Research Review

Fetal Responses to Music

Reviewed by Julia Priest, M.S., M.Mus.

Parents often ask music and movement teachers whether class is beneficial for their newborns and young infants. Some parents express their plan to wait "until s/he can really get something out of it." What can we tell them to support our intuitive conviction that their children should come to class early and often?

This article reports on three current studies that should help early childhood music and movement specialists speak with evidence-based clarity about the music perception and learning abilities of fetuses, newborns, and, by extension, young infants. For the sake of simplicity, we will honor the scientific convention of calling a human being before birth a *fetus*, reserving the terms *infant* and *baby* for the neo-natal period. The studies described in this article were designed to be more convincing than some of their predecessors by virtue of being prospective (the researchers carried out the experiment on people instead of asking people to reconstruct and narrate past events from memory), randomized (substantially similar subjects were randomly assigned to the control or experimental groups, or else a single subject experienced the control stimulus and the research stimulus in random order), and double-blind (there was a sham stimulus; also, the statisticians did not know which data they were analyzing).

Study 1

Al-Qahtani, N. H (2005). Foetal response to voice and music. *Australian and New Zealand Journal of Obstetrics and Gynecology,* 45, 414-417.

The womb is relatively quiet, so the mother's voice and other nearby sounds emerge clearly from the background noise of maternal digestion, heartbeat, and so on. Dr. Al-Qahtani reminds us that scientists were observing fetal response to external sounds as early as the 1920's. However, measuring the responses is always confounded by the fact that fetuses move unpredictably and even their heart rates vary unpredictably. Statisticians have developed a panoply of arithmetical tests to separate out spontaneous variations in the data from variations that are likely to be in response to the research stimuli.

Ten women, whose pregnancies were 37 to 40 weeks advanced, participated in the study. Dr. Al-Qahtani played both instrumental music and vocal sounds for each fetus. For the instrumental example, she chose Spanish guitar music because it comprised a wide range of frequencies and dynamics. The vocal stimulus was a female voice reciting nursery rhymes. A tape recorder playing silence provided the sham stimulus.

As a baseline, each fetus was observed and measured for 10 minutes while in the quietest state of sleep, as evidenced by still eyes and body and a characteristic heart rate pattern. Then a single earphone, placed against the mother's belly, played a 15-second stimulus which was randomly chosen: music, voice, or silence. Nine such stimuli (three music, three voice, and three silence) were played in random order, with 3.5-minute silent intervals between every stimulus.

When all the data were collected and analyzed, it turned out that fetal movements and heart rates during the sham noises did not differ significantly from the random fetal events

Julia Priest

Julia Priest is director and teacher of Music & Movement of Newton, a music program offering Music Together® classes for children birth to Kindergarten. She has been a singer and teacher since 1987 and holds certifications in Music Together® and Orff-Schulwerk.

during baseline or silent times. However, during both spoken voice and guitar music, fetal heart rates accelerated, on average, to a degree that would be very hard to explain by chance. There were no measurable differences between responses to music and responses to speech.

One potential problem with this study was that, to avoid causing maternal anxiety, the mothers did not have earplugs nor did they listen to alternate music. We know that fetuses do react to their mothers' emotions; so, in this case, it is possible that the mothers somehow transmitted information about each stimulus from their nervous system to their fetuses.

Interestingly, Dr. Qahtani reports that similar studies have found decelerations instead of accelerations of heart rate. She posits that different kinds of musical stimuli may explain contradictory findings. For scientists, studying music can be mysterious because it is such a complex stimulus. It can vary, as we know, by pitch, volume, duration, timbre, tempo, and so many other dimensions. For musicians and music teachers, the same mystery presents a world of opportunity—to soothe people or to energize them, or to communicate subtle and deep emotions. Fetuses show incipient responses to the complexity of music. They are so attuned to vocal quality and other characteristics of speech that they can discriminate, *in utero,* between a stranger's voice and that of their own mother. If fetuses are so sensitive to timbre, then how much more so must newborn babies be?

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Two weeks before my son's due date, I was hired to sing for a temple for the Jewish High Holidays. [I was] a little tentative about accepting a job so close to the due date. Each time I sat down between songs, my son would wriggle in my belly. However, when I stood to sing, he would calm right down, almost as if he were listening and didn't want to distract me. Since then, I sing lullabies to him each night to soothe him to sleep. *—Diane Plaster, Los Angeles, CA*

Study 2

Kisilevsky, B.S., Hains, S.M.J., Jacquet, A.-Y., Granier-Deferre, C., and Lecanuet, J.P. (2004). Maturation of fetal responses to music. *Developmental Science,* 7, 5, 550-559.

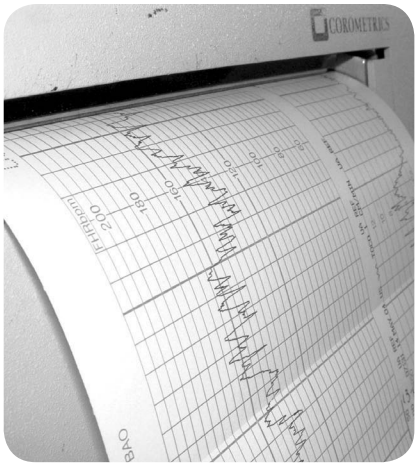
Specialists in our field often hear mothers assert, "I listened to Baby Mozart throughout my pregnancy," with a satisfied or defensive tone, as if insisting that they took their prenatal vitamins and never touched wine. The idea that music magically, effortlessly benefits development is widespread, but the support for it is "mostly anecdotal and is perhaps reinforced by a plethora of commercial audio-recordings (e.g. music, heart sounds) and devices purported to enrich the fetal environment and increase infant IQ." On the other hand, it is clear from prior research that external music is indeed heard clearly enough to be recognizable *in utero;* that the auditory system is substantially working after 33 weeks gestational age; and that immediately before birth, babies can detect certain gross auditory differences such as male/female voices, familiar/unfamiliar voices, and low/high piano pitches.

Two research teams, one in Canada and one in Paris, collaborated on the following study. They chose Brahms' *Lullaby* because its tempo is known to be soothing. The lullaby was presented to the fetuses in a five-minute, recorded piano arrangement. The authors attempted to separate out mothers' responses from fetal responses by masking the mother's hearing with earphones playing dissimilar music

(either country or guitar music).

While the lullaby recording was played to the fetuses, the researchers measured fetal heart rate and body movements. They were particularly interested in the thirty seconds before and after the music started, and again in the thirty seconds before and after the music stopped.

When the researchers analyzed their data, they separated the fetuses (N=114) into groups by gestational age (GA). The first group was between 28 and 32 weeks GA when studied, which means that their auditory systems were not fully developed. Another group of fetuses were 33-34 weeks GA, the age at which, previous research has suggested, the auditory system is fully developed. A third group was at 35-36 weeks GA when they participated in this study. The last group was labeled *term fetuses* because, at 37 weeks or more GA, they would no longer be considered premature had they been born.



The term fetuses showed heart rate deceleration no matter how loud or soft the music was played. In other words, the most mature fetuses may have been paying some primitive form of attention to the music.

When the music was turned on, all fetus age groups showed changes of heart rate. Statistical testing strongly suggested that these changes could not have occurred by chance. In the youngest fetuses, heart rates generally accelerated at the onset of music if it was played loudly; this was thought to indicate arousal. If the same music was played more softly, heart rates generally decelerated at the onset of music, which was thought to indicate attention. The deceleration effect became more common in the older fetuses. The term fetuses showed heart rate deceleration no matter how loud or soft the music was played. In other words, the most mature fetuses may have been paying some primitive form of attention to the music.

The Paris team threw an additional variable into the mix: they played the lullaby twice for each fetus. For half the fetuses, the researchers played the lullaby first at an ordinary tempo, 69 beats per minute, and then again at a faster tempo, 118 beats per minute. The other half of the group heard the fast version before the *a tempo* version. During the course of listening to the five-minute recording, term fetuses showed an increase in heart rate to the faster tempo, but no change with the normal-tempo music.

Understanding this study depends on getting comfortable with the technical terms "arousal" and "attention." The youngest fetuses may have been excited or even alarmed by the onset of music in their environment. The more mature fetuses, because they may have been able pay some primitive form of attention to the music, could also respond differentially to faster and slower tempo. If tempo and timbre are both salient features of music for fetuses, we are forced to speculate how many other features of music might they also differentiate with some degree of clarity, such as pitch, melodic contour, or even rhythmic pattern. We will also want to know whether they will remember, as newborns, the music they heard while *in utero*.

Study 3

James, D.K., Spencer, C.J., and Stepsis, B.W. (2002). Fetal learning: a prospective randomized controlled study. *Ultrasound Obstetrics and Gynecology* 20, 431-438.

The researchers chose a three-minute track of "Little Brown Jug" by Glenn Miller because, they said, it has a "wide range of tone and is rhythmical." Twenty pregnant women were studied 92 hours prior to their elective date of delivery. Each pregnant woman wore headphones on her abdomen for five consecutive hours. None of the women

I used to think that the ideal condition during pregnancy was that of calm reflection; not a busy and stressful life of a music teacher, dealing with so many kids and so much energy, all day, every day. But one of the greatest revelations of my pregnancy was realizing how completely perfect my job is—I've surrounded my growing baby with music, movement, dancing, and singing, all day, every day! In the course of one day, my baby has had the chance to hear all styles of music, my singing voice, children singing, drumming circles, recorder playing, the foundational rhythmic & melodic patterns via echo work with children. My baby has moved with me as I danced with scarves, played walk-and-stop games, rocked to lullabies, and the list goes on. What a joy!
—Jill M. Courtney, Bloomington, IN

had been exposed previously to the Glenn Miller track during pregnancy, so their fetuses had formed no associations, whether positive or negative, with it. For one initial silent hour, researchers took a baseline recording of all the fetuses' heart rate and movements. Thereafter, the experimental group was differentiated from the control group by having a continuously looped recording of the Glenn Miller track played through the headphones to the fetuses. Meanwhile, mothers in the control group continued to wear silent headphones on their bellies. The sham stimulus was used to keep the mothers unaware of whether they were in the experimental group or the control group, making this study nearly a double-blind study, which is the most powerful design for an experiment.


Photo by Sue Pizarro

All the neonates showed significant differences in their heart rate and movements while hearing the music compared to the silent condition. They showed more state transitions (awake to asleep, etc.) and spent more time awake.

For the fetuses in the experimental condition, music was played through the headphones on their mothers' bellies the entire time. During the first and fourth hours of this period, fetal heart rate and movements were recorded for all fetuses, both control and experimental groups.

The striking finding from this study that early childhood teachers might want to share with parents is that, during the fourth hour of hearing music, fetuses who heard music showed significant differences in their heart rate and movements compared to fetuses in the control group. They showed more state transitions (awake to asleep, etc.) and spent more time awake.

Three to five days after birth, all babies were studied again in a quiet room, thirty minutes after feeding. The babies' heart rates were measured through special neonatal electrodes attached to an electrocardiogram machine. A trained observer took notes of the infants' body, limb, and eye movements. In this neonatal situation, thirty minutes of "baseline" (no music) were followed by an hour of "Little Brown Jug" looped music, played through a headphone two to three feet from the baby's head. All of the newborns, including those in the control group, now heard this music. All the neonates showed significant differences in their heart rate and movements while hearing the music compared to the silent condition. They showed more state transitions (awake to asleep, etc.) and spent more time awake.

There were, however, also marked differences between those babies who had heard four hours of music *in utero* and those who had not. The music group changed sleep-wake state more efficiently and spent more time awake than the non-music group.

The limitations of this study include the fact that mothers in the experimental group may have become aware of the music vibrating on their abdomens, and their knowledge or feelings about this may have had an effect on fetal behavior. Another problem is that fetuses and babies change spontaneously and unpredictably: even the control group exhibited significant changes during their time of listening to silence.

The authors believe their study demonstrates that fetal exposure to music results in the development of altered behavior in the fetus before birth and in the newborn, and consider this to be evidence of a kind of learning, albeit the most primitive kind. Music and movement specialists should feel more comfortable in assuring parents that their babies' remarkable capabilities include some ability to learn music.

In conclusion, we can tell parents that fetuses not only hear music *in utero*, but also seem to be able to tell the difference between music and other rhythmic noises such as the mother's heartbeat, seem to give music some form of attention, and seem to form some kind of primitive memory traces of the music they hear. Rather than asking whether their baby is old enough to benefit from music class, perhaps parents should be asking us whether to start

music class when their fetus is at 33-weeks gestational age, or wait until 37 weeks, three weeks prior to the estimated due date. The scientific evidence so far tends toward supporting Kodály's contention that music education begins "nine months before the birth of the mother."

It is worth noting that the body of research on prenatal cognitive abilities is small. The sense of hearing, being the fetus's most developed sense, is naturally the easiest to study and provides a natural opportunity for scientists to investigate ways that thinking develops in the unborn human.

ECMMA & AMTA: A Developing Friendship

By Rick D. Townsend, Ph.D.

Do you remember that special feeling the last time an acquaintance became a friend? Perhaps you shared some classes, or rode the same bus. Maybe you attended some of the same events, or just glanced at each other as you passed in school or work hallways. Then one day you discovered that you had common interests, and suddenly a good relationship began to develop. Your mutual strengths and interests began to enrich one another, and you realized that it was better when you were together. You were friends.

In similar fashion, the American Music Therapy Association (AMTA) and ECMMA have shared similar purposes in several aspects of their respective missions for many years now.

Consequently, the respective boards of AMTA and ECMMA have decided to implement a trial plan by which the two groups will begin to share important information and resources.

Beginning this summer, ECMMA will provide AMTA members with a link to one feature ECMMA Online *Perspectives* article as each issue is released. Additional articles may be purchased at a special reduced cost for all AMTA members. AMTA will reciprocate by providing information and access to their annual journal, *imagine*. ECMMA members will receive information and links to those articles through ECMMA EXTRA! each year.

ECMMA will establish a special AMTA liaison to communicate important AMTA event opportunities to ECMMA members, and vice-versa. Already this summer, AMTA has publicized the 2010 ECMMA Convention on their bulletin board announcements.

By developing appropriate lines of communication, expert speakers and writers from the each community will be more readily available to the other at appropriate times.

We welcome this special opportunity for AMTA and ECMMA members to benefit from one another's strengths. We like to think that a good friendship is developing—one that will enrich the lives of everyone involved for many years.

During my wife's pregnancy, I was teaching at a college in a very small town in Kansas. We did not have good television reception, so my wife watched videotaped episodes of Matlock while she did her chores. She continued this practice even after the birth of our daughter, especially during feeding time. As a newborn, our daughter quickly learned that when she heard the show's theme song, food would soon be coming. If feeding did not commence shortly after the first strains of the tune, the cries would ring throughout the house. *—Steve Elmore, Wichita, Kansas*

When I was pregnant with my daughter, I decided to sing and play the guitar until she moved. Finally, when I stopped, she kicked. The music was enjoyable and soothing to her. With kicking she was saying, "Don't stop!" At two months old, during her first concert, she only cried between songs when the music stopped! *—Bev Granoff, Tewksbury, MA*

I remember when I was pregnant that I always listened to music. When my husband and I would go to concerts in the park, or hear live music of any kind, my son would move all over my belly. I thought he didn't like the music, that it bothered him, and that's why he moved so much. Looking back now, I wonder if he was secretly jamming out and playing the air guitar or the make believe drums in my tummy. He has grown to be a talented musician, so I wonder if it did have something to do with what he heard *in utero*? *—Tommi Rogers, Long Beach, CA*

ECMMA Staff