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# Fetal Response to Mozart's Music

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Objective: This study aimed to determine whether fetal arm movements change when music is presented to the mother or directly to the fetus through the mother's lower abdomen, and whether maternal mood influences changes in fetal arm movements. Methods: Using a diagnostic ultrasound apparatus, fetal arm movements were measured in 47 pregnant women in the 35-36th week of pregnancy. Subjects were divided into two groups: a maternal presentation group, in which the mothers listened to music through headphones; and a fetal presentation group, in which music was presented directly to the fetus through headphones placed on the mother's abdomen. Fetal arm movements were observed and recorded by ultrasound for a total of 10 min (5 min without music followed by 5 min with music). The music used was Mozart's Sonata for Two Pianos in D Major, K. 448. The Profile of Mood States-Brief Form (POMS) was used to investigate the influence of maternal mood on fetal arm movements. Results: In the maternal presentation group, changes in fetal arm movement did not differ between mothers with different moods. In the fetal presentation group, fetal arm movements increased when the mother was energetic and decreased when the mother lacked energy. Fetal arm movement also decreased when the mother had a high level of fatigue and increased when the mother had a low level of fatigue. Conclusion: Presenting music directly to the fetus while the mother is relaxed has the potential to increase fetal response to the music and may possibly promote fetal well-being.

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**Keywords:** Prenatal training; Fetal movements; Mozart; POMS

## Introduction

Prenatal training has attracted attention in recent years, and music has been a focus of discussion as a means of mother-child communication in addition to speaking to and touching the fetus through the abdomen. Music has various effects on the mood and emotions of listeners,[1-3] and listening to music also reportedly relieves stress in pregnant women.[4] When pregnant women are in a stressed state, stress hormones diminish umbilical cord blood flow, which may cause fetal distress,[5] and stabilizing the emotions of pregnant women is therefore a recognized therapeutic effect of prenatal training music. Moreover, as reported by Field[6] and Larsson,[7] the mental state of pregnant women is thought to affect the development of the fetus.

With regard to hearing in fetuses, Arabin et al.[8] reported that the sense of hearing in fetuses develops early. The precursor of the auditory apparatus is developed by the 10th week of pregnancy, and the tympanic membrane is formed by the 14th week. In about the 18th week, the auditory ossicles of the middle ear are complete, and the fetus can hear sounds. In addition, from recordings of intrauterine sound made with a miniature microphone inserted into the uterus, it is said that the loudness of sound is decreased by 20-40 dB

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within the uterus. This is because it is attenuated by the lower abdomen, uterine wall, and amniotic fluid. The decrease is greater for high-frequency sounds than for low-frequency sounds.[9] During the last trimester, the fetus may be able to hear music via its sense of hearing, and prenatal training music may accordingly have a direct influence on fetal behavior. The development of hearing in fetuses, including vibration and sound, is said to be such that from the 30th week of pregnancy, relatively loud sounds of 110 dB cause an increase in fetal heart rate and movement.[10] It has been reported that at higher frequencies, the frequency and size of responses increase but the threshold decreases. At full term, the fetus can distinguish the voice of its own mother from other voices, and can differentiate various types of music.[11,12]

There have also been reports regarding the effects of music on the behavior of fetuses. When women in the final trimester of pregnancy listened to music they liked at an average of 75 dB using two floor speakers, there was no change in fetal movement.[13] In contrast, fetal breathing motion decreased and fetal movement increased when pregnant women in the 34-40th week of pregnancy listened to music they liked using headphones.[14] Fetal movement, however, is just one of five items used to assess fetal well-being.[15] Earlier studies show that variability in fetal heart rate occurred when researchers played various classical music pieces to fetuses from 30 weeks gestational age via headphones placed on the maternal abdomen.[16,17] However, in these studies fetal responses were not uniform. This may be because the researchers did not prevent the mothers from listening to the music, for example, using headphones, and as a result, the maternal emotional responses could have influenced fetal behavior.

To be sure, so far, a few studies have dealt with the cases in which music is presented to pregnant women, but very few studies have investigated whether the changes of fetal movement at the time of the presentation of music occur as a result of the pregnant mother listening to the music or the fetus listening to it. Furthermore, among studies on the behavior of fetuses, there are also very few studies that have analyzed fetal behavior in combination with the mood of their mothers.

Considering the above, the present study aimed to determine changes in fetal movement when music was presented in two different ways; that is, when pregnant women listened to music and when music was presented directly to fetuses through their mother's lower abdomen. We also sought to understand the differences in the behavior of fetuses depending on maternal mood. Changes in fetal arm movements, which have been reported to respond specifically to the mother's emotions,[18] were observed as fetal behavior.

## Subjects and Methods

### *Subjects*

Forty-seven healthy pregnant women with singleton fetuses ranging in gestational age from 35 to 36 weeks were recruited at the Obstetrics and Gynecology department of Miyamura Hospital. Among these 47 women, 4 were excluded from the final sample for the following reasons: examination interrupted (n = 2) and fetal movements not recorded because of technical problems (n = 2). We monitored fetal heart rate (FHR) of the remaining pregnant women to determine fetal arousal levels to control for fetal condition. The FHR tracings were assessed visually and divided into four patterns of HRP (heart rate pattern): A through D.[19] HRP-B (active sleep) is reported to be the most frequently observed pattern.[19-21] During the observation period, 32 fetuses showed HRP-B, which has a wide oscillation bandwidth with frequent accelerations during movements; 6 showed HRP-A (quiet sleep), which has a stable heart rate with a narrow oscillation bandwidth; and 5 showed both HRP-A and HRP-B. Thus, we performed the following experiments only on the 32 pregnant women whose fetuses showed HRP-B. The pertinent characteristics of the participants are given in Table 1. The mean age of final participants (n = 32) was 31.9 years (standard deviation (SD) = 3.5, ranging from 24 to 40 years); all were Japanese. Sixteen women were nulliparous, and the remaining 16 women had one or two children. The average gestational age of the 32 fetuses at the time of testing was 35.7 weeks (SD = 0.5 weeks, ranging from 35 to 36 weeks). All participating women were followed up until delivery. All fetuses were delivered after 36 weeks (Mean ± SD = 38.8 ± 1.1 weeks, ranging from 36 to 40 weeks), and none of them were small-for-dates. The average weight of neonates was 3,076 g at birth (SD = 430, ranging from 2,460 to 4,420 g); 17 were male and 15 were female. All newborns had an Apgar score of >7 at 5 min and did well after birth. The study was approved by the Ethics Committee of Nagasaki University, and informed consent was obtained from each subject. We determined gestational age by a combination of last menstrual period and sonogram.

### *Procedures*

Ultrasound observations of fetal activity and FHR monitoring were carried out for 30 min between 14:00 and 16:00

in a quiet room. The women were asked to refrain from ingesting food and coffee for at least 2 h prior to their visit. The 32 participants were randomly assigned to the following two groups: (1) a maternal presentation group (n = 15), in which the pregnant women listened to music; and (2) a fetal presentation group (n = 17), in which music was presented to the fetus directly through the mother's lower abdomen. These two independent groups were homogeneous for maternal age, $p = 0.60$; primiparity / multiparity, $p = 1.0$; gestational age at the time of testing, $p = 0.82$; gestational age at birth, $p = 0.81$; sex of neonate, $p = 0.98$; birth weight of neonate, $p = 0.68$; and Apgar score (5 min), $p = 0.36$ (Table 1).

**Table 1.** Maternal and infant characteristics for each group

| | | Maternal group (n = 15) | Fetal group (n = 17) | Total (n = 32) |
|---|---|---|---|---|
| Pregnant mother | | | | |
| Age (years) | | 32.3 (4.0) | 31.6 (3.2) | 31.9 (3.5) |
| Primiparae / multiparae | | 7 / 8 | 9 / 8 | 16/ 16 |
| Gestational Age (w) | | 35.7 (0.5) | 35.7(0.5) | 35.7 (0.5) |
| Infant | | | | |
| Sex | Male | 8 | 9 | 17 |
| | Female | 7 | 8 | 15 |
| Birth weight (g) | | 3020 (330) | 2966 (385) | 2991 (355) |
| Gestational Age at delivery (w) | | 38.9 (1.2) | 38.8 (1.1) | 38.8 (1.1) |
| Apgar score (1 min) | | 9.0 (0) | 8.9 (0.2) | 9.0 (0. 2) |
| Apgar score (5 min) | | 10.0 (0) | 9.9 (0.1) | 10.0 (0.4) |

Data are presented as mean (SD)

With the women in the semi-Fowler position, an electrocardiogram (Fukuda Denshi) was attached and the fetal position was monitored with an ultrasound apparatus. In the maternal presentation group, the women wore headphones (Victor Stereo Monitor Headphones HP-M1000) to listen to the music. In the fetal presentation group, one of the ear pads of the same headphones was set on the mother's lower abdomen (at the position of the fetal head). In the fetal presentation group, to prevent the mother from hearing the music from the headphones on her lower abdomen, the mother wore sound-blocking headphones (Peltor Optime III H540A CE EN 352). The music used was Mozart's Sonata for Two Pianos in D Major, K. 448, which, even among the Mozart pieces well known to be useful in prenatal training, is recognized to be particularly effective in elevating mood and activating brain activity.[22-25] This music is also reported to have a mood-elevating effect when used in prenatal training.[1] In the maternal presentation group, 3 (20%) of the women had previously heard Mozart's Sonata for Two Pianos in D Major, K. 448, and 12 (80%) had not. The music was played using a CD player (Sony Atrac 3 plus MP3 CD Walkman D-NE20), and volume was adjusted using an amplifier (Onkyo). In the maternal presentation group, the music was played for the women at a volume of 65 dB.

When music is presented to the lower abdomen, and as a result the volume in the uterus is decreased by 20-40 dB.[9] It has been reported that fetuses are responsive to music volumes of 105 dB and above.[26,27] Therefore, to ensure that the music heard by the fetuses in the fetal presentation group was at a similar volume to that heard by the mothers, the music was played at a volume of 105 dB on the lower abdomen of the women.

The experimental procedure comprised 5 min without music followed by presentation of the music for 5 min in both groups. The number of fetal arm movements reportedly increases when the mother has increased feelings of joy.[17] In the present study, therefore, we considered the number of arm movements to be an indicator of the well-being of the fetus.

Ultrasound observations of fetal activity were made with one 5.0 MHz real-time linear array ultrasound scanner (Mochida Luketron Sonovista-Color II model MEU-1584an). Examinations were performed by one operator, who held one transducer stationary on the maternal abdomen to observe isolated fetal arm movements. Another technician monitored FHR for 30 min using a cardiotocograph (Toitu MT-516, Japan; paper speed 3 cm/min) to analyze the FHR patterns.

*Data Analysis*

Fetal arm movements were recorded on DVD for off-line analysis. We counted the number of fetal arm movements during each 5-min period. Fetal movement recordings occurring within 2 s of each other were considered to belong to the same movement.[20,28] We then calculated the mean values for each of the 5-min periods (silent period, music presentation). Fetal arm movements were observed and recorded with a diagnostic ultrasound apparatus during the experiment, and later analyzed. Data are presented as means ± SD.

Comparisons were made with the Wilcoxon signed rank test, and SPSS ver. 11.5J for Windows was used in the analysis.

*Questionnaire*

To investigate the effects of maternal mood on fetal arm movements, maternal mood was evaluated before the experiment using the Profile of Mood States-Brief Form (POMS). POMS consists of 30 items in six scales: Tension-Anxiety (T-A), Depression-Dejection (D), Anger-Hostility (A-H), Vigor (V), Fatigue (F), and Confusion (C). Total scores are calculated for each scale with a 5-step rating of 0-4 points. Higher scores for a scale indicate stronger moods for that scale. Later, when analyzing the effects of maternal mood on fetal arm movements, we calculated the median value for each of the six emotions in both groups, and divided subjects into high and low groups by whether their scores were higher or lower than the median value. The number of fetal arm movements was then compared between the two groups.

To investigate the changes in mood caused by listening to music in the maternal presentation group, POMS was also measured after women had listened to music to obtain the changes in each of the scales resulting from listening to music.

## Results

1. Changes in maternal mood after listening to music

Changes in the POMS score before and after listening to music were investigated in the maternal presentation group (Table 2). Significant decreases ($p < 0.05$) were found in A-H, from 45.6 (±6.8) before to 43.3 (±6.5) after music presentation. The T-A score was 44 (±6.9) before the presentation of the music and after it, it was 42.1 (±6.5) ($p = 0.35$); the D score was 44.6 (±4.1) before the presentation of the music and after it, was 42.5 (±3.2) ($p = 0.07$); the V score was 47.9 (±8.8) before the presentation of the music, while after it, was 46.1 (±7.5) ($p = 0.12$); the F score 44.5 (±4.2) before the presentation of the music, while after it, it was 43.1 ($p = 0.2$); and the C score was 47.1 (±6.4) before the presentation of music, and it was 45.8 (±5.6) after it ($p = 0.54$).

**Table 2.** Change in POMS score before and after music presentation in the maternal presentation group

| | Before Music presentation (0-10) | After Music presentation (0-10) | *p* value |
|---|---|---|---|
| T-A | 44.0 (6.9) | 42.1 (6.5) | 0.35 |
| D | 44.6 (4.1) | 42.5 (3.2) | 0.07 |
| A-H | 45.6 (6.8) | 43.3 (6.5) | 0.03 |
| V | 47.9 (8.8) | 46.1 (7.5) | 0.12 |
| F | 44.5 (4.2) | 43.1 (5.6) | 0.20 |
| C | 47.1 (6.4) | 45.8 (5.6) | 0.54 |

Data are presented as mean (SD)

2. Changes in maternal heart rate

The heart rate in the 15 women in the maternal presentation group was 80.6 (±8.6) beats/min during the 5-min silent period, and 79.6 (±8.6) beats/min during the 5-min music presentation period; this difference was not significant. ($p = 0.05$). The heart rate in the 17 women in the fetal presentation group was 80.2 (±9.2) beats/min during the 5-min silent period and 79.0 (±9.0) during the 5-min music presentation period; this difference was not significant ($p = 0.18$) (Table 3).

3. Fetal arm movements

1) Overall analysis

In the maternal presentation group, the number of fetal arm movements was 5.2 (±2.7) during the 5-min silent period and 4.2 (±3.4) during the 5-min music presentation period. No significant difference was seen between these two periods ($p = 0.21$). In the fetal presentation group, the number of fetal arm movements was 7.5 (±4.4) during the 5-min silent period and 5.4 (±2.5) during the 5-min music presentation period, and this difference was not significant ($p = 0.05$) (Table 3).

2) Comparison between the two groups according to maternal mood

To investigate the influence of maternal mood on fetal arm movements, the median value for each of the six POMS scales was calculated and the participants were divided into high and low groups by score, using the median as the reference value, and compared.

In the maternal presentation group, the change in fetal movement was –1.0 (±4.0) in the high T-A group ($n = 7$) and –1.0 (±4.3) in the low T-A group ($n = 8$) ($p = 0.77$); 0.13 (±4.9) in the high D group ($n = 8$) and –2.9 (±2.5) in the low D group ($n = 7$) ($p = 0.77$); –1.25 (±6.6) in the high A-H group ($n = 4$) and –0.91 (±3.0) in the low A-H group ($n = 11$) ($p = 0.51$); –1.38 (±4.0) in the high V group ($n = 8$) and –0.57 (±4.3) in the low V group ($n = 7$) ($p = 0.49$); 0.4 (±4.4) in the high F group ($n = 5$) and –1.7 (±3.8) in the low F group ($n = 10$) ($p = 0.39$); and 0.14 (±3.6) in the high C group ($n = 7$) and –2.0 (±4.3) in the low C group ($n = 8$) ($p = 0.16$) (Figure 1; a-f).

**Table 3.** Maternal heart rate and number of arm movements in the maternal presentation and fetal presentation groups

| | Maternal presentation group | | | Fetal presentation group | | |
|---|---|---|---|---|---|---|
| | Before Music presentation | During Music presentation | *p* value | Before Music presentation | During Music presentation | *p* value |
| Maternal heart rate | 80.6 (8.6) | 79.6 (8.6) | 0.05 | 80.2 (9.2) | 79.0 (9.0) | 0.18 |
| Number of fetal arm movements | 5.2 (2.7) | 4.2 (3.4) | 0.21 | 7.5 (4.4) | 5.4 (2.5) | 0.05 |

Data are presented as mean (SD)

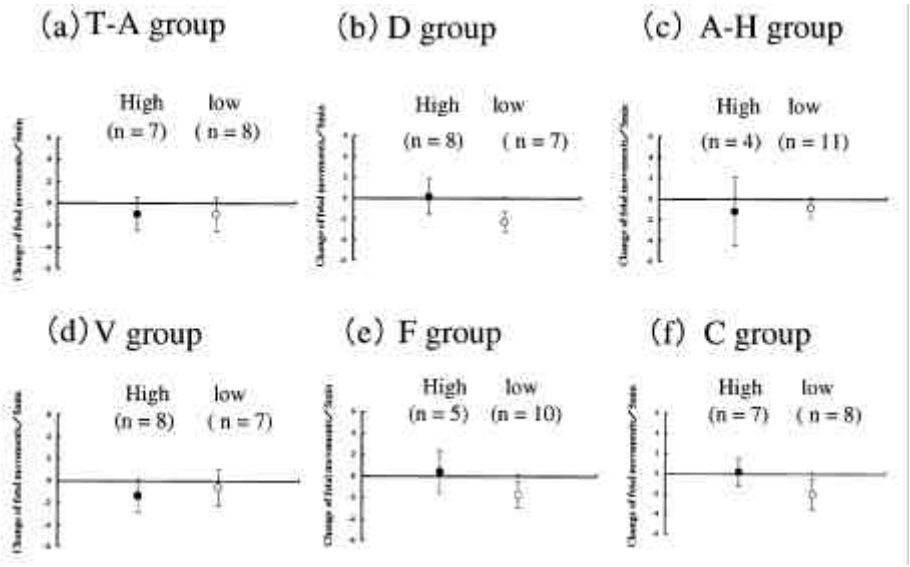


**Figure 1.** (a)-(f) Changes in fetal movements.

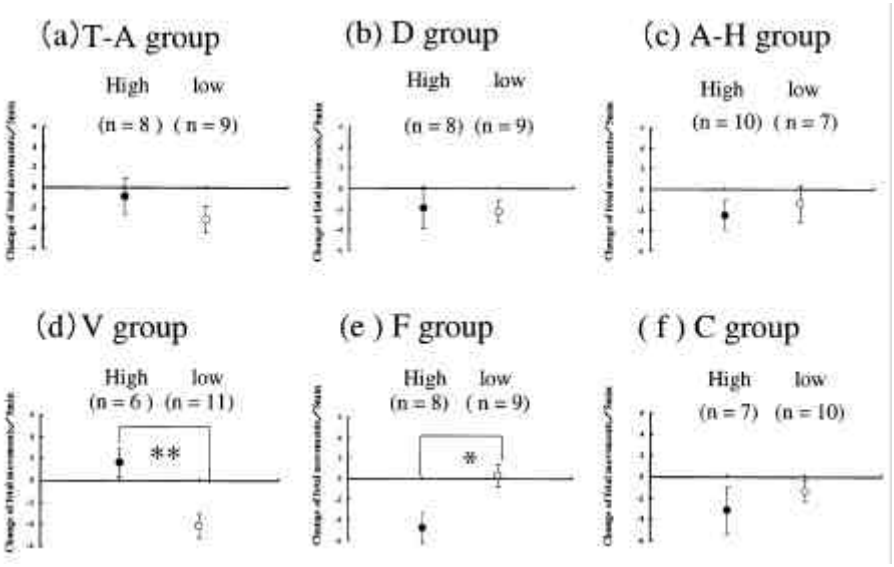


**Figure 2.** (a)-(f) Changes in fetal movements.
(d) Asterisks indicate a significant difference from baseline (**: $p < 0.01$).
(e) Asterisks indicate a significant difference from baseline (*: $p < 0.05$).

In the fetal presentation group, the change in fetal arm movement was –0.88 (±4.9) in the high T-A group (n = 8) and –3.11 (±4.0) in the low T-A group (n = 9) (p = 0.44); –1.88 (±5.8) in the high D group (n = 8) and –2.222 (±3.3) in the low D group (n = 9) (p = 0.96); –2.5 (±4.4) in the high A-H group (n = 10) and –1.43 (±4.8) in the low A-H group (n = 7) (p = 0.41); and–3.14 (±5.9) in the high C group (n = 7) and 1.3 (±3.3) in the low C group (n = 10) (p = 0.14) (Figure 2; a-c, f) None of these differences were significant. However, the change in fetal arm movement was –1.67 (± 3.2) in the high V group (n = 6) and –4.09 (±3.7) in the low V group (n = 11) and –4.75 (±4.2) in the high F group (n = 8) and 0.33 (±3.2) in the low F group (n = 9), both of which were significant differences (p = 0.004)(p = 0.02) (Figure 2; d, e).

## Discussion

In this study, we investigated the changes in fetal arm movement that resulted from listening to Mozart's Sonata for Two Pianos in D Major, K. 448. Two methods of listening to music were used: one in which only the mother listened to music and another only the fetus listened to music through the mother's abdomen. No differences in fetal arm movement were observed as a result of listening to music in either case. Comparison of fetal arm movement between groups divided according to maternal mood revealed no differences in fetal arm movement when the mother herself listened to music; however, when music was presented directly to the fetus, fetal arm movement increased in the high V group compared with the low V group, and decreased in the high F group compared with the low F group.

According to a previous study by Araki et al.[18] fetal arm movement increases when feelings of joy are evoked in the mother, and decreases with feelings of maternal sadness. One reason that no change in fetal arm movement was observed when the mothers listened to music in the present study may have been the size of the stimulus. Videos used in previous studies strongly stimulated emotions in the mothers, and had an arousal effect.[29] The music used in the present study tended to cause a decrease in heart rate, and improved D scores and decreased V scores were seen. Thus, contrary to the previous study, arousal may have declined from the relaxation produced by listening to the music, resulting in no effect on fetal movement. It has also been reported that fetal breathing motion decreased and fetal movement increased when women in their 34-40th week of pregnancy listened to their favorite music using earphones.[14] However, in the maternal presentation group in the present study, 20% of the women had previously heard Mozart's Sonata for Two Pianos in D Major, K. 448, and 80% had not. Thus, the subjects' lack of familiarity with the music may have affected the present results.

When the music was presented directly to the fetus, there was change in fetal arm movement depending on the mother's mood. Kisilevsky et al.[30] observed the extent of the maturation of the fetal response to music, and reported that in the 35th week of pregnancy and afterwards the number of fetal movements and their duration showed an increased, which corresponds with our findings. However, in the study of Kisilevsky et al. when music was presented to the fetuses, the fetal movements increased regardless of whatever mood the mothers were in. We used a headphone in our study, whereas they used a loudspeaker, which may have had a greater effect on the fetuses.

Fetal movement is one of five markers of fetal well-being,[15] and a decrease in fetal movement is often a sign of fetal distress, such as from too little amniotic fluid, and may predict fetal distress during birth or a low Apgar score.[31] Our results show that presenting music directly to fetuses, particularly when the mother has high vigor and low fatigue, has the effect of increasing fetal arm movement. Therefore, creating an atmosphere for the mother in which she can relax and letting the fetus listen to music have the potential to increase fetal movement and promote fetal well-being.

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