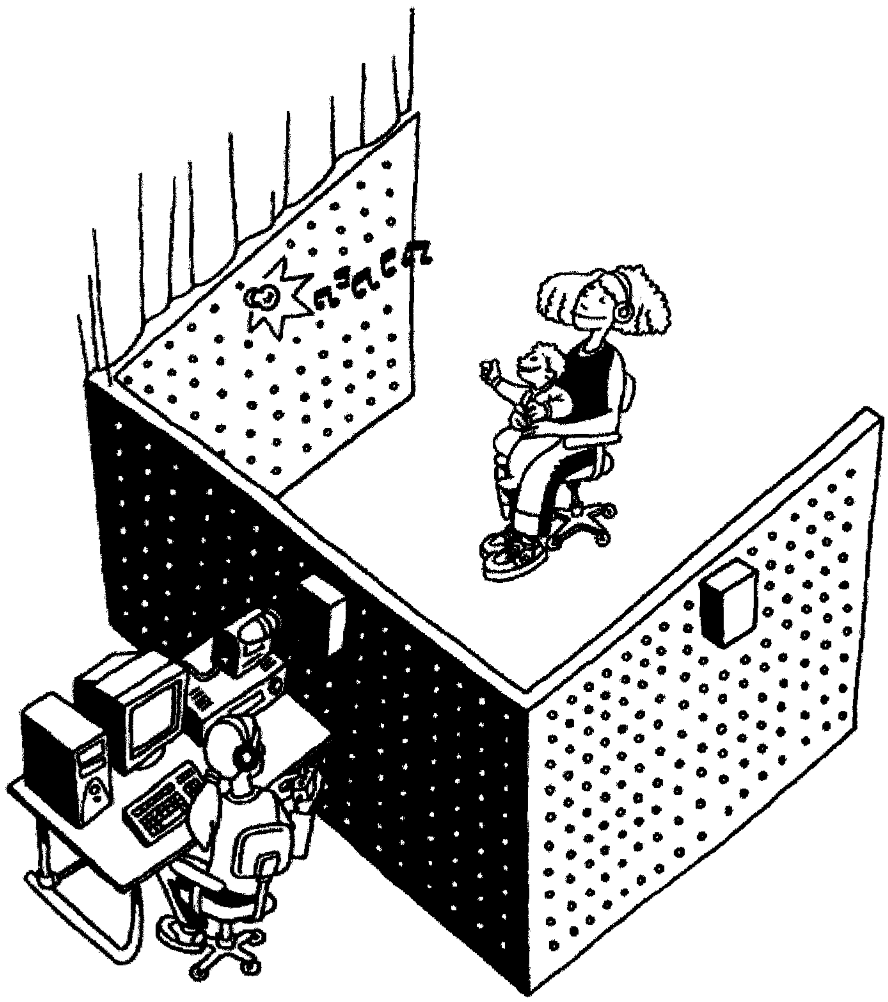
Testing in the HPP was conducted in a testing booth consisting of three 120 cm X 180 cm white cardboard panels. The areas between the booth and the ceiling were covered with white curtains to enclose the area and prevent the infant from getting distracted. One red light was located at each side of the panel. Behind each one of these lights there was a hidden loudspeaker, mounted to the panel. The center panel had another red light and a hidden video camera, which was manipulated by the experimenter. Videotaping of all testing was done to assess experimenter reliability. Mother and experimenter were required to wear tight-fitting earphones delivering masking music for the duration of the entire procedure. This was done to guarantee that neither mother nor experimenter biased the infant's response.

Before starting the procedure the infant was seated comfortably on the mother's lap in the center of the booth, facing the center light on the center panel. When the infant was facing forward and looking at the light, the experimenter pushed a button in the computer and started a trial. During each trial, one of the sidelights flashed urging the infant to look at it. Once the infant turned his or her head and looked at the light, the sound stimulus was played. The stimulus continued to play until the sound finished or the infant looked away. When the infant turned away from the source for at least two seconds, sound and light went off and the trial ended. A new one began when the infant was again looking at the center panel (refer to figure 2). If necessary, the experimenter used a puppet to get the infant to face forward.

Testing sessions included 16 trials: 4 training trials and 12 test trials. Training trials served the purpose of teaching infants to turn their heads towards the blinking light, located in either side of the panel. During each training trial, the light went off once the infant turned its head towards it. However, the light was kept on for as long as the infant looked at it, during test trials. The computer registered infant looking time for each one of the 12 test trials. Preferences for the two types of stimuli used in the test trials were calculated on the basis of infants' looking times. An average longer looking time for one type of stimulus over another was taken as an indication of infant preference for the former. Figure 2 depicts an illustration of the HPP.

Figure 2

Illustration of the Headturn Preference Procedure



Test materials and trials

All testing (i.e., pilot test and experiments) was conducted on the HPP using 16 different trials to assess infant musical preferences. The first four trials were training trials. The remaining trials were 12 different test trials presented randomly, 6 to each side of the infant. For the purpose of this study, 8 different excerpts of each piece were selected. Because two contrasting pieces were used in each test, infants heard a total of 16 excerpts per test. Each excerpt lasted 20-22 seconds in duration. Testing time differed for each individual infant and generally lasted between 5 and 10 minutes.

In experiments 1, 2 and 4, babies heard 16 different excerpts; 8 from the Forlane mixed with 8 from the Prelude. In experiment 3, babies heard 16 excerpts of the Forlane; half in piano timbre mixed with another half in orchestra timbre. Figure 3 shows a schematic representation of one of the 12 test orders.

Figure 3

Schematic representation of one possible test order

Test stimuli
Piece A = 8 different excerpts (a1,a2,a3,a4,a5,a6,a7,a8)
Piece B = 8 different excerpts (b1,b2,b3,b4,b5,b6,b7,b8)

↓

Training trials	Training trial 1 - a1 (left)
	Training trial 2 - b1 (right)
	Training trial 3 - b2 (left)
	Training trial 4 - a2 (right)
Test trials	Testing trial 1 - b8 (left)
	Testing trial 2 - b4 (left)
	Testing trial 3 - a7 (left)
	Testing trial 4 - a3 (right)
	Testing trial 5 - b3 (right)
	Testing trial 6 - a6 (left)
	Testing trial 7 - b6 (right)
	Testing trial 8 - a4 (right)
	Testing trial 9 - a5 (left)
	Testing trial 10 – b7 (right)
	Testing trial 11 - b5 (left)
	Testing trial 12 - a8 (right)

Overview of the experiments

This study consisted of four experiments that were designed to investigate infants' perception and long-term memory for complex music. Experiments 1 to 3 addressed questions related to infant preferences for complex pieces in single and multiple timbres. Using a more elaborate research design, experiment 4 addressed the question of long-term memory. Pilot study and experiments are described ahead in detail. Each infant took part in only one experiment and, therefore, underwent a single testing session. The Headturn preference procedure was used to collect data for the four aforementioned experiments. In order to test the suitability of the stimuli and to familiarize the experiment with the Headturn preference procedure, the 4 experiments were preceded by a Pilot study.

Pilot study

As noted, the purpose of the pilot study was to test the suitability of the stimuli and test materials, and familiarize the experimenter with the procedure. Ten 9-month-old infants (age range 8 months, 3 weeks to 9 months, 3 weeks; mean age = 9 months, 2 weeks) participated in the pilot test. These infants did not meet the sample inclusion criteria because of age. Seven infants (6 girls, 1 boy) completed the test in the Head-turn preference procedure. Data from an additional 3 infants (all boys) were not included in the final results due to equipment failure (n=1) or experimenter lack of headphones (n=2). At test, infants heard 8 different excerpts of the Prelude in piano timbre mixed with 8 different excerpts of the Forlane.

Experiment 1: Infants' preferences for piano music

The purpose of this experiment was to examine infants' preferences for complex pieces of music in a single timbre: piano. Specifically, this experiment investigated whether infants would show a preference when presented with contrasting complex pieces of piano music played by the same pianist.

Sixteen 8.5-month-old infants (range 8 months – 8 months, 3 weeks) were recruited. Fifteen infants (8 boys, 7 girls) completed the test in the Head-turn preference procedure and composed the final sample. Data from one additional baby was not included in the final sample due to fussiness. At test, infants heard 16 excerpts of piano music; 8 different excerpts of the Prelude mixed with 8 different excerpts of the Forlane.

<u>Experiment 2: Infants' preferences for orchestra music</u>

The aim of this experiment was to investigate infants' preferences for two complex pieces of music played in multiple timbres (i.e., orchestra timbre). This experiment examined whether infants could distinguish between two complex pieces of music in the same style and played by the same ensemble.

The final sample included 15 infants (9 boys and 6 girls) aged between 7 months, 3 weeks to 8 months, 3 weeks. One additional baby was recruited but did not finish the test due to equipment failure. At test, infants heard 16 excerpts of orchestra music, that is, 8 excerpts of the Prelude mixed with 8 excerpts of the Forlane, all in orchestra timbre.

Experiment 3: Infants' preferences for contrasting timbres

As noted, studies on infant perception and differentiation of musical instruments by timbre are scarce. The purpose of this study was to study infants' preferences for contrasting timbres: single (i.e., piano) and multiple (i.e., orchestra). At test, infants heard 16 excerpts of the Forlane, 8 of them played in piano timbre and another 8 played in orchestral timbre.

Twelve infants (8 boys, 4 girls) were recruited for this experiment. A group of 10 infants (range 8 months to 8 months, 3 weeks) constituted the final sample. Data from two additional infants (2 boys) were not included in the final sample due to experimenter error (n=1) and infant restlessness (n=1) resulting in very low looking times (i.e., average looking times lower than 3 seconds for both pieces).

Experiment 4: Infants' long-term memory for complex music

The purpose of this experiment was to replicate previous findings (see Jusczyk & Hohne, 1997; Saffran, Loman & Robertson, 2000) and assess infants' ability to recall familiar complex pieces of music after a two-week delay. The prediction was that infants' would listen longer to the familiar than to unfamiliar piece. Only piano music was used for this experiment.

Fifty-two infants (age range 8 months to 8 months, 3 weeks) were recruited for the experiment. Data from 12 infants were not included in the final sample due to developmental disabilities (n=1), fussiness (n=1), parental interference at test (n=1), no listening information – no diary (n=1), colds or ear infections at test (n=2), and too small (n=5) or too large (n=1) retention period. In addition, 10 families dropped out of the study before the actual lab test. The final sample, then, was composed of 30 infants (15 boys, 15 girls).

Infants in the final sample completed all experimental phases: familiarization, retention and test. Thirty infants were assigned randomly to one of two groups: Prelude or Forlane and went through the following experimental phases:

I. Familiarization phase - The researcher scheduled a home visit with each family. During the visit, she explained the study and asked the parents to sign consent forms. Parents and caretakers answered a short questionnaire on the musical behaviors of the family and received a CD that contained the designated piece, the Forlane or the Prelude in piano timbre. In order to guarantee optimal listening conditions for the infant, parents and caretakers were instructed to listen to the musical piece three times a day, when the infant was in a quiet and alert state and the home environment was calm and peaceful. Parents and caretakers also were asked to fill out a music listening diary (see appendices K and L) providing the date, time and infant mood during each listening session. The researcher followed up on each family by phoning once during the 10-day listening period, to ensure that the procedures were being followed properly.

II. Retention phase: As soon as the familiarization phase terminated, the researcher scheduled a CD pick-up date. CDs were collected to ensure that no listening of the familiar piece occurred during the two-week retention phase.

During the retention phase, families listened to all the music they desired, except the familiar experimental piece. A lab visit was scheduled for the first day after the two-week retention phase.

III. Test phase: Infants were tested in the lab using the Headturn-preference procedure. At test, infants heard 8 different excerpts of the familiar piece of music (i.e., either the Forlane or the Prelude) mixed with 8 different foil excerpts of an unfamiliar piece of music (i.e., either the Forlane or the Prelude). In other words, infants who had the Forlane as the familiar piece had the Prelude as the unfamiliar one and vice-versa. All excerpts were in piano timbre.

Chapter IV

Data Analysis and Results

Data from the present study were analyzed according to the nature of the methods employed. Infant perception data yielded through the Headturn preference procedure conformed to its traditional analytical approach, that is, paired sample t-test analysis. An analysis of variance was also used in the comparison between experiments 1 and 2. Interview data was analyzed using descriptive statistics, such as frequency counts and Chi-square distribution tests.

Analysis of infant data

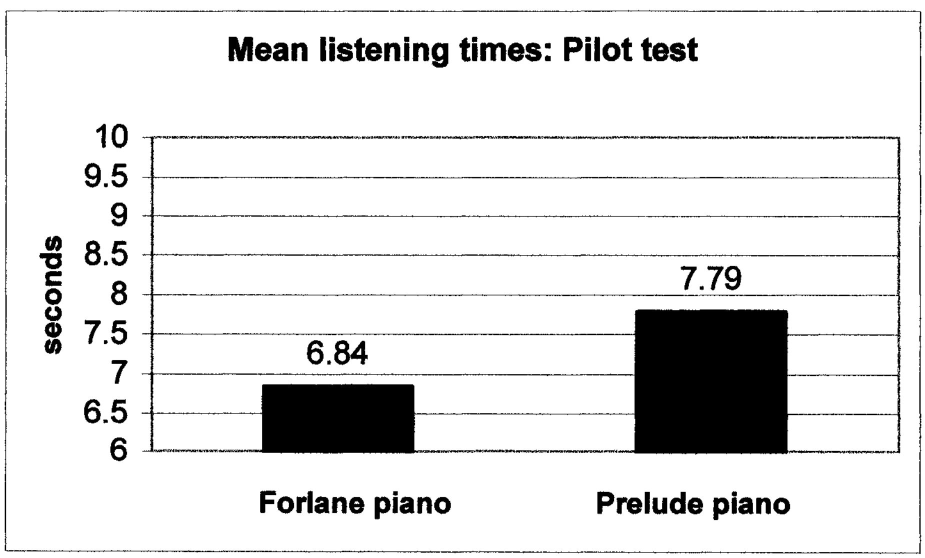
Two-tailed t-tests were used to analyze data from all experiments except experiment 4. A one-tailed t-test was used in the analysis of experiment 4 (long-term memory) because the direction of the difference between the two sample means was predicted beforehand. For all experiments, listening times were calculated for each child and collapsed across groups. The analysis was done on the basis of group results only. Because the study did not include an experiment addressing specifically infants' preferences for simple or complex stimuli, power tests of effect sizes were calculated and compared across the results of this study and those found by Jusczyk & Hohne (1997) and Saffran, Robertson & Loman (2000). Analysis of data is reported separately for the pilot test and for each experiment. Power analyses are included at the end of the section.

Pilot study test results

In order to determine whether infants in the pilot test showed a preference for the Prelude or the Forlane in piano timbre, a paired-sample t-test was performed. Although there were 10 infants in the pilot test sample, results were computed solely for 7 infants. Data from an additional 3 infants were not included in the analysis due to equipment failure (n=1) and lack of headphones (n=2). No significant differences between listening times for either piece were found [t (6) = -1.715, SD = 1.458, p > .05, two-tailed], as per graph 1.

Graph 1

Paired-sample t-test: Pilot test



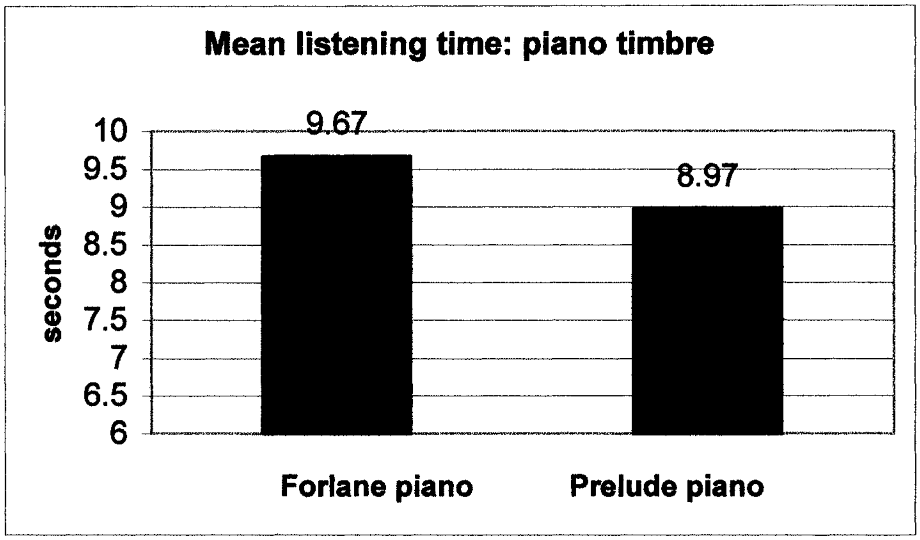
Although the sample size was relatively small and did not reach statistical criteria, the results suggested that the stimuli and procedure were adequate for use in the subsequent experiments (i.e., average looking times were comparable to other published studies). The pilot test provided the experimenter with much needed experience with the procedure and with infant testing. It should be noted that pilot study test data could not be collapsed with experiment 1 data due to the difference in the age of subjects in both groups.

Results from Experiment 1: Infants' preferences for piano music

Sixteen infants participated in experiment 1. Data from one infant were excluded from the analysis because the child cried and dropped out of the test. Eight babies listened longer to the Forlane, six babies preferred the Prelude, and one baby showed no preferences for either piece. Paired-sample t-test comparisons revealed no significant listening differences for either piece played in piano timbre [$t\ (14) = .737$, $SD = 3.719$, $p > .05$, two-tailed], as shown in graph 2. In other words, babies did not show a preference for either piece in piano timbre.

Graph 2

Paired-sample t-test: Experiment 1

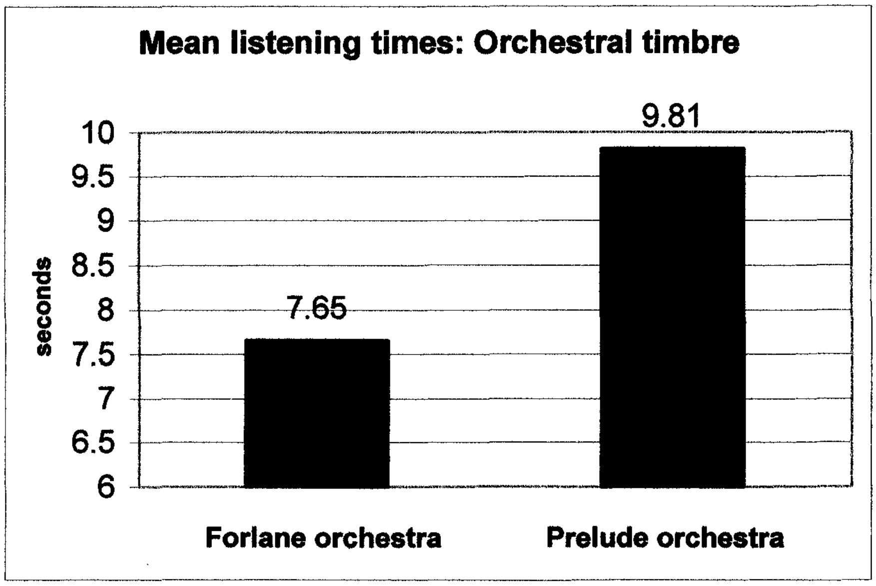


Results from Experiment 2: Infants' preferences for orchestra music

Sixteen different infants took part in experiment 2, which compared attentive listening times to the Prelude and the Forlane in orchestral timbre. One infant did not finish the test due to a technical problem in the HPP procedure. Fifteen babies completed the test. Eight babies showed a preference for the Prelude, three babies showed a preference for the Forlane, and four babies showed no preferences for either piece. Paired sample t-test comparisons revealed a significant preference for the Prelude in orchestral timbre [t (14) = -2.662, SD = 3.138, p < .05, two-tailed]. Listening times for both pieces are shown on graph 3.

Graph 3

Paired-sample t-test: Experiment 2



<u>Comparing results from experiments 1 and 2</u>

A two-way repeated measures analysis of variance (ANOVA) was conducted to examine the effects of timbre (piano or orchestra) and piece (Prelude or Forlane) on infants' musical preferences. The analysis showed no significant main effects for either timbre or piece. In other words, babies did not show significant preferences for either timbre ($F = 0.260$, $df = 1$, $p > .05$) or for one piece over another ($F = 1.332$, $df = 1$, $p > .05$). However, the interaction of timbre and piece was significant ($F = 5.198$, $df = 1$, $p < .05$). This is not surprising, given that infants showed a clear preference for the prelude in orchestral (experiment 2) but not in piano timbre (experiment 1). Table 5 depicts the results of the ANOVA comparing the results of experiments 1 and 2.

Table 5

Analysis of variance (ANOVA) comparing experiments 1 and 2

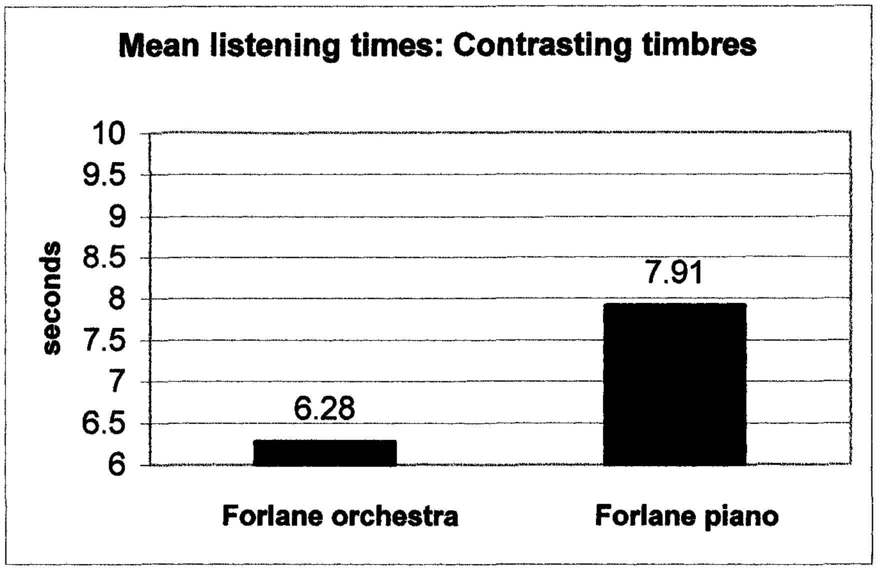
Source	**Sum of squares**	**df**	**Mean square**	**F**	**p**
Timbre (Between groups)	5.275	1	5.275	0.262	0.613
Piece (Within groups)	7.942	1	7.942	1.342	0.257
Timbre X Piece	30.888	1	30.888	5.218	**0.030**
Error	165.761	28	5.920		

Results from Experiment 3: Infants' preference for contrasting timbres

Twelve infants were recruited for experiment 3. Data from two infants were not included in the final sample due to experimenter error (n=1) and infant restlessness at test (n=1). The final sample was composed of 10 infants. Seven babies showed a preference for the piano timbre, two babies showed a preference for the orchestral timbre and one baby showed no preferences for either timbre. A paired-sample t-test revealed a significant preference for the piano timbre [$t(9) = -2.271$, $SD = 2.279$, $p < .05$, two-tailed]. Infants listened significantly longer to the Forlane in piano than in orchestral timbre. Graph 4 shows attentive listening times for the Forlane played in the two contrasting timbres, piano and orchestra.

Graph 4

Paired-sample t-test: Experiment 3



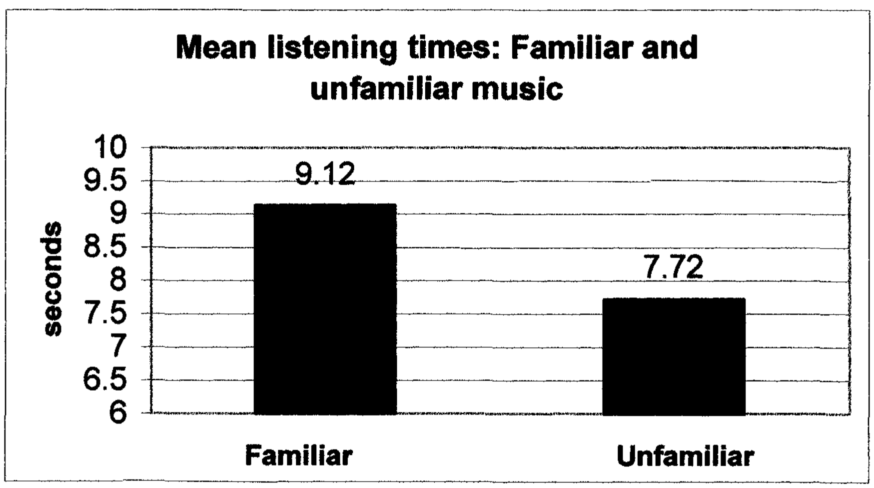
<u>Results from Experiment 4: Infants' long-term memory for complex music</u>

Fifty-two infants (age range 8:0-8:3 weeks) were recruited for this experiment. Data from 12 infants were not included in the final sample due to late report of developmental disabilities (n=1), fussiness (n=1), parental interference at test (n=1), no listening information – no diary (n=1), colds or ear infections at test (n=2), retention period too short (n=5) or too long (n=1). In addition, 10 families dropped out of the study before the actual lab test. The final sample was then composed of 30 infants (15 boys, 15 girls). To determine whether babies could remember the familiar piece of music after a two-week delay, listening times for both the familiar and the unfamiliar pieces were collapsed and compared.

A one-tailed t-test was used for this particular data set because the difference in the sample means was predicted beforehand. Because this experiment meant to replicate previous findings using more complex stimuli, it was hypothesized that at test, infants would attend longer to the familiar piece of music. Eighteen babies showed a preference for the familiar piece, eight babies showed a preference for the unfamiliar one, and four babies showed no preferences for either piece. A paired-sample t-test was performed and confirmed the predictions [t (29) = 1.939, SD = 3.973, p< .05, one-tailed]. Infants attended longer to the familiar than to the unfamiliar piece of music. Graph 5 depicts average listening times for the familiar and the unfamiliar music.

Graph 5

Paired-sample t-test: Experiment 4



Power analyses - Effect sizes

One limitation of this study is the fact that it did not include an experiment that contrasted infant preferences for simple versus complex music. An alternative way to examine the extent to which musical complexity affected infants' perception of music was to run power analyses. Such analyses would yield important information on the effects of stimulus complexity on infants' long-term memory for music.

Effect sizes are squared point biserial correlations between both the independent and the dependent variables. This measure is used to indicate the proportion of variance accounted for by an independent variable that is dichotomous. In order to compare results and determine the extent to which musical complexity affected infants' long-term memory for complex music, effect sizes were calculated for two groups of results: the present and a study that used a quasi-identical design. Effect size for each set of results are presented in table 6:

Table 6

Effect size (ES) for two studies on infant long-term memory for music

	Stimuli	**Testing materials**	**Sample**	**Effect size (Cohen's r^2)**
Saffran et al. (2000)	Music: Slow movements of piano sonatas by W.A. Mozart.	8 (taken from the beginnings sections of the pieces)	12	$r^2 = 0.42$ (high)
Present study	Music: Prelude and Forlane (piano) by M. Ravel	16 (taken from all sections of the pieces)	30	$r^2 = 0.11$ (medium)

Interestingly, effect-sizes were of a high magnitude for simple music (i.e., r^2>.167). In the case of complex music (i.e., this particular study), the effect-size was of a medium magnitude (i.e., .139 > r^2 >.022).

Analysis of interview data

One hundred mothers of infants who participated in the aforementioned experiments, ranging from 18 to 44 years of age (mean age = 32) were interviewed on musical background, listening preferences, musical behaviors with their infants (e.g., singing and listening), repertoire choice, and best time for musical activities to take place (see questionnaire in the appendix section). Each mother was also asked to describe episodes in which she was surprised by her infant's memory, if any. While some questions were dichotomous (yes/no), others were of an open-ended nature, and allowed for multiple responses. Descriptive data yielded through interviews was analyzed by means of frequency counts, percentages and Chi-square distribution tests because of its categorical nature.

Measures

Seventeen variables were studied and coded in the following manner:

1. Maternal occupation was defined as the mother's report of main activity. It was coded into three categories: student, housewife and worker under maternity leave.
2. Maternal experience was defined by the number of children each women had. Whereas primipari women had only one child and were first time mothers, multipari women had two or more children and were not first time mothers.
3. Maternal musical experience was defined by mothers' previous experiences playing instruments, in school, pre-university college or university. Mothers were asked to indicate whether they did or did not have previous musical experiences.
4. The existence of a musician in the family was only considered when the musician, amateur or professional was closely related to the women and their families. Only fathers, grandfathers and grandmothers counted as musicians in the family.
5. Maternal ensemble participation was a category used to address the musical experiences of women who did or did not necessarily have formal musical training but had been or were part of a musical group, be it a youth orchestra, a school band, a church choir, or a rock band among others.
6. Mothers' music listening times were indicated by women's choices of one out of four categories: 0-1, 1-3, 4-6 or 7 and more hours per week.

7. Mothers' listening preferences were divided into 6 different categories: varied, pop, classic, children's music, ethnic and other. Varied was the code used to designate the preferences of women who mentioned two or more contrasting styles. Ethnic was the term used to define mothers' preference for music of a culture other than French or English Canadian. Pop, classic, children's music, and other are self-explanatory categories.
8. Time spent with baby was coded into three categories: 0-5 hours, 6-12 or 13-24 hours per day.
9. Caretaking role was dichotomously coded. Mothers were divided into those who took care of the child with very little or no help from others, and those who shared infant caretaking with other family members or professionals.
10. Infant memory episodes were dichotomously coded. Women were divided into those who described one or more moments of surprise with their infant's memory, and those who did not describe any. Descriptive reports and anecdotes of infant memory were placed within one of 10 different categories.
11. Play baby is an abbreviated form of "playing music for the baby". It was defined as the act of selecting and playing a CD or cassette for the baby to listen to. This question was of a dichotomous nature, that is, mothers answered yes or no.
12. Play style referred to the musical styles that mothers selected and played for their babies. Styles were coded into 4 categories: children's songs, classical music, pop and other.

13. Sing baby referred to singing for the baby and was coded dichotomously. Mothers answered yes or no when asked about their habits of singing to their infants.

14. Sing style referred to the musical styles that mothers sung for their babies. Styles were coded into 4 categories: children's songs, invented, pop and other. It should be noted that the category children's songs included lullabies and playsongs sung in several languages.

15. Musical appropriateness related to maternal beliefs of appropriate music for infants. Mothers were asked to indicate whether they believed in the existence of appropriate music for babies. They were also asked to justify their answers.

16. What appropriate referred to mothers' beliefs of what appropriate music for babies was. This was an open-ended question that generated a large number of answers. The analysis of data yielded 8 different categories.

17. Best time referred to mothers' belief on the best time for their infants to listen to music. Mothers were asked to choose between 5 categories: Quiet and alert, fussy, crying, sleepy, and other. It should be noted that some mothers also described places (e.g., car) and time of day (e.g., morning or evening) when they believed music was a good activity for their babies.

Table 7 summarizes each studied variable including the nature of the question and how the responses were categorized. Data for each variable are discussed ahead.

Table 7

Descriptive variables

Variable label	Nature of question	Response: Number of categories
Maternal occupation	Open-ended	3 (student, housewife, professional)
Maternal experience	Dichotomous	2 (primiparous, multiparous)
Maternal musical experience	Dichotomous	2 (yes/no)
Musician	Dichotomous	2 (yes/no)
Ensemble participation	Dichotomous	2 (yes/no)
(Mothers' music) listening time	Forced choice	4 (0-1; 1-3, 4-6, 7+ hours)
(Mothers') listening preferences	Open-ended	6 (varied, pop, classic, children, other, ethnic)
Time spent with baby	Open-ended	3 (0-5 hours, half-day, full day)
Caretaking role	Dichotomous	2 (yes/no)
Infant memory episodes	Dichotomous	2(yes/no) + 10 categories of descriptions
Play baby	Dichotomous	2 (yes/no)
Play style	Open-ended	4 (children, classic, pop, other)
Sing baby	Dichotomous	2 (yes/no)
Sing style	Open-ended	4 (children, invented, pop, other)
(Musical) appropriateness	Dichotomous	2 (yes/no)
What appropriate	Open-ended	8 different categories
Best time	Forced choice	5 different categories

Observer and translator reliability

Maternal responses in French, Portuguese and Spanish were translated into the English language. Two external translators, one familiar with French and English, and another familiar with English, Portuguese, and Spanish checked for inconsistencies in the translations of open-ended responses. Translator reliability was calculated by dividing the number of agreements by agreements plus disagreements. Reliability was computed at .94 for the French language translation, and .96 for the Portuguese and Spanish translation. In addition, one external observer analyzed and categorized maternal responses to 6 open-ended questions, in about 30% of the interview data. Observer reliability was computed in the same manner as the translator reliability, that is, by dividing the number of agreements by agreements plus disagreements. Observer reliability was computed at .84 for the categorization of maternal open-ended responses.

Results

Maternal occupation

Participating mothers were students (7%), housewives (33%) and workers from different fields undergoing or just completing maternity leave (60%). Chi-square distribution tests were performed so to understand how occupation affected mothers' musical beliefs and behaviors. Results of these tests are reported in table 8.

Table 8

Cross tabulation: Maternal occupation

Test	**Pearson Chi-square value**	**df**	**significance**
Occupation X listening time	3.507	6	.743
Occupation X listening preferences	10.788	10	.374
Occupation X time spent with baby	10.437	4	**.034**
Occupation X infant memory	2.236	2	.327
Occupation X play baby	.690	2	.708
Occupation X play style	5.123	6	.528
Occupation X sing baby	8.871	2	**.012**
Occupation X sing style	5.273	4	.260
Occupation X appropriateness	1.347	2	.510
Occupation X best time	8.251	12	.765

Not surprisingly, maternal occupation affected time with baby. While student mothers and housewives reported spending lots of time with their babies, several mothers, who were returning to their jobs, reported spending few hours with their little ones. Interestingly, professional mothers reported singing to their babies more often than both student mothers and housewives.

Maternal experience

There were more primipari (65%) than multipari (35%) women in the sample. Maternal experience did not affect maternal listening times, listening preferences or musical behaviors with babies. However, maternal experience did affect mothers' descriptions of surprising episodes of infant memory. Primipari women described more surprising episodes of infant memory than did multipari women. Table 9 shows the cross-tabulation of maternal experience with other variables of interest.

Table 9

Cross Tabulation: Maternal experience

Test	**Pearson Chi-square value**	**df**	**significance**
Experience X listening time	.846	3	.838
Experience X listening preferences	1.417	5	.922
Experience X time spent with baby	2.825	2	.244
Experience X infant memory	3.884	1	**.050**
Experience X play baby	.088	1	.767
Experience X play style	2.874	3	.411
Experience X sing baby	1.565	1	.211
Experience X sing style	5.298	2	.071
Experience X appropriateness	.905	1	.342
Experience X best time	2.921	6	.819

Maternal musical experience

Chi-square values were calculated to determine whether maternal musical experience affected mothers' musical behaviors with their babies. Interestingly, mothers' musical experiences affected their music playing behaviors. Mothers, who had had some musical training, reported playing music to their babies more often than mothers who had never had any musical training. Table 10 summarizes the effects of maternal previous musical experience on mothers' overall musical behaviors with infants.

Table 10

Cross Tabulation: Maternal musical experience

Test	**Pearson Chi-square value**	**df**	**significance**
Musical experience X listening time	1.164	3	.762
Musical experience X listening preferences	3.778	5	.582
Musical experience X play baby	5.130	1	**.024**
Musical experience X play style	1.129	3	.770
Musical experience X sing baby	.176	1	.675
Musical experience X sing style	3.639	2	.162
Musical experience X appropriateness	2.312	1	.128

Existence of a musician in the family

It also was of interest whether the existence of a musician in the family affected the musical behaviors of mother-infant dyads. Table 11 shows the effects of having a musician in the family on maternal musical behaviors with infants. Overall, having a musician in the family affected mothers' choices of vocal repertoire. Mothers, who reported having a musician in the family, sung more invented or pop songs, while mothers with no musicians in their families sung more stereotyped songs and lullabies.

Table 11

Cross Tabulation: Existence of a musician in the family

Test	**Pearson Chi-square value**	**df**	**significance**
Musician X listening time	1.099	3	.777
Musician X listening preferences	5.122	5	.401
Musician X play baby	2.899	1	.089
Musician X play style	1.003	3	.801
Musician X sing baby	.821	1	.365
Musician X sing style	6.404	2	**.041**
Musician X appropriateness	1.395	1	.238

Mothers' ensemble participation

Only 30% of the women in the sample reported participation in a musical ensemble. Most ensemble experiences had taken place when the women were in school or university (87%). An additional 13% of women reported current ensemble participation such as singing in a church or secular choir. Ensemble participation did not affect maternal musical behaviors with babies. Yet, it affected the music listening preferences of mothers in this study. Mothers, who had never participated in a musical ensemble, reported listening to pop music more often than mothers who had ensemble experience. By contrast, mothers with ensemble experiences reported listening to classical music more often than their non-ensemble-experienced peers. Table 12 shows the effects of ensemble participation on maternal overall musical behaviors.

Table 12

Cross-tabulation: Mothers' ensemble participation

Test	Pearson Chi-square value	df	significance
Ensemble X listening time	2.124	3	.547
Ensemble X listening preferences	14.395	5	**.013**
Ensemble X play baby	.485	1	.486
Ensemble X play style	4.172	3	.243
Ensemble X sing baby	.007	1	.932
Ensemble X sing style	.816	2	.665
Ensemble X appropriateness	2.081	1	.149

Mothers' music listening times

Mothers interviewed for the purpose of this study listened to music for many hours. Sixty-six percent reported listening to an average of 7 hours or more per week, 16% listened to music an average of 4-6 hours per week, 13% said they listened to an average of 1-3 hours of music every week, and only 5% reported listening to less than one hour of music every week. There were no relationships between maternal listening times and musical behaviors with babies. Preferred listening styles were also well distributed among all 4 groups of listening times, as seen on table 13.

Table 13

Cross tabulation: Mothers' music listening times

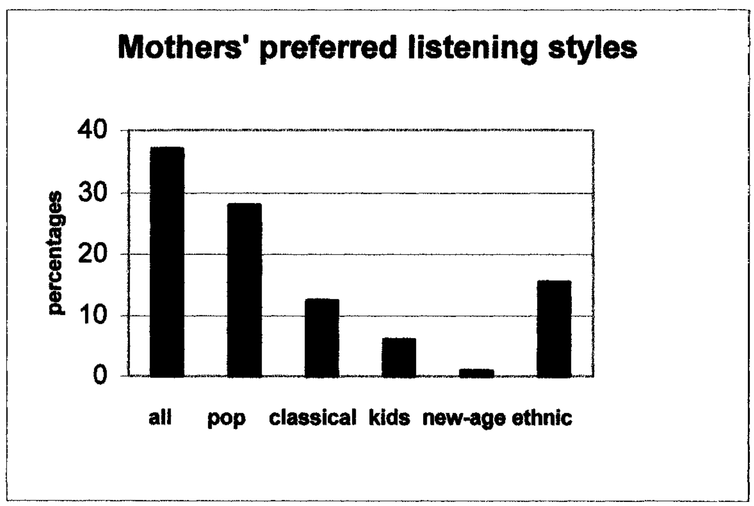
Test	**Pearson Chi-square value**	**df**	**significance**
Listening times X listening styles	6.336	15	.974
Listening times X play baby	5.434	3	.143
Listening times X sing baby	4.306	3	.230
Listening times X appropriateness	1.490	3	.685

Mothers' preferred listening styles

When asked what types of music they listened to, 37% of women reported listening to varied styles, 28% heard primarily pop music, 12.5% listened mainly to classical music, 6% to children's songs, and 1% to new age music. An additional 15.5% of women reported listening to music of their own ethnic group or culture. Graph 6 shows the distribution of maternal preferred listening styles in this study.

Graph 6

Mothers' preferred listening styles



Time spent with baby and maternal caretaking role

About 75% of the mothers spent 24 hours per day, seven days a week with their babies, 17% spent half the day with their babies during the week and full days on weekends, and only 8% reported spending less than 5 hours a day with their infants. Among these women, 65% shared caretaking with fathers, partners or grandparents, while 35% did not have anyone to help take care of the baby.

Reports of infant memory episodes

In order to identify whether there were infants in the sample with an outstanding memory for music, mothers were asked to report any episodes in which they were surprised with their infants' memory. Seventy-two percent of the women described infant memory episodes. As mentioned earlier, primipari women outnumbered multipari women in the amount of descriptions. According to mothers, infants recognized familiar faces and voices, toys, music, sounds from TV, music played during pregnancy, places, objects, and feeding times, among others. As seen on Table 14, there were no outstanding infant memory episodes. The episodes that mothers described are consistent with those found in the infant memory literature studies. No mother reported a rather unusual memory ability in her infant.

Table 14

Infant memory episodes

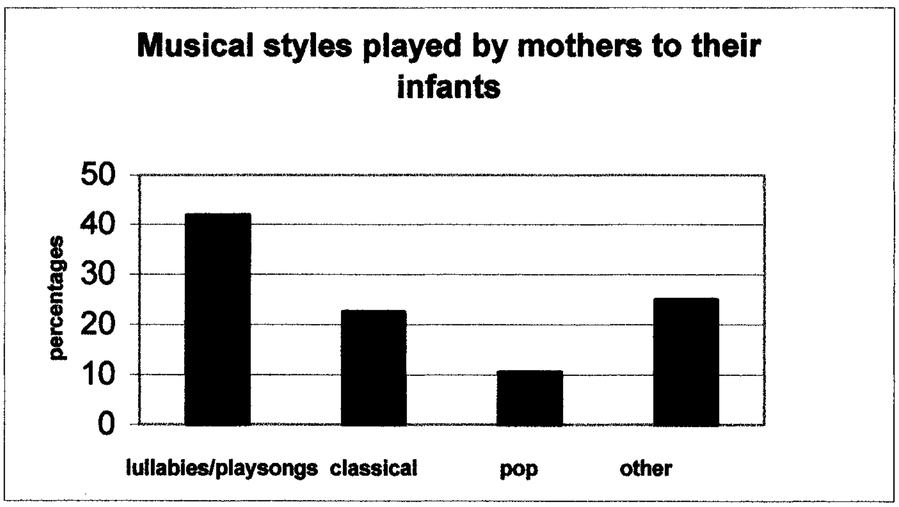
Events	Percentage
Familiar faces and voices	28%
Songs with and without lyrics	26%
Toys	15%
Objects in the house (vase, lamp, curtains)	7%
Music from pregnancy	6%
Sounds from TV (publicity, voices)	6%
Places (Vaccination place, pediatrician's clinic)	4%
Movement associated with objects	3%
Feeding time	3%
Pets (dog, cat)	2%

Playing music for the baby

While 79% of the women reported playing music for their babies, 21% stated that they did not. Playsongs and lullabies were the preferred styles (42%), followed by a variety of styles including ethnic music (25%), classical music (22.5%) and pop/radio (10.5%). Graph 7 shows music styles played by mothers to their babies.

Graph 7

Musical styles played by mothers to their infants

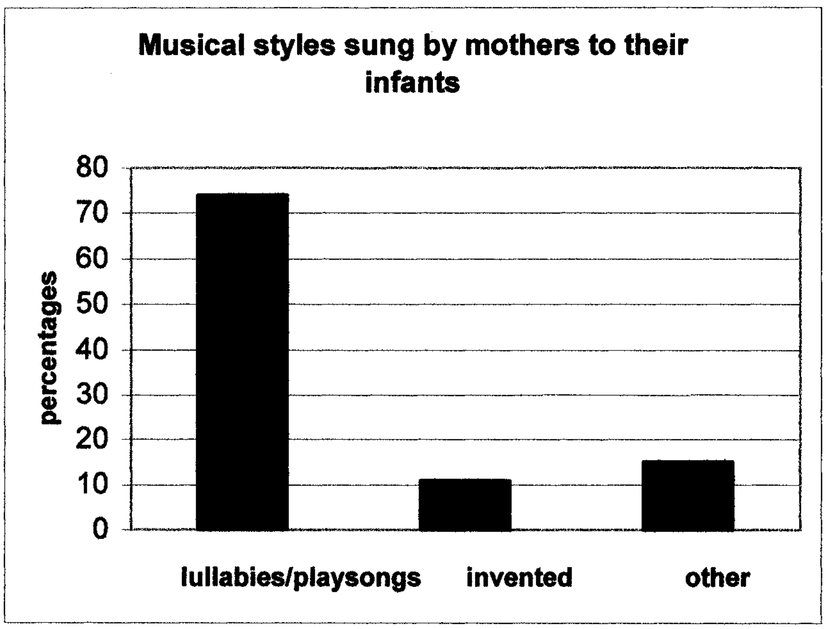


Singing to the baby

Singing to the infant was very popular among mothers, more popular than playing music to the infant [Pearson Chi Square .05 = 7.018, $p < 0.05$]. While 93% reported singing to their babies, only 7% of the mothers said that they did not sing at all. These mothers explained that they did not sing to their babies due to a lack of knowledge of repertoire, shyness or lack of confidence in their singing voices. Lullabies and playsongs were by far the most preferred singing styles (74%), followed by other styles including pop (15%) and invented songs (11%). It should be noted that immigrant women mentioned singing in their own language more often than in English or French. Preferred singing styles were summarized in graph 8.

Graph 8

Musical styles sung by mothers to their infants



Maternal ethnic background

Although the questionnaire did not address the topic directly, many questions related to maternal ethnic background and culture emerged during the interviews. As an example, eighty percent of the immigrant and foreign mothers reported listening and singing songs of their culture and in their own language more often than songs in either French or English. This finding is noted here due to its relevance to music education.

Musical appropriateness

Of interest to this thesis was the issue of whether or not appropriate music exists. When asked such a question, 72% of the women argued for the existence of appropriate music for babies, 22% said that there is no such thing, and 6% responded that they did not have an answer to this question. Interestingly, 16% of all women in the sample claimed that hard rock, rap and loud music were not appropriate at all. Although most mothers believed in the existence of appropriate music for babies, there was no real agreement as to what appropriate music is. Mothers gave a wide variety of answers, when asked to provide examples of appropriate music. Some mothers cited particular styles as appropriate music (e.g., lullabies or classical). Others talked about certain musical features that they believed should be present in infant music such as melodic, rhythmic and repetition of melodies among others. Table 15 shows examples of appropriate music for babies, according to the women interviewed.

Table 15

Examples of appropriate music for babies

Examples	Percentages
Calm and soothing music	22%
Rhythmic and live music	19.5%
Classical music	18%
Music with one or more of the following features: simple, repetitive, melodic, and sung in high-pitch.	18%
Lullabies and playsongs	12.5%
Choice of repertoire depends on baby's mood: rhythmic music for happy baby / calming music for the cranky or sleepy baby.	4.5%
Other styles (new age, Abba, Simon & Garfunkel and others)	4.5%
I don't know, but I am sure there is a style that is appropriate.	1%

Best time for musical activities

Best time for musical activities varied across families. More than half of the mothers (57%) used the infant's mood and state as indicators of when to play music. According to these women, rhythmic music was used to entertain a happy baby, slow music was used either to soothe or lull a sleepy baby, and no music was used when the infant was sick or upset. In other families, music was used exclusively to arouse and amuse a happy baby (13%), to put a baby to sleep (11%), or as a passive listening activity to a quiet and alert baby (16%). Only a few mothers used music to calm a cranky or fussy baby (3%). Additionally, several mothers reported singing to their babies or listening to music mostly in the morning while changing diapers, bathing or bottle-feeding the infant. The car also was mentioned as an optimal environment for musical activities such as singing or listening to take place.

Summary of Findings

Infant data

Data obtained through infant testing in the Headturn preference procedure indicated that:

1) Infants did not have a preference for either the Prelude or the Forlane played in piano timbre.
2) Infants listened significantly longer to the Prelude than to the Forlane played in orchestra timbre.
3) Infants listened significantly longer to the Forlane played in piano timbre than in orchestra timbre.
4) As predicted, infants listened significantly longer to the familiar piece over the unfamiliar one.

Interview data

Interview data served the purpose of describing mother-infant musical behaviors. The data suggested that:

1) Maternal occupation affected mothers' time spent with baby and singing behaviors. Although working mothers reported spending comparatively less time with their babies than student mothers or housewives, they also reported singing to their babies more often than the aforementioned groups.
2) Maternal experience affected mothers' descriptions of infant memory episodes. Primipari women reported more infant memory episodes than multipari women.
3) Maternal previous musical experience affected mothers' music playing behaviors with their babies. Mothers, who had had previous musical training, described more playing behaviors than mothers who had never had any musical training.
4) Maternal ensemble experience affected their musical preference. Mothers who had never participated in a musical ensemble reported listening to pop music more often than mothers who had ensemble experience. In contrast, mothers with ensemble experiences reported listening to classical music more often than their non-ensemble-experienced peers.

5) Having a musician in the family affected mothers' choices of singing repertoire. Mothers, who reported having a musician in the family, sung invented or pop songs more frequently, while mothers with no musicians in their families sung more stereotyped songs and lullabies.
6) Mothers sang more often than played music for their babies.
7) Mothers held a belief that "appropriate music for babies" exists. Yet, there was no agreement as to what appropriate music was.
8) There was no consensus as to what the best time for babies to be exposed to music was. Best time for music varied across families and was dependent on individual infants' routine and mood.

Chapter V

Discussion and Summary

The present study had two main purposes. The first purpose was to examine infants' preferences for and discrimination of two distinct pieces of complex music played in single and multiple timbres (i.e., piano and orchestra respectively). The second purpose was to investigate whether, after a two-week delay, infants could remember a familiar complex piece of music. Because infants rely on caretakers to provide musical experiences for them, maternal musical beliefs and uses of music with the participating infants were also investigated.

The infants' perspective: Interpretation of HPP test results

Experiment 1 assessed infants' preferences for two complex pieces of music played in piano timbre. Infants showed no preferences for either the Prelude or the Forlane piece when they were each played in piano timbre. As infants did not show any preference for either piece in piano timbre, it is not possible to come to clear conclusions regarding discrimination. Whereas the lack of preference for either piece in piano timbre could be indicative of infant lack of discrimination, it is also possible that infants did in fact discriminate between the two contrasting pieces but did not have any preference for either one. Clear conclusions regarding infants' discrimination between the Forlane and the Prelude in piano timbre could only be made if results of a redesigned Experiment 1 indicate a significant preference for either piece.

Experiment 2, however, yielded some clear results. When orchestral excerpts of both pieces were presented, babies listened significantly longer to the Prelude than to the Forlane. Such preference was clearly an indicator of discrimination. In other words, babies could tell apart these two complex pieces of music when they were played in orchestra timbre. However, the specific musical feature or features that accounted for infant discrimination of the Prelude and the Forlane in orchestral timbre are currently unknown and yet to be determined.

The contrasting results of Experiments 1 and 2 raise questions concerning the role of timbre in infant preferences for and discrimination of contrasting complex pieces of music. It is possible that the orchestral pieces were in general more appealing to infants than the piano pieces. If that were the case, infants were possibly more engaged and thus more attentive to subtleties in the orchestral than in the piano versions of the pieces. Such differentiated listening may have accounted for infants' abilities to discriminate between the Forlane and the Prelude in orchestra, as per Experiment 2.

To test this hypothesis, Experiment 3 examined infant preferences for the Forlane in two contrasting timbres: piano and orchestra. Interestingly, infants listened significantly longer to the piano than to the orchestral version of the Forlane. These results suggest both a preference for the piano timbre over the orchestral one and discrimination between both timbres. The fact that infants preferred the piano over the orchestra version of the Forlane suggests that they can pay sustained attention to the piano timbre. Therefore, the contrasting results of Experiments 1 and 2 were unlikely related to infants' innate preferences and differentiated attention for the orchestral timbre.

An alternative explanation for the different results of Experiments 1 and 2 relates to the segregation of musical phrases. It is possible that the orchestration of the Prelude and the Forlane facilitated infant perception and discrimination of complex music. Whereas melodies were very salient in the orchestral versions due to the constant change of instruments and tone colors, melodic salience was not always obvious in the piano versions. Considering that infants are sensitive to melodic contours (Ferland & Mendelsohn, 1989; Trehub, Bull & Thorpe, 1984), it is possible that melodic salience enhanced infant perception and discrimination for the pieces in orchestra but not in piano timbre. Moreover, it could be that two complex pieces of music played in multiple timbres are easier for babies to tell apart than the same complex pieces played in single timbres. These are no more than speculations that still need to undergo empirical substantiation.

Regardless if infants did not have a preference or could not discriminate between the Prelude and the Forlane in piano timbre (Experiment 1), their preference for the piano timbre was noteworthy in Experiment 3. However, when infant listening times for experiments 1 and 2 were compared between groups, no significant differences were found. In other words, babies between groups did not show overall preferences for either the Prelude or the Forlane, or for the piano or orchestral timbres. It was only when two versions of the Forlane in contrasting timbres were compared within groups (Experiment 3) that infants showed a preference for the piano timbre over the orchestral one. Because preferences for the piano over other timbres have been found in at least two other previous studies involving infants (e.g., Wilkin, 1991; 1995), future studies need to investigate whether the aforementioned instrument has a natural appeal to infants. Such conclusions cannot be made on the basis of the results of Experiment 3 as the sample size was relatively small and only two pieces of music were used.

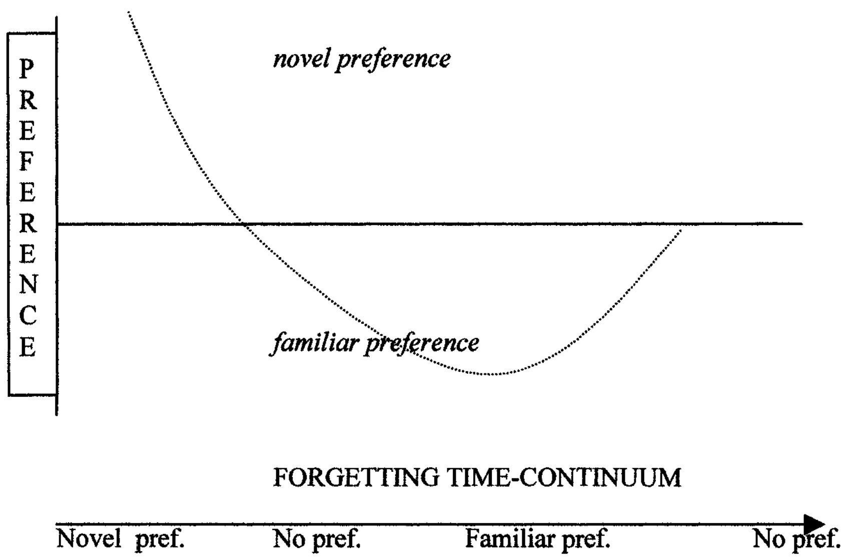
The results found in Experiment 4 were clear and conclusive. This experiment meant to replicate findings from previous studies regarding infants' long-term memory for sounds (Jusczyk & Hohne, 1997; Saffran, Loman & Robertson, 2000) using complex pieces of music. It was predicted that infants would prefer to listen to the familiar piece of music after a two-week delay over the unfamiliar one. Consistently with the predictions, infants listened significantly longer to the familiar piece of music over the unfamiliar one. When the listening preferences of these infants (Experiment 4) were compared with the listening preferences of a group of infants who had never heard the piece prior to testing (i.e., infants from Experiment 1), it was clear that the musical familiarization period had played a role in infants' preferences for music. Infants in the exposure group demonstrated an ability to retrieve musical information that was previously encoded and stored in memory. Hence, babies could remember the familiar piece of music after a two-week delay.

Attempting to understand the role of complexity on infants' long-term memory for music, effect-sizes were calculated. The results of the present study were compared with those found in a study that used a quasi-identical design (Saffran, Loman & Robertson, 2000). The main difference between the comparison study and the present one referred to the selection, use and manipulation of the stimuli. The comparison study used slow movements of early Mozart piano sonatas, which were cut into 8 twenty-second long different excerpts (i.e., 4 familiar and 4 unfamiliar). Additionally, excerpts were taken solely from the beginnings of the sonatas. The calculation of effect-sizes for the two studies generated some interesting results. While long-term memory for Mozart produced an effect-size of a large magnitude, long-term memory for Ravel yielded an effect-size of a medium magnitude. By simply comparing the effect-sizes, one could be led to believe that simple music (e.g., Mozart) is perhaps easier than complex music (e.g., Ravel) for infants to encode. It should be noted, however, that the present study used twice as many excerpts as the comparison study, all taken from throughout the pieces. In addition, the present study used excerpts from a comparatively more complex piece than the comparison Mozart study. It is possible, then, that the different approach to the stimuli may have increased the task difficulty and therefore accounted for the difference in effect-sizes. Thus, the comparison of the effect-sizes of these studies in itself cannot support any claims regarding complex music being more difficult than simple music for infants to encode. Further studies are still needed to address this issue.

By replicating previous findings using complex stimuli (see Jusczyk & Hohne, 1997; Saffran, Robertson & Loman, 2000; Trainor, Wu, Tsang & Plantinga, 2002), this study supports an emerging model of infant long-term memory for musical experiences. The model, which I propose here, could perhaps be constructed as a function of inverting the direction of infant preferences in the multifactor model of infant novel and familiar preferences described in chapter II. However, such a model could be applicable solely in the absence of "remembering cues" presented during the retention period. The results found by Saffran, Loman & Robertson (2002), Trainor, Wu, Tsang & Plantinga (2002) and those of the present study seem to fit well in this model. Figure 4 depicts a preliminary version of the proposed model of infant long-term memory for musical experiences in the absence of remembering cues.

Figure 4

A proposed model of infant long-term memory for musical experiences in the absence of remembering cues



The shape of the curve would obviously shift according to the combination of factors such as infants' age, task complexity, familiarization time and amount of delay between familiarization and testing. At this time, this model is only a theoretical one, grounded on the visual perception literature and on three experiments on infants' long-term memory for music. Future research could prove useful in validating the present model, notably since there are many questions regarding infants' memories that have not yet been answered and are of interest to several fields, including music education.

Because of the lack of studies in the area, caution in the generalization of the results from this experiment is needed. Although experiment 4 suggested that infants could remember complex pieces of music after a two-week delay, the longer-term effects of such memories are still unknown. Notably, since most children experience infantile amnesia when they are between ages 2 and 3 (Bauer, 1997). During this period, memories of several episodes that took place during the first two years of life will become irretrievable. Answers regarding the permanence of early musical experiences will only be available through longitudinal studies, which hopefully will be conducted in the near future.

To summarize, results from this portion of the study provide additional evidence that at 8.5 months of age, infants already display some remarkable abilities to process musical information. These rather young listeners showed some discrimination abilities and long-term memory for musical pieces that are otherwise considered complex and perhaps inappropriate or even inadequate for their age (consult Dalla Bella et al., 2001; H. Papousek, 1996). More impressively, infants seem to have relied on one or more musical attributes that made each piece coherent across excerpts, in order to show clear preferences, as demonstrated in Experiments 2-4. These specific musical attributes remain unknown and yet to be determined.

Maternal perspectives: Interpretation of interview results

Caretakers mediate the musical experiences of their infants (Bertsch, 2000; Custodero & Johnson-Green, 2002; Ilari, 2002b; O'Neill, Trainor & Trehub, 2001; Trehub et al., 1996). For this reason, descriptive data obtained through interviews with parents proved important as it complemented and shed light into some issues that were relevant to the understanding of infants' preferences and long-term memory for music. Several interesting findings emerged from the interviews conducted with mothers.

Contrary to some beliefs that modernization and changes in lifestyles may have reduced maternal musical activities with their infants (Lind & Hardgrove, 1978; M. Papousek, 1996), this study found music to be a prominent activity in most households. The majority of interviewed mothers reported using some music with their infants. In corroboration with previous findings (e.g., Custodero & Johnson-Green, 2002), singing was reported as the primary musical activity of infant-mother dyads. It should be noted that several women sang during home visits, notably when they were not certain of the musical style they wished to cite.

An interesting fact was that professional mothers sang more often to their babies than mothers who were housewives or students. A possible explanation for this difference in behavior of mothers relates to time spent with the infant. Not surprisingly, professional women in this study also reported spending considerably less time with their infants than housewives. It is possible then, that these working mothers tried to compensate for their absence by maximizing the quality of the time they spent with their babies. Singing, possibly in conjunction with other activities that foster bonding (e.g., rocking, moving, massaging) perhaps was used for this purpose. Alternatively, it is also possible that the professional women in this study were more educated and/or more conscious of the importance of singing to infants than the housewives or student mothers. Because no information regarding the women's education levels was obtained, such explanations are only speculative.

Previous musical experiences seemed to have influenced maternal musical behaviors with their infants. Mothers who had had previous experiences playing instruments reported listening to music with their babies more often than mothers who had never had such prior experiences. It was equally interesting that maternal previous ensemble experience affected their musical preferences. While mothers, who had never participated in an ensemble, listened primarily to pop music, mothers with previous ensemble experiences reported listening mostly to classical music. These findings are worthy of reassessment as they suggest some indirect effects of musical training on women's later musical behaviors with their children.

Having a close relative (e.g., a husband, partner or parents), who was a musician, also influenced mothers' musical behaviors with their infants. Mothers, who reported an existing musician in the family, sung invented or pop songs to their infants more frequently than mothers with no musicians in the family. The latter, reported singing lullabies and stereotyped children's songs frequently to their infants. Some caution in the interpretation of this particular finding is needed. Because women were not given a precise definition of what a musician was, it is possible that the category encompassed too many different definitions of the term "musician" (e.g., amateur or professional, music connoisseur or performer). Such definitions may have accounted for the actual results. Notwithstanding, it is still likely that a musician influences the musical behaviors of the members of his or her family. Because musicians obviously value music, they may nurture the musical attitudes and abilities of those that surround them including family members (for a discussion see Campbell, 2000; Freeman, 1976 cited in Custodero & Johnson-Green, 2002).

Language and culture emerged as other important issues related to mothers' uses of music with their babies. Mothers whose first language was not English or French reported singing songs of their culture and in their own language more often than foreign songs in the aforementioned idioms. Considering that music reflects identity and social behavior (Crozier, 1997), this finding does not come as a surprise. Moreover, the literature on sociolinguistics suggests that immigrant mothers will choose what language to speak to their children depending on their social economic status, education and enculturation level (Ebbec, 2001; Saravanan, 2001). Analogously, this could have been the case with singing. Given that approximately 50% of the sample was composed of recently immigrated women, it is possible that their ties to their home countries were still strong (i.e., low levels of enculturation). This might have led them to sing songs of their native countries more often than foreign songs.

Regardless of cultural differences, it was startling how stereotyped and somewhat predictable mothers' choices of repertoire were. Concurrent with the literature, lullabies and playsongs emerged as the most popular styles used by mother-infant dyads in this study. This was quite clear for singing behaviors and less clear for playing behaviors. What is unclear, however, is whether this choice of repertoire reflected some aspects of intuitive parenting (Papousek, 1996), or was in fact a byproduct of a stereotype of appropriate music/musical behaviors with babies that are commonly disseminated in our society. Whereas the arrival of a baby changes the family dynamics and leads parents to rethink some of their values and behaviors, including musical ones (e.g., Bertsch, 2000), new parents are also "bombarded" with information on what behaviors should and should not be used with their infants (see Schoenstein, 2002). This obviously includes musical behaviors. Thus, it is possible that both intuitive parenting and cultural norms/stereotypes played a role in parents' uses of music with their infants.

Strikingly, most mothers believed in the existence of appropriate music for infant listeners. Yet, there was no consensus as to what appropriate music for babies might be. This is not surprising since there are multiple meanings associated with the issue of musical appropriateness. Whereas musical appropriateness can be understood in the light of age-related perceptual abilities, it also can be interpreted as an endorsement of cultural norms and values. Furthermore, musical appropriateness may vary according to the different cognitive processes involved in different musical activities of infants and children (e.g., listening, playing, singing, moving). It is not surprising, then, that mothers did not agree on a particular musical style or styles that were supposedly more appropriate for babies.

There also was no agreement as to what time was best for babies to be exposed to music. Participating mothers usually relied on their infants' mood and routine to choose to sing or play music for them. This finding suggests that the use of music with infants is not determined by maternal/parental behaviors per se. Rather, the use of music with babies appears to be dependent on a mutual "agreement" between mothers/caretakers and babies. It appears that through trial and error, parents learn how to respond to the behaviors of their stressed or happy infants and decide what activities to pursue, including what types of music to use, when and where. Accordingly, the best time for musical activities to take place seemed to be decided by both parents and infants.

In sum, the interview data gathered for this study supports the notion that mothers mediate the musical activities of their babies. Mothers' previous experiences and beliefs regarding music seemed to be important in determining their uses of music with their little ones. Because all participating mothers were part of a community, it is likely that they were also influenced by various cultural norms of their communities. Among these cultural norms, some may have affected maternal beliefs and uses of music with their infants. The infants also seemed to have contributed to mothers' decision-making regarding music. Mothers selected musical activities according to their infants' mood and routine. And although the routine of babies who participated in this study was different, it was clear that most of them were exposed to some form of music, usually accompanied by their mothers.

Mothers, babies and music: Integrating interview and HPP findings

This study found mothers to be quite stereotypical in selecting repertoire for their babies to hear. Most mothers selected lullabies, playsongs and simple pieces of classical music for their babies to listen to, perhaps sustaining an implicit belief that infants are ill equipped to process complex music. However, data yielded through the HPP testing suggested that babies are in fact sophisticated listeners, capable of discriminating and encoding some pieces of complex music. These rather idiosyncratic findings reveal a conflict between maternal beliefs regarding infants' music cognition and the actual music-related perceptual and cognitive abilities of infants.

While further studies are still needed to shed light into infants' cognition and musical preferences, the results of the present study suggest that infants are attuned to the acoustical environment that surrounds them. Furthermore, the results of Experiment 4 lend support to the notion that "human children are psychological and intellectual sponges" (Small, 1998, p. 44) who pick up and encode much information from their environment, simple or complex. Thus, it is important to fine tune mothers and caretakers beliefs with what is currently known about infant music cognition, specially since mothers and caretakers shape the acoustical environment in the home.

This is not to say that mothers should play complex music for their babies or that complex music is the most appropriate for infants. Rather, this study suggests that infants can encode complex pieces of music during the first year of life. Thus, mothers and caretakers do not need to limit their infants to simple or stereotyped "baby" music. They should select music that they deem appropriate, be it simple or complex, always attuned to their infant's reaction. By choosing repertoire according to their own likes and to their infants' reactions, mothers could engage in some meaningful and enjoyable musical activities with their infants (see Csikszentmihalyi, 1990). Such activities would be beneficial for both infants and mothers alike by enhancing both: early music learning and social bonding.

Limitations of the study

This study was designed with much attention to the issue of ecological validity. Ecological validity relates to one's ability to apply research findings from controlled laboratory studies to everyday life (Schmuckler, 2001). In order to produce results that could be ecologically valid, much emphasis was put on the selection of repertoire. For this reason, real music with its particular tempo variations, changes in dynamics, pitch organization and expressiveness was used as opposed to laboratory-controlled artificial melodies. Beside the fact that artificial melodies do not always correspond to music that exists in the real world, it is often questionable whether these controlled melodies fit major definitions of music (for a discussion see Ilari, 2002b). Although real music is arguably more ecologically valid, its use in infant research is not free of problems. The main problem associated with the use of real music relates to the difficulty in identifying exactly what features accounted for infant discrimination. For this reason, the interpretation of findings from this study considered solely the perception of music as a whole. Except for the discrimination of contrasting timbres (i.e., piano and orchestra), no claims could be made here regarding infant perception of specific musical features. This obviously is one limitation of this study.

A second limitation of this study is the absence of an experiment that directly compared infants' preferences for simple versus complex music. By comparing infants' preferences for these two types of music, it would have been possible to determine whether infants could discriminate between the two types of music and had clear preferences. Studies conducted with adult participants have suggested that complexity is one possible factor that is related to liking music (Hargreaves, 1984; Orr & Ohlssohn, 2001; Russell, 1987). Since infants behave in many adult-like ways when it comes to perceiving music, it is possible that complexity affects their musical preferences as well. The data from the present study cannot support or contradict such claims.

Conclusions and implications of the study for music education

The major implication of this study for the field of music education relates to the development of curriculum for early childhood music education. As mentioned earlier, interviewed mothers showed clear beliefs regarding the issue of appropriate music for the infant listener. Such beliefs were seen in the media, in the music industry and even in the work of many infant researchers. A survey of music-related resources in the form of CDs, videotapes and toys geared towards the infant population (see appendix S) also revealed a rather stereotyped vision of the infant listener. Along with repetition, simplicity was one of the biases in the selection of repertoire for these resources, which included primarily lullabies, playsongs and short pieces of music from the Baroque and Classical periods. An implicit assumption underlying this choice of repertoire is that simple music possibly is easier for infants to learn and therefore is more appropriate.

This study, however, found no apparent evidence of limitations in infants' abilities to process complex music. In fact, research findings were quite the opposite. Infants in this study showed some notable abilities to discriminate between contrasting complex pieces of music. Infants also showed abilities to learn and memorize complex music through passive and repeated listening experiences. Taken together, these findings suggest that infants are capable of perceiving and remembering complex pieces of music. A question that then remains is: Why is complex music seldom incorporated into the early childhood music education curriculum?

I believe that there are four factors that possibly explain why complex music is seldom included in early childhood music education programs. The first factor is the novelty of infant music cognition research. As mentioned earlier, it was only two decades ago that researchers began to demonstrate that infants are sophisticated listeners. Since the dissemination of research findings is neither rapid nor efficient, it is possible that some time will evolve before the population at large, including teachers, starts viewing the infant as a competent listener. By increasing dialogue and exchange of ideas between researchers and early childhood music educators, it is possible to achieve a more efficient dissemination of information and elaboration of research that is meaningful for practitioners in the field.

Related to the novelty of infant cognition research is the impact of cultural values on beliefs and uses of music. This is the second factor that might explain the lack of complex music in early childhood music education programs. As members of a community, we are all influenced to a larger or lesser extent by its cultural values and beliefs, which are transmitted in many ways, media included. Even if they go unnoticed, such values and beliefs permeate many activities of everyday life, including musical ones. Early childhood music educators also are heavily influenced by the musical beliefs of their community, which are transmitted to some extent through their teaching. In an ever-growing multicultural world, it is important for early childhood educators to be attuned to possible conflicts between their musical beliefs and uses and those of the infant-parent dyads in their classrooms.

A third factor that has perhaps prevented many teachers from using complex music with their infant learners relates to the concept of sequencing in music education. As Campbell (2000) suggested, many people believe that music learning in children should follow a simple-complex continuum, although there is no clear definition of what "simple" and "complex" music are. Additionally, the problem with this continuum is that it often ignores cultural values and practices (see Blacking, 1967/1995; Sakata, 1987), parental listening preferences (Bertsch, 2000) and the many functions of music in everyday life (DeNora, 2000; Gregory, 1997; Hargreaves & North, 1997; 1999).

Furthermore, the simple-complex continuum disregards the fact that there are multiple ways of learning music such as singing, moving, playing, composing, improvising and listening (see Peery & Peery, 1987). Teachers should examine the function of each piece of music within the lesson prior to deeming it appropriate or inappropriate for their infant learners. If, on the one hand, simple music is possibly more appropriate for both parent and child to learn to sing, on the other hand, infants do not show apparent limitations in listening to complex music. In fact, educators may play a role in helping parents bring complex music to their children by, for example, having parents move with their babies or tap to the beat of complex musical works. These tasks may provide infant-parent dyads with what Vygotsky (1934/1987) called the *zone of proximal development*, that is, a task that a child can only master with the help of a more skilled person. Hence, early exposure to complex music may not be just enjoyable, but could have some effects on children's later music learning.

Infant music education is a socially mediated process. Although music educators "show the way" by encouraging parental singing, increasing knowledge of repertoire and uses of music, I believe it is the parent who ultimately will teach music to the infant. In other words, parents are the first music educators of their infants. Because parents mediate the musical experience of their babies, it is important that they (i.e., parents) have a chance to bring music that they enjoy to the classes, regardless of its complexity. The role of the early childhood music educator then, is to prepare lessons that include a wide variety of activities and repertoire, for the education and enjoyment of parents and their babies.

Implications for future research

A traditional approach in infant music perception and cognition research has been the study of infant discrimination of simple, isolated musical patterns, scales and motifs. In the past few years, however, the development of new testing procedures have allowed for the presentation of long duration stimuli to infants. Notwithstanding, researchers have still been very conservative in their choices of repertoire for studies with infant listeners. Most studies have used simple and highly structured pieces of music such as Mozart early piano sonatas, lullabies, playsongs and folksongs. This choice of repertoire somehow suggests an implicit belief regarding infants' limited abilities to process music. This study challenges this view. Hopefully, other researchers will consider using more complex or varied musical styles in their studies and will help uncover more information on infant musical development.

Even if there are some limitations associated with its use, I suggest that more studies on infant perception of "real" music be conducted. There are at least two reasons that justify such approach. The first reason is that research with real music is meaningful and relevant to the practice of many early childhood educators, music therapists, nurses and other professionals working with infants. Like Walker-Andrews & Bahrick (2001), I also believe that research should consider how the stimuli and task are related to the natural environment, to be ecologically valid and meaningful to other members of society. A second justification is the fact that this type of research would complement and validate the existing findings on infant perception of musical patterns.

Additionally, there are several questions that go beyond the scope of this study, which are worth investigating:

1. Is the segregation of simultaneous melodies facilitated by timbre? Do infants show enhanced segregation abilities when music is played in multiple and not single timbres?
2. What do infants attend to when listening to complex pieces of music? Do they hear the simultaneous musical features or do they focus on individual ones such as the melody or the underlying rhythm?
3. Can infants remember complex pieces of music for periods of longer than 2 weeks?
4. After they experience infantile amnesia, can children remember music (simple and complex) that they heard repeatedly during the first year of life?
5. To what extent do early musical experiences that took place during infancy shape adults' later musical preferences?
6. Do infants prefer complex over simple music?
7. Is the *model for infant long-term memory for musical experiences in the absence of remembering cues* accurate? If so, what shifts in the model when remembering cues are presented?
8. What are the cultural differences in maternal-infant music making?
9. Are there gender differences in parents' uses of music with infants across cultures?

Hopefully, research will shed light on these and other related questions in the near future. Answers to such questions would not only help us increase our understanding of how music is and can be used with infants, but also how infants make sense of the music that surrounds them.

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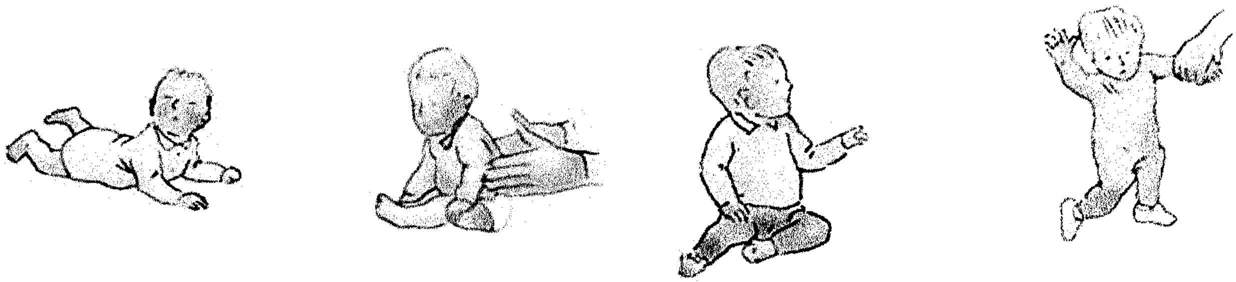
Appendices

Appendix A: Certificate of ethical acceptability for funded and non-funded research involving humans

Appendix B: Recruitment poster (English)



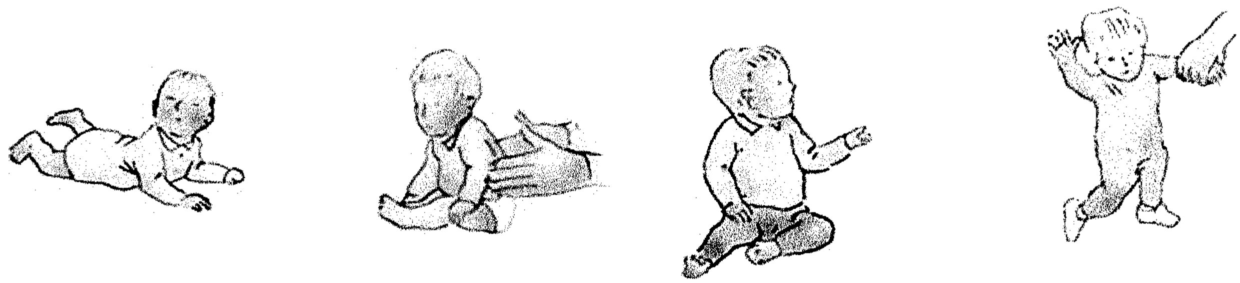
♫ BABIES' MEMORY FOR MUSIC ♫

We are currently searching for <u>6-8 month-old</u> babies without hearing problems to participate in a study on memory for music. If you choose to participate, you and your baby will receive a tape of recorded classical music to listen to for a few days in the comfort of your own home, and then you will both be asked to visit our lab once for an observation test. Want more details? Please contact:

Beatriz @ 845-4907 or by e-mail : <u>bilari@po-box.mcgill.ca</u>

♫ Testing will take place at the Speech Perception Lab. This research project is supervised by Dr. Linda Polka (School of Communication Sciences and Disorders) and Dr. Eugenia Costa-Giomi (Faculty of Music).

Appendix C: Recruitment poster (French)



La memoire musicale chez les enfants

Nous cherchons en ce moment des bébés âgés de 6-8 mois, sans problèmes d'audition pour participer à une étude sur la mémoire musicale. Si vous décidez d'y participer avec votre enfant, vous receverez une cassette avec de la musique classique que vous et votre enfant écouterez pendant quelques jours chez vous et, par la suite, on vous demandera de visiter notre laboratoire une seule fois pour un test d'observation. Pour plus de détails, contactez s.v.p.:

Debora - 5281475
ou par courriel:
bilari@po-box.mcgill.ca

♫ Le test aura lieu au laboratoire de l'École d'ortophonie de l'Université McGill. Ce projet de recherche est dirigé et supervisé par Dr. Linda Polka (ortophonie) et Dr. Eugenia Costa-Giomi (musique).

Appendix D: Recruitment ad published in newspaper "A voz de Portugal" (June 6th, 2001, page 6)

Universidade McGill

A memória musical dos bebés

A fim de participarem num estudo sobre a memória musical dos bebés, procuram-se mamãs com bebés de 7 a 9 meses que estejam interessadas nesta pesquisa.

Se aceitar participar receberá um CD de música clássica para ouvir com o seu bebé por alguns dias, no conforto da sua casa.

Depois de ouvir a música, será convidada a vir ao nosso laboratório com o seu bebé para um teste de observação e o seu bebé será presenteado como agradecimento pela sua participação.

Para mais informações, ligue para Beatriz pelo tel. 845-4907 ou por email: bilari@po-box.mcgill.ca.

Appendix E: Consent form for non-exposure participants (English)

Project title: **Infants' memory for music**
Main Researcher: **Beatriz Ilari**
McGill University - Faculty of Music
555 Sherbrooke Street West
Montréal, QC H3A 1E3

INFORMED CONSENT FORM

Previous studies have shown that 8-month-old babies can remember words from stories that they have heard a few times, up to 2 weeks after they have heard them. The purpose of this study is to investigate whether 8 month old babies can also remember parts of a piece of music that they have already heard.

You will come with your infant to the university lab for an observation session. During the session, your baby will be seated in the comfort of your lap facing the center panel of a 3-sided booth. From time to time a light will flash on either the right or the left side of the booth to direct your baby to look in that direction. When your baby turns and looks at the light, a short piece of music will be played. This process is completed once your child has heard 10 short pieces of music. Throughout the process you will be listening to music through earphones. This will prevent you from influencing your baby's responses. An observer located right behind the center panel of the booth will watch and record when your child looks left or right. The observer will also use a puppet to get your child to look ahead between trials. A video camera will film your infant during the process so that we can check the reliability of the observer. The pieces of music will be played at a safe and comfortable level. Should your baby become fussy or tired, we will stop the session. Also, we can take a break or terminate the session at any time, if you desire. This observation process usually takes approximately 15 minutes.

There are no known risks associated with participation in the study. You and your baby's participation in this study is entirely voluntary and you may withdraw from the study at any given time. All information collected during the study will be confidential and used for research purposes only. You and your baby will not be identified under any circumstances. This research is being supervised by Dr. Eugenia Costa-Giomi (McGill University – Music Education) and Dr. Linda Polka (McGill University – Speech Pathology). Should you have any questions at any time, please feel free to contact Beatriz Ilari at 845-4907.

This study has been explained to me and my questions have been answered to my satisfaction. I agree to participate in this study.

Date: ____________________________ Baby's name: _______________________

Parent's name: ____________________ Parent's Signature: ___________________

Appendix F: Consent form for non-exposure participants (French)

Titre du projet: La mémoire musicale chez les enfants
Chercheur principal: **Beatriz Ilari**
McGill University - Faculty of Music
555 Sherbrooke Street West
Montréal, QC H3A 1E3

RENSEIGNEMENTS

Il a été démontré par les études de psychologie que les enfants âgés de huit mois sont capables de se rappeler des mots appartenant à des histoires qu' ils ont entendues un certain nombre de fois jusqu'à deux semaines après les avoir entendues. La recherche qui fait l'objet de ce terme d'adhésion a pour but de vérifier si les petits enfants de huit mois sont capables aussi de se rappeler des parties d' une pièce de musique qu'ils ont entendue auparavant.

Vous recevrez quatre visites courtes du chercheur, qui vous posera quelques questions sur la routine journalière ou l' emploi du temps journalier de votre enfant, ainsi que sur vos préférences en matière de musique. À l' occasion de la première visite, vous recevrez un enrégistrement sur cassette de quelques morceaux de musique qu' on vous demandera de faire écouter à votre enfant pendant une période de dix jours. Avec la cassette, vous recevrez aussi un "journal", où vous serez prié(e) de prendre note de la date et du nombre de fois que votre enfant aura écouté l'enrégistrement, et de son humeur pendant l' auditon. Quand votre enfant aura écouté l'enrégistrement en question au moins une fois par jour pendant dix jours consécutifs, vous êtes prié de mettre de côté la cassette pour une période d'environ deux semaines.

Après ces deux semaines, vous viendrez avec votre enfant au laboratoire de l'université pour une séance d' observation. Pendant toute cette séance, votre enfant restera assis sur vos genoux, devant le panneau central d'une cabine à trois panneaux. De temps en temps, une lumière brillera soit du côté droit soit du côté gauche de la cabine pour amener votre enfant à regarder dans cette direction. Quand votre enfant se tournera et regardera la lumière, un court morceau de musique sera joué. Tout ce processus sera complet quand votre enfant aura entendu dix courts morceaux de musique. Tout au long du processus vous écouterez de la musique par des haut-parleurs à ouïe (cela pour éviter que vous influenciez les réponses de votre bébé). Um observateur placé derrière le panneau central de la cabine, juste au milieu, observera et notera quand votre enfant regarde à droite ou à gauche. Pour que votre enfant regarde devant lui entre deux essais, cet observateur pourra aussi attirer son attention au moyen d' un guignol. Une caméra de vidéo enrégistrera les séances pour que la fiabilité de l'observateur puisse être contrôlée. Les morceaux de musique seront joués à un volume approprié, afin d'assurer que l'expérience se déroulle dans_tout comfort et toute sécurité. Si votre enfant donne des signes d'agitation ou de fatigue, la séance sera interrompue. Nous pouvons aussi faire une pause ou terminer la séance_quand vous le voudrez. D' habitude le processus d'observation dure environ un quart d'heure.

La participation à cette étude n'entraîne aucun risque connu. Votre participation et la participation de votre enfant à cette étude est l' objet d'une décision entièrement libre, et vous pourrez quitter l' étude à n'importe quel moment. Toutes les informations qui puissent résulter de cette étude sont confidentielles_et ne seront utilisées qu'à des fins de recherche scientifique. Vous et votre enfant ne serez identifié(e) en aucune cinrconstance.

Si vous avez des questions, vous êtes prié(e) de vous adresser à **Beatriz Ilari au numéro 845-4907**. Le test aura lieu au laboratoire de l'École des Sciences des Communications et Troubles (School of Communication Sciences and Disorder) de l'Université McGill. Ce projet de recherche est dirigé et supervisé par Dr. Linda Poka (PhD) et Dr. Eugenia Costa-Giomi (PhD).

<u>ADHÉSION</u>

J' ai été renseigné sur cette étude et toutes mes questions ont fait l'objet de réponses satisfaisantes. **Je consens à y participer.**

Date: Montréal, le ____________ Nom de l'enfant: __________________

Nom du parent: _______________ Signature du Parent:________________

Appendix G: Consent form for exposure participants (English)

Project title: **Infants' memory for music**
Main Researcher: **Beatriz Ilari**
McGill University - Faculty of Music
555 Sherbrooke Street West
Montréal, QC H3A 1E3

INFORMED CONSENT FORM

Previous studies have shown that 8-months old babies can remember words from stories that they have heard a few times, up to 2 weeks after they have heard them. The purpose of this study is to investigate whether 8 month old babies can also remember parts of a piece of music that they have already heard.

You will receive 4-5 short visit from the researcher and will be asked a few questions related to your baby's daily routine and your musical interests. During the first visit you will receive a tape of recorded music that you will be playing for your baby for a period of 10 days. With this tape, you will get a "listening diary" in which you will write down the date and times when your baby listened to the tape, and his/her mood during the listening. After your baby has listened to the tape for 10 consecutive days, you will put the tape away for approximately two weeks.

After these two weeks, you will come with your infant to the university lab for an observation session. During the session, your baby will be seated in the comfort of your lap facing the center panel of a 3-sided booth. From time to time a light will flash on either the right or the left side of the booth to direct your baby to look in that direction. When your baby turns and looks at the light, a short piece of music will be played. This process is completed once your child has heard 10 short pieces of music. Throughout the process you will be listening to music through earphones. This will prevent you from influencing your baby's responses. An observer located right behind the center panel of the booth will watch and record when your child looks left or right. The observer will also use a puppet to get your child to look ahead between trials. A video camera will film your infant during the process so that we can check the reliability of the observer. The pieces of music will be played at a safe and comfortable level. Should your baby become fussy or tired, we will stop the session. Also, we can take a break or terminate the session at any time, if you desire. This observation process usually takes approximately 15 minutes. There are no known risks associated with participation in the study. You and your baby's participation in this study is entirely voluntary and you may withdraw from the study at any given time. All information collected during the study will be confidential, used only for research purposes. You and your baby will not be identified under any circumstances. This research is being supervised by Dr. Eugenia Costa-Giomi (McGill University – Music Education) and Dr. Linda Polka (McGill University – Speech Pathology). Should you have any questions at any time, please feel free to contact **Beatriz Ilari at 845-4907.**

This study has been explained to me and my questions have been answered to my satisfaction. I agree to participate in this study.

Date: ___________________________ Baby's name: _____________________

Parent's name: ___________________ Parent's Signature: _________________

Appendix H: Consent form for exposure participants (French)

Titre du projet: La mémoire musicale chez les enfants
Chercheur principal: **Beatriz Ilari**
McGill University - Faculty of Music
555 Sherbrooke Street West
Montréal, QC H3A 1E3

RENSEIGNEMENTS

Il a été démontré par les études de psychologie que les enfants âgés de huit mois sont capables de se rappeler des mots appartenant à des histoires qu' ils ont entendues un certain nombre de fois jusqu'à deux semaines après les avoir entendues. La recherche qui fait l'objet de ce terme d'adhésion a pour but de vérifier si les petits enfants de huit mois sont capables aussi de se rappeler des parties d' une pièce de musique qu'ils ont entendue auparavant.

Vous recevrez quatre visites courtes du chercheur, qui vous posera quelques questions sur la routine journalière ou l' emploi du temps journalier de votre enfant, ainsi que sur vos préférences en matière de musique. À l' occasion de la première visite, vous recevrez un enrégistrement sur cassette de quelques morceaux de musique qu' on vous demandera de faire écouter à votre enfant pendant une période de dix jours. Avec la cassette, vous recevrez aussi un "journal", où vous serez prié(e) de prendre note de la date et du nombre de fois que votre enfant aura écouté l'enrégistrement, et de son humeur pendant l' auditon. Quand votre enfant aura écouté l'enrégistrement en question au moins une fois par jour pendant dix jours consécutifs, vous êtes prié de mettre de côté la cassette pour une période d'environ deux semaines.

Après ces deux semaines, vous viendrez avec votre enfant au laboratoire de l'université pour une séance d' observation. Pendant toute cette séance, votre enfant restera assis sur vos genoux, devant le panneau central d'une cabine à trois panneaux. De temps en temps, une lumière brillera soit du côté droit soit du côté gauche de la cabine pour amener votre enfant à regarder dans cette direction. Quand votre enfant se tournera et regardera la lumière, un court morceau de musique sera joué. Tout ce processus sera complet quand votre enfant aura entendu dix courts morceaux de musique. Tout au long du processus vous écouterez de la musique par des haut-parleurs à ouïe (cela pour éviter que vous influenciez les réponses de votre bébé). Um observateur placé derrière le panneau central de la cabine, juste au milieu, observera et notera quand votre enfant regarde à droite ou à gauche. Pour que votre enfant regarde devant lui entre deux essais, cet observateur pourra aussi attirer son attention au moyen d' un guignol. Une caméra de vidéo enrégistrera les séances pour que la fiabilité de l'observateur puisse être contrôlée. Les morceaux de musique seront joués à un volume approprié, afin d'assurer que l'expérience se déroulle dans_tout comfort et toute sécurité. Si votre enfant donne des signes d'agitation ou de fatigue, la séance sera interrompue. Nous pouvons aussi faire une pause ou terminer la séance_quand vous le voudrez. D' habitude le processus d'observation dure environ un quart d'heure.

La participation à cette étude n'entraîne aucun risque connu. Votre participation et la participation de votre enfant à cette étude est l' objet d'une décision entièrement libre, et vous pourrez quitter l' étude à n'importe quel moment. Toutes les informations qui puissent résulter de cette étude sont confidentielles_et ne seront utilisées qu'à des fins de recherche scientifique. Vous et votre enfant ne serez identifié(e) en aucune cinrconstance.

Si vous avez des questions, vous êtes prié(e) de vous adresser à **Beatriz Ilari au numéro 845-4907**. Le test aura lieu au laboratoire de l'École des Sciences des Communications et Troubles (School of Communication Sciences and Disorder) de l'Université McGill. Ce projet de recherche est dirigé et supervisé par Dr. Linda Poka (PhD) et Dr. Eugenia Costa-Giomi (PhD).

<u>ADHÉSION</u>

J' ai été renseigné sur cette étude et toutes mes questions ont fait l'objet de réponses satisfaisantes. **Je consens à y participer.**

Date: Montréal, le ____________ Nom de l'enfant: ________________

Nom du parent: ______________ Signature du Parent:________________

Appendix I: Maternal interview questions (English)

Infants' Memory for Music – Interview questions

DEMOGRAPHIC INFORMATION
Mother
Age:
Nationality:
Profession:

Infant
Date of birth:
Has your baby been diagnosed with any hearing impairments? N Y (Explain)

Is this your first child? N Y
If not, how many children do you have and how old are they now?

MUSICAL BACKGROUND

Do you play or have you played a musical instrument? Y N
If yes, which one?
For how long?

Is anyone in your family a musician?
Who?

Have you ever participated in a musical group? Y N
If yes, when and what type of group?

As an average, how much listening/playing do you normally do in a week?

Less than 1 hour 1-3 hours 4-6 hours 7 hours or more

What types of music do you listen to? List at least two. (If you do not know the style but know the composer/singer, the name is welcome as well.)

Which one of these activities have you done during the last week? For how long?

Activity	Less than 1 hour	1-3 hours	4-6 hours	7 hours or more
Listen to the radio				
Watch TV				
Listen to a CD/tape				
Other musical activities				

YOU AND YOUR BABY

How much time do you spend with your baby on a daily basis?

Is there someone else who takes care of your baby? Y N
Who?

BABIES AND MEMORY

Can you describe any special moment in which you were surprised with your baby's memory?

BABIES AND MUSIC

Do you play music for your baby? Y N

If yes, what type of music and when?

Do you or someone else in your family sing to your baby? Y
N
If yes, what songs do you/they sing? (If you don't remember, feel free to sing it).

Do you think there is such a thing as appropriate "music for babies"? Y N
Why?

If you answered yes, what type of music would be appropriate for a baby to listen to?
(You can name songs or simply describe them).

When do you find appropriate for a baby to listen to music? (Check all that apply)
When the baby is…
Quiet and alert
Fussy
Crying
Sleepy
Other:

Appendix J: Maternal interview questions (French)

La mémoire musicale chez les enfants

INFORMATIONS DÉMOGRAPHIQUES
Mère
Âge:
Profession:

Enfant
Date de naissance:
Votre bébé a-t-il eu un diagnostique indiquant une déficience au niveau de l'audition?
N O (expliquer)
Est-ce qu'il s'agit de votre premier enfant? N O
Si la réponse est non, combien d'enfants en avez vous et quel est leur âge?

EXPÉRIENCE MUSICALE
Jouez-vous ou avez vous un instrument musical? O N
Si oui, lequel?
Depuis combien de temps?

Avez-vous un musiciein dans votre famille?
Qui?

Avez-vous déjà participé à un groupe musical? O N
Si oui, quand? Quel type de groupe?

Por une estimation, comvien de temps vous écoutez/jouez de la musique pendant la semaine?

Moins d'une heure 1-3 heures 4-6 heures 7 heures et plus

Quel types de musique écoutez-vous? Citez au moins deux. (Si vous ne savez pas comment nommer le style, vouz puvez écrire le nom du chanteur ou du compositeur.)

Parmi les activités ci-dessous, laquelle avez-vous pratiqué pendant la semaine passé? Pendant combien de temps?

Activité	Moins d'une heure	1-3 heures	4-6 heures	7 heures et plus
Écouter la radio				
Regarder la télé				
Écouter un DC/cassete				
Autres activités musicales				

VOUS ET VOTRE BEBÉ

Combien de temps passez-vous avec votre bébé dans une journée?

Est-ce qu'il y a une autre personne qui s'occupe de votre bébé? O N
Qui?

BÉBÉS ET MÉMOIRE

Pouvez-vous décrire un moment particulier où vous avez été supreis(e) par la mémoire de votre bébé?

BÉBÉS ET MUSIQUE

Jouez-vous de la musique pour votre bébé? O N

Si oui, quelle sorte de musique? Quand?

Est-ce que vous ou quelqu'un d'autre dans votre famille chante pour votre bébé?

O N

Si oui, quelles chansons vous chantez (Ou ils chantentent)? (Si vous ne vous rappellez pas du nom de la chanson, vous pouvez la chanter).

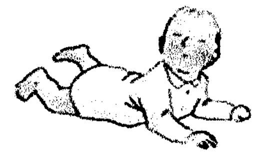
Pensez-vous qu'il existe une "musique pour bébés"? O N
Pourquoi?

Si vous avez répondu oui, quel type de musique serait appropriée pour qu'un bébé l'ecoute? (Vous pouvez citer ds titres de chansons ou les décrire tout simplement).

Quel moment considérez-vous comme approprié pour que le bébé écoute de la musique? (Cochez toutes les options qui s'appliquent). Quand le bébé est...

quiet et atentif
agité
en train de pleurer
somnolent
autre:______________

Appendix K: Listening diary (English)



BABY DAILY LISTENING DIARY

Please fill out the diary every day. There is an example to help you. Should you have doubts, don't hesitate to contact us. Also, in case you decide to have your baby listen to the music more than one time each day, kindly add this information to the "comments" section.

Enjoy the music and thank you!

Example

Today's date	**Tuesday, February 6th.**
Time	**11:30 AM and 14:45**
Heard the entire piece of music?	**Yes**
Accompanied by…	**Mom + Tom (Brother)**
Baby's mood	**Alert and quiet**
Activities done while listening to the music	**Rocking, playing with puppets, dancing, tapping on the baby's body**
Comments	**When the music started she became more agitated. I rocked her and then we played with finger puppets. We heard the entire tape again in the afternoon before her afternoon nap, when Tom joined us. The three of us danced to the music and then Tom helped me tap the rhythm on her body, which made her babble and laugh.**

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

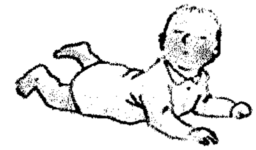
Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Today's date	
Time	
Heard the entire piece of music?	
Accompanied by…	
Baby's mood	
Activities done while listening to the music	
Comments	

Appendix L: Listening diary (French)



JOURNAL QUOTIDIEN DE L'ÉCOUTE MUSICALE DU BÉBÉ

S.V.P. remplissez le journal à chaque jour. Il y a un exemple pour vous aider. Si vous avez des questions, n' hesitez pas à nous contacter (Débora: 528-1475). Si vous décidez de faire votre bébé écouter la cassette plus d'une fois par jour, ajoutez cette information dans la section des commentaires.

Bonne musique et merci!

Exemple

Date	**Mardi, le 6 février.**
Horaire	**11:30 AM (2 fois) / 4:30 PM (2 fois)**
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	**Oui**
Activité pendant l'écoute	**Bercer, balancer, jouer avec une poupée et donner des petits coups doucement sur son ventre.**
Accompagné par…	**Mamam + Thierry (frère)**
Humeur du bébé	**Attentif et quiet**
Commentaires	**Quand la musique a commencée, elle a commencé à bavarder, devenant plus agitée. Nous avons écouté la cassette entière à nouveau en après midi, avant le sommeil de l'après-midi.**

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par...	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par...	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Date	
Horaire	
Le bébé a-t-il écouté la musique 4 fois aujourd'hui?	
Activité pendant l'écoute	
Accompagné par…	
Humeur du bébé	
Commentaires	

Appendix M: Infant certificate (English)

Infant Scientist Degree

This is to certify that

Raphinha

has participated in research at

McGill University

and has received
the honorary degree of Infant Scientist

Signed ______________________ Date ______________

Appendix N: Infant certificate (French)

Certificat Scientifique Pour Enfant

Ceci certifie que

Tom Jobim

a participé dans un projet de recherche à

l'Université de McGill

et a reçu ce certificat honoraire

Signature ____________________ *Date* ____________

Appendix O: Feedback letter to parents (English)

Montreal, May 15th, 2002.

Dear parents and friends,

We are very pleased to announce that the study "Infants' memory for music" is now complete. At this time we would like to share some results with you.

Our goal with this study was to learn about babies' long-term memory for music. We knew from previous studies that 8-month-old babies are able to remember simple music for two-weeks. Yet, we were not sure whether this would happen with music that is considered very difficult and highly intellectualized. By comparing the responses of a group of babies who heard the piano piece at home with a second group who did not listen to it, we learned that 8-month-old babies can remember complex pieces of music for at least two weeks. While babies who had never heard the piece before did not show any listening preferences, those babies who heard the piece at home listened longer to it than to an unfamiliar piano piece.

It is likely that we will publish this study in a scientific journal. If that occurs and you would like to receive a copy of the paper, kindly let us know. Results from this study will be presented at the following scientific meetings:

143rd Meeting of the Acoustical Society of America – June 2002: Pittsburgh, PN (USA).
25th Meeting of the International Society for Music Education – August, 2002: Bergen, Norway.

On the behalf of all the researchers and staff involved in this study, we would like to take this opportunity to thank you for your participation. You and the other 109 families who participated in this study have helped us learn more about the ways in which babies make sense of the music that surrounds them. We could not have done it without your help.

Do not hesitate to contact us should you have any questions.
Best wishes to you and your family,

Beatriz Ilari – PhD candidate
Dr. Linda Polka (Speech Perception) & Dr. Eugenia Costa-Giomi (Music Education)

McGill Speech Perception Lab
Tel (514) – 398-1210 E-mail: spedvlab@hotmail.com

Appendix P: Feedback letter to parents (French)

Montréal, le 15 Mai 2002.

Chers parents et amis,

Nous sommes fiers de vous annoncer que notre étude, "La mémoire musicale chez les nourissons", est terminée. Nous aimerions profiter de cette opportunité pour partager avec vous certains resultats.

L'objectif de cette étude était d'apprendre plus au sujet de la mémoire musicale à longue durée chez les nourissons. Nous savions déjà, à partir d'études précédentes, que les bébés âgés de 8 mois étaient capables de retenir un morceau de musique simple durant deux semaines. Mais, nous n'étions pas certains d'obtenir le même résultat avec un morceau de musique qui est consideré tres difficile et intellectuel. En faisant la comparaison des résultats de deux groupes de bébés, un groupe dont les enfants avaient entendu à la maison le morceau que nous avons choisi, et l'autre dont le morceau ne leur était pas familier, nous avons trouvé que les bébés de 8 mois sont capables de retenir un morceau de musique de haute complexité durant au moins deux semaines. Ceci se déduit car les bébés! qui n'avaient jamais entendu le morceau auparavant ne montraient aucune préférence pour celui-ci, mais ceux qui avaient entendu le morceau à la maison le préférait à un morceau inconnu.

Il est fort possible que nous allons publier nos résultats dans un journal scientifique. Si ceci se produit, et si vous aimeriez recevoir une copie de l'article, s'il-vous-plait contactez nous. Les résultats seront aussi présentés durant les conferences scientifiques suivantes:

-143eme rendez-vous de la Société Acoustique de l'Amerique – Juin 2002, Pittsburgh, PA, USA.

-25eme rendez-vous de la Société Internationale pour l'Education Musicale – Août 2002, Bergen, Norvège.

De la part de tous les chercheurs et du personnel impliqués dans cette étude, nous aimerons vous remercier de la participation de vous et de votre enfant. Les 110 familles qui ont accepté de faire partie de cette étude nous ont énormément aidé à mieux comprendre la façon dont les nourissons perçoivent la musique qui leur entoure. Nous n'aurions pas pu le faire sans vous!

Nous vous prions, à vous et à votre famille, d'accepter nos salutations les plus distinguées. Si vous avez des questions, n'hesitez pas à nous contacter aux coordonées ci-dessus.

Sincèrement,

Beatriz Ilari – Candidat au Ph.D.

Dre. Linda Polka (Perception de la Parole) & Dre. Eugenia Costa-Giomi (Education Musicale)

Laboratoire de la Perception de la Parole –

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Appendix Q: Newspaper article published in São Paulo, Brazil (online version)

15/06/2002 - 06h27

Bebês reconhecem músicas complexas

CLAUDIO ANGELO
Editor-assistente de Ciência da **Folha de S.Paulo**

Esqueça o "nana nenê". Um estudo realizado no Canadá por uma pesquisadora brasileira mostra que bebês conseguem assimilar músicas complexas e se lembrar delas semanas depois.

O trabalho foi apresentado no último dia 6 no encontro da Sociedade Acústica Americana, em Pittsburgh (EUA) pela musicista Beatriz Ilari, da Universidade McGill. Ele ajuda a abaixar o tom da noção comum de que crianças são mal equipadas para lidar com complexidade musical e que, portanto, devem ouvir melodias simples nos primeiros meses de vida.

"Nunca acreditei nisso como professora", diz Ilari, 30, que está concluindo o doutorado na Faculdade de Música de McGill.

Segundo a brasileira, a idéia de que bebês só assimilam músicas mais simples vem das canções de ninar e foi difundida por pediatras e educadores do mundo inteiro em meados da década de 90, após a publicação de um estudo nos EUA que dizia que ouvir Mozart tornava os bebês crianças mais inteligentes depois.

"O problema é que o experimento que revelou o 'efeito Mozart' nunca foi replicado."

Ravel
Para investigar se as crianças eram capazes de se lembrar de música complexa, a equipe de Ilari expôs dois grupos de bebês de oito

meses de idade a um prelúdio ou a uma forlana (uma dança) da obra "Le Tombeau de Couperin", de Maurice Ravel (1875-1937), compositor impressionista francês famoso por seu "Bolero".

A peça é considerada complicada em relação a obras de Mozart (1756-1791) e Bach (1685-1750). "As composições antigas seguiam regras mais rígidas", afirma Ilari. "No século 20, a forma de combinar notas mudou. A música passou a conter mais informação".

Os 30 bebês testados no experimento ouviam o prelúdio ou a forlana de Ravel três vezes ao dia durante dez dias.

No final do período, as crianças foram levadas para o laboratório da universidade, onde os pesquisadores as submeteram a um teste que media o seu interesse por determinadas músicas.

Durante o teste, a criança tinha a atenção despertada por uma luz piscando numa parede. Após alguns segundos a luz apagava e uma música passava a tocar num alto-falante escondido até que o bebê virasse a cabeça em outra direção, sinal de perda de interesse.

"Nossos resultados indicam que essas crianças mostraram preferência pela peça de piano que ouviram", afirmam as pesquisadoras no artigo.

Bebês que haviam ouvido o prelúdio em casa prestavam mais atenção nele do que na forlana e vice-versa. Um grupo de crianças que não tinha ouvido nenhuma das duas músicas previamente não prestou atenção a elas.

Após duas semanas, período no qual os bebês não voltaram a ouvir as músicas, o teste foi repetido, com o mesmo resultado.

Os resultados obtidos no final dos testes foram, então, comparados a dados de estudos anteriores que usaram o mesmo procedimento para avaliar a capacidade de bebês de reconhecer fala humana, por meio de histórias, e músicas de Mozart.

A assimilação é medida por um índice, que relaciona o tempo que os bebês passaram prestando atenção aos sons.

Nos dois casos (voz e Mozart) o índice de retenção de memória foi em média quatro vezes maior. A retenção das peças de Ravel foi considerada média. "Ainda assim, os bebês foram capazes de aprender com música simples e complexa", disse a brasileira.

Uma série de estudos nos últimos anos tem demonstrado que os bebês têm um ouvido de fazer inveja a qualquer músico. "Eles reconhecem a voz da mãe aos três dias de vida e, aos seis meses, começam a diferenciar a língua materna de outras", disse Ilari.

Educação
O novo estudo ajuda a ampliar os superpoderes auditivos infantis conhecidos, embora os pesquisadores ainda não saibam como isso se relaciona ao desenvolvimento do cérebro.

No entanto, acima de tudo, Ilari acredita que possa influenciar na educação musical das crianças - ajudando a descobrir, por exemplo, se existe um tipo de música adequado para elas.

"Os pais não precisam ficar nessa euforia de tocar o que não gostam por causa da criança. Eles podem tocar qualquer coisa - desde que o bebê não chore."

Appendix R: CNN Story aired on June 29th, 2002 and available online

AIRS: Saturdays 1 p.m. ET / Sundays 4 p.m. ET

COOL SCIENCE

Can infants un-Ravel classical music?

June 27, 2002 Posted: 3:02 PM EDT (1902 GMT)

By Marsha Walton
CNN Sci-Tech

(CNN) -- Looking for music to soothe and stimulate your infant? Then you might want to look beyond lullabies and nursery rhymes.

Canadian researchers say babies can remember complex classical music, even after a two week delay. Their findings were detailed at a recent meeting of the Acoustical Society of America.

"We have this idea that babies are maybe poor listeners, but in fact, they're not," said Beatriz Ilari of McGill University in Toronto.

For her study, Ilari, a violinist, music teacher and doctoral candidate, chose the "Prelude" and "Forlane" from "Le Tombeau de Couperin" by Maurice Ravel.

"First, because it's unusual," said Ilari. "It is a beautiful piece of music, also a piece that, for people who are trained in classical music, we know it's considered very complex," she said.

Researchers gave a Ravel CD to parents, either the "Prelude" or "Forlane." Parents were told to play that piece to their seven- to eight-month-old infants three times a day, for 10 days. The CDs were then collected. After two weeks of not hearing that music, babies were tested at a McGill laboratory.

The test consisted of listening to 20-second excerpts of music, eight from the familiar piece mixed with eight from the unfamiliar one. During testing, the baby was seated comfortably on a parent's lap in a three-wall pegboard booth.

A red light was mounted on each side of the booth, to the left and right of the baby. One light would blink to attract the baby's attention. Once the baby looked at the light, a musical excerpt would come on through a loudspeaker hidden behind the light.

The excerpt would keep playing until the baby turned its head away, in another direction. Listening times were recorded for each excerpt and added up for each piece.

The researchers found that babies listened 20-30 percent longer to the music piece they had heard at home, compared to an unfamiliar piece.

Ilari says she knows the babies learned, because the same tests on a control group of infants who hadn't heard either piece of music showed those babies had no preference for either music selection.

One reason for the study, said the McGill scientists, is the constant questioning by parents about what music is appropriate for infants and children.

"There's this frenzy that the parents want their babies to be so smart," said Ilari.

But there's a lot more to music appreciation than just trying to expose a baby to the most complicated pieces with hopes of creating a musical prodigy.

Parents are usually the first music educators a child has, and the bonding experience of listening together is at least as important as the type of music they choose. Whether it's Tchaikovsky or "Twinkle Twinkle Little Star," when parents enjoy something and they play it for their children, they make it more pleasant for the children, said Ilari.

She says she and her colleagues learned a lot more from the study than just the amount of time the babies spent listening to the classical selections.

"We had a lot of parents, many unfamiliar with classical music, say that they really liked Ravel," said Ilari. "They asked to keep it after the study, because it was helpful in putting their baby to sleep, or calming the baby at feeding time," she said.

Some parents who introduced music to their kids at very early ages say there are a wide range of benefits. Victor and Adele Ronchetti's ten year old son Victor picked up a violin at age four and hasn't put it down. He's now in a young artists program at the Juilliard School in New York.

"Listening to music is great," said Adele Ronchetti. "I think playing an instrument is terrific. It keeps you away from the television set. You never hear about anybody who plays the violin building a bomb in their basement. I mean, I think it keeps you on the right track socially, it builds your self esteem. I think it's good for so many things," she said.

http://www.cnn.com/2002/TECH/science/06/27/coolsc.babymusic/index.html

Appendix S: Survey of musical resources for infants

Sixty baby-directed music resources were consulted. Among them there were 4 videos, 12 toys and 44 CDs. Table S shows the repertoire found in each one of them.

Table S – Repertoire found in 60 baby-related music resources

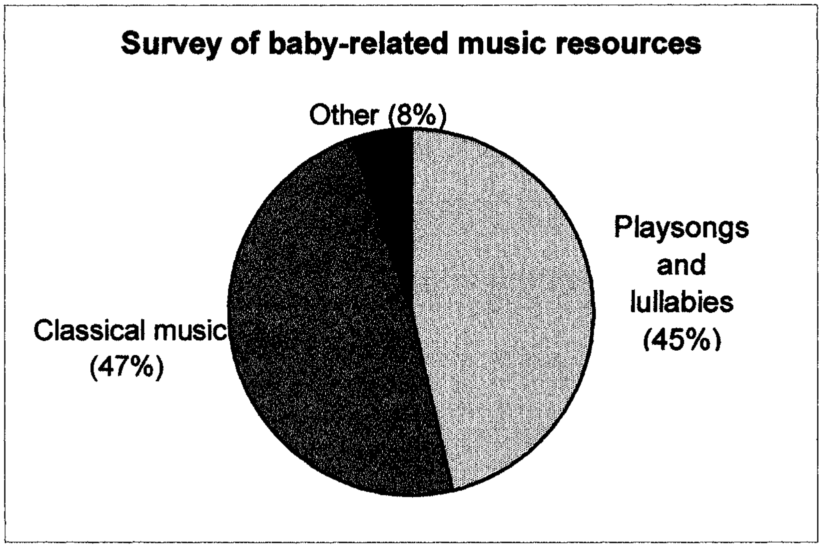
Title	Format	Musical Content
Adventures in classics – Sleepytime strings (Mommy & me, 2000)	CD	Slow string pieces of classical and romantic composers.
Atmospheres: Baby's first bedtime classics (St Clair, 2000)	CD	Traditional folk and classical lullabies.
Baby Bach (Baby Einstein Company, 2000)	Videotape or CD	Scales, sound effects and music by Bach.
Baby Bach Touch-and-play pipes (Baby Einstein Company, 2001)	Toy	Simple music by Bach.
Baby Beluga – Raffi (Rounder, 1996)	CD	Children's songs.
Baby by the Sea (Sleep lullabies, 2001)	CD	Instrumental lullabies blended with ocean sounds.
Baby Genius (ITM Classics, 1999)	CD	Mainly pieces of baroque and classical. Two slow pieces by romantic composers.
Baby loves classics (Brentwood Records, 2000)	CD	Soothing folk and classic lullabies.
Baby Mozart (Baby Einstein Company, 2000)	Videotape or CD	Scales, sound effects and music by Mozart.
Baby Mozart Moving Melodies (Baby Einstein Company, 2001)	Toy	Mozart music.
Baby Music School – Classic (The Baby School Company, 2002)	Videotape	Short and simple *a capella* pieces of baroque, classical and romantic composers.
Baby's first playtime songs (St Clair, 1999)	CD	Traditional playsongs in English language.
Bedtime with the Beatles: Instrumental versions of classic Beatles songs – A lullaby album (Sony, 2000)	CD	Beatles hits slowed down and transformed into lullabies.
Berceuses du Monde Entier (Le chant du monde, 1995)	CD	French, Yiddish, Russian, Celtic and Creole Lullabies.
Berceuse: Music for peace and calm (Naxos, 1999)	CD	Lullabies of classical, romantic and 20^{th} Century composers
Brazilian lullaby (Ellipsis Arts, 1999)	CD	Brazilian lullabies.
Build your baby's brain through the power of music – vol.1 (Sony, 1998)	CD	World's favorite classics – Primarily Bach & Mozart.

Candy classics – sing along (Peter Pan, 2000)	CD	Pop songs containing the word "baby" intended for toddlers and children to sing along.
Classical music for babies – Classics played on a music box (Fine Tune, 2000)	CD	Baroque, classical and excerpts of Tchaikovsky's Nutcracker played on a music box.
Classic for kids: Brain power and babies (Platinum, 1999)	CD	Baroque, classical and Nutcracker excerpts.
Dragon Tunes (Kid Rhino, 2001)	CD	Children's songs
For the new arrival (Happy baby, 1995)	CD	Popular lullabies combined with artificial womb sounds.
Guitar Lullaby (Ellipsis, 2000)	CD	Guitar pieces of contemporary Latin American composers.
Infant twirling tunes CD player (Playskool, no date available)	Toy	Sixteen traditional children's songs.
Koala baby musical mobile (Kidsline, 2001)	Toy	Brahms' lullaby.
Kindermusik CD (Kindermusik, 2001)	CD	Simple children's songs.
Le chant des enfants du monde vol.3 – Lullabies (Arion, 1994)	CD	World lullabies.
Les berceuses du monde entier(Gallimard, 1999)	CD	World lullabies *a capella* and accompanied.
Listen, Learn & Grow: Lullabies (Naxos, 2000)	CD	Lullabies of baroque, classical and romantic composers.
Listen, Learn and Grow – Newborn through preschool (Naxos, 1999)	CD	Orchestral and piano pieces, mainly from the baroque and classical periods.
Lullabies (Benson, 1997)	CD	Folk and classical lullabies.
Lullaby favorites (Music for little people, 1997)	CD	Well-known lullabies in English such as Rock a bye baby and Hush.
Lullabies for little dreamers (Rhino Records, 1996)	CD	Slow pop songs of the 1970s. Lyrics always include the words baby and sleep.
Magic Time (Peter Pan, 2002)	CD	Popular English lullabies.
Mama's lullaby (Ellipsis Arts, 2001)	CD	World lullabies.
Martha Stewart Baby: Sleepytime (Rhino Records, 2001)	CD	Slow pop songs of our times.
Mediterranean Lullaby (Ellipsis, 2000)	CD	Lullabies of Mediterranean countries.
Melody beats piano (Little tikes, 2000)	Toy	Six children's songs.
Mellow my baby (Sugar Beats, 2002)	CD	Slow, soothing songs and lullabies.
Mozart for baby (Happy baby, 1999)	CD	Pieces by Mozart.
Mozart's lullaby (Malaco, 2000)	CD	Slow pieces by Mozart.
Mozart's magic cube (Embryonics, 2001)	Toy	Selections by Mozart.
Mozart magic orchestra with Wolfgang (Munchkin, 2000)	Toy	Music by Mozart.
Mozart for mothers to be (Phillips, 1996)	CD	Andantes and adagios by Mozart.

Music blocks Mozart set (Neurosmith, no available date)	Toy	Music by Mozart.
Musical mobile- Little Suzy's zoo (Dolly, 2001)	Toy	Brahms' lullaby.
*Odile & Balivon (*BMG Canada, 1998)	CD	Children's songs in French.
Parents: The lullaby album (EMI, 1993)	CD	Lullabies of classical and romantic composers.
Photo Frame - Silverplated Cube Baby Frame & Music Box *(*Godinger Silver Art, *2001)*	Toy	Theme and variations on Twinklt twinkle little stars.
*Sesame Street Music Works (*Sesame Workshop, *2001)*	Videotape	Simple children's songs from Sesame street.
Smart Symphonies (Grammy Foundation, 2000)	CD	A mixed sampler containing music from all periods and styles.
Songs of Innocence (Virgin, 1999)	CD	Complex contemporary compositions mixing world music and children's voices.
Sunshine symphony (Neurosmith, 2001)	Toy	Selection of Bach, Brahms, Mozart & Tchaikovsky.
Sweet Dreams (Madacy Kids, 2001)	CD	Traditional American lullabies mixed with lullabies of classical composers.
*Symphony animal mobile (*Tiny Love, 2001)	Toy	Selections by Bach, Mozart & Beethoven.
The baby symphony (Madacy, 1999)	CD	Instrumental lullabies and slow songs.
The Mozart effect – music for babies (The children's group, 1998)	CD	Music by Mozart.
The planet sleeps (Sony, 1996)	CD	World lullabies
The world sings goodnight, vl. 1 and 2 (Silverware Records, 1993/1996)	2 CDs	66 world lullabies
Up all night (Baby Genius Products, 1999)	CD	New age music for babies.

The analysis of repertoire found in these resources is depicted on chart S.

Chart S: ***Survey of 60 baby-related music resources – three categories***



Charts S1, S2 and S3 depict musical styles within each category.

Chart S1: ***Lullabies and play songs (27 resources)***

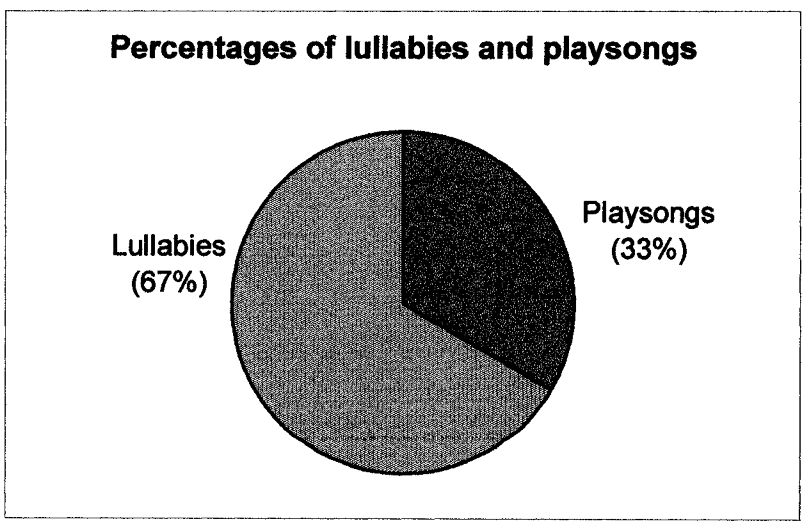


Chart S2: ***Classical music CDs for babies (28 resources)***

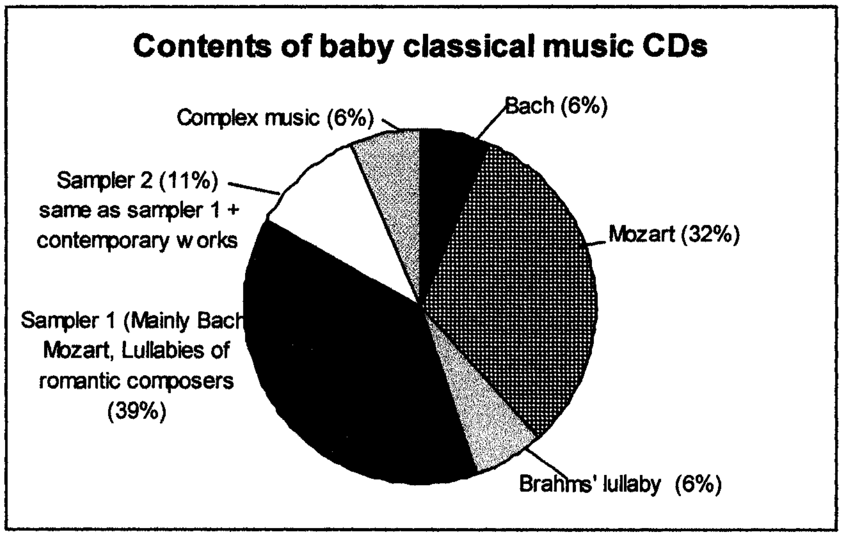


Chart S3: ***Styles within category "other" (5 resources)***