Music: A Synthesis of Prenatal Stimuli

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Abstract

We consider The hypothesis that music is an organized pattern of sounds simulating prenatal stimuli, ~~is considered~~. First The published experimental evidence concerning fetal behavior, and concerning the fetal response to acoustic, tactile, and chemical stimuli is reviewed. The elements of rhythm, intonation, and harmony in music are compared with their counterparts in prenatal stimuli; namely, the combined pulsations of the maternal and fetal hearts, maternal speech, and the harmonic generation produced by the presumed large nonlinear response of the fetal hearing to maternal speech. ~~The~~ We advance a mechanism by which music evokes feelings; ~~is~~ ~~considered,~~ namely, that music revives ~~evokes echos of~~ learned neuro-hormonal responses to consistently recurring prenatal stimuli, and these responses ~~echos~~ are accompanied by ~~experienced as~~ emotions. Conclusions are drawn concerning possible future research, and concerning the implications of the hypothesis for theories of learning.

Listening to music is for almost everyone an experience accompanied by a range of feelings. The question arises how music, which is an organized pattern of sounds, affects us in this manner. When we ask how other art-forms such as literature or drama cause the feelings they do, we can usually understand (in terms of connections to our own experience) the relation of these feelings to the events we read or see enacted. In the case of music, the connection between the sounds we hear and the feelings they evoke is much harder to state. This difficulty suggests that music evokes responses formed during a very early period of life when ~~the notion of~~ communication by means of verbal exchange is absent. We will therefore consider what stimuli act on a fetus in utero, and survey what is known concerning the fetal response to each type of stimulus. Following this we will consider the hypothesis that music constitutes a ~~reconstruction~~ synthesis of the vibratory elements of prenatal stimuli, and that the feelings evoked by music are ~~echoes of~~ an accompaniment to the learned neuro-hormonal responses to these stimuli.

Taste, Smell, and Temperature

Under normal conditions the fetus is surrounded by amniotic fluid of almost constant salinity, pH, and temperature. It is therefore unlikely that smell, taste, or temperature play an important role.

Tactile

Tactile stimuli are restricted to those caused by pressure fluctuations in the amniotic fluid, and to forces transmitted directly through the wall of the uterus. It is known that the quiescent fetus will actively respond to a directly-transmitted force by squirming. Hooker[1] reports that a fetal response to tactile stimuli can occur as early as 8 1/2 weeks after fertilization of the egg.

Due to its density, the amniotic fluid does not exert uniform pressure. As the mother changes her position, the distribution of pressure on the fetus changes. Moreover, as the mother changes her state of motion, the fetus is pulled in a manner similar to that of a passenger in a vehicle that accelerates or rounds a curve. Schmeidler[2] reports, from observations of a single case — and this fact leads one to accept her results with caution — that fetal movements (which may begin to be felt as early as the twelfth week of pregnancy) decrease following a period of maternal activity. For ~~However, It is not known whether~~, Such a ~~the~~ decreased, in fetal activity, would be ~~is a~~ result, (from either) ~~of~~ forces produced by the motion, or ~~of a~~ from a possible chemical change in the blood supplied to the fetus. Hiccups, a form of behavior commonly exhibited by fetuses, appears to be linked with a change in the mother's position.[3]

Visual

In the ninth month of pregnancy the eyelids of the fetus cease to be fused. Even if the eyelids remain closed we cannot assume that no light enters the eyes. Eyelids, and even thick layers of skin, transmit light. Although it is unlikely that the fetus receives any visual stimuli containing spacial patterns, there is a possibility that temporal patterns of light reach the retina.

Acoustic

Present is the continual pulsing of both the maternal and fetal hearts, the sounds of digestion, and the vibrations produced by the circulation of the blood ~~coursing~~ through the large arteries of the uterus. Also present is the intermittent sound of the mother's voice, and other voices. There are sounds of chewing, swallowing, sneezing, coughing, yawning, brushing of teeth, etc. Last, there are external sounds and noises such as that of clattering dishes, machines, etc. The fetal response to loud sounds was noted as early as 1925 by Peiper[4], and in 1927 by Forbes.[5] Forbes mentions that a rap on the side of a tub in which a pregnant mother was bathing caused the fetus to jump within a fraction of a second. There is a question of whether the fetal response was tactile or auditory, although the mother was not conscious of feeling tactile sensations. Forbes also tells of a pregnant mother who was troubled by great fetal activity during periods of applause at a concert. Ray[6] has confirmed that vibration will produce a fetal response. Sontag[7] reports that an intense vibration coupled to the abdoman of an 8-month pregnant woman will, ~~in about 90%~~ ~~with approximately a 90% probability~~ in 9 out of 10 cases, occasion an immediate convulsive fetal response. This response involves violent kicking and moving. In all cases there is an increase in fetal heart rate.

In addition, Bernard and Sontag[8] have reported that the human fetus in utero is capable of perceiving a wide range of tones produced in the air close to the abdomen of the mother. The fetus responds to tonal stimulation ~~is expressed in~~ with sharp body movements and cardiac acceleration.

Maternal Emotions

There is evidence that the emotions of the mother can ~~act as a stimulus that~~ affects the fetus. The experiencing of an emotion by the mother is accompanied by variations in the concentrations of hormones, oxygen, glucose, and carbon dioxide in her blood. Further, it is known that such substances are capable of passing through the placenta to the fetus, which is thereby affected. The production by the fetus of hormones which have molecular sizes small enough to permit them to pass through the placenta is related to the rate of production of these hormones by the mother. That is, the endocrine systems of the mother and fetus do not act independently, but interact to form a mutual pool. One example of this interaction occurs in the case of pregnant diabetic mothers. Infants born to such mothers are prone to an overactive pancreas which, before birth, was stimulated to supply the additional insulin needs of the mother.[9]

At present, little is known specifically of the immediate or long-range effects on the fetus of the mother's emotions, although there is considerable evidence that the mother's emotions do affect the fetus. Sontag[10, 7] links anxiety of the pregnant mother to a marked increase in fetal movement, and to a greater incidence of irritability, hyperactivity, frequent stools, and feeding problems after birth.

Electromagnetic

The possible effects of variations in electric potentials to which the fetus is subjected have not at present been investigated. This is an area which may prove to be important. For example, the *rhythmic variations in the potentials associated with cardiovascular* contractions may directly influence, or even establish, rhythmic variations of electric potentials in the fetal brain.

Pattern Recognition

Let us consider the existence of patterns in the fetal environment, and the likelihood that these patterns affect the fetus. For example, speech conforms to rules of grammar and syntax, and thus provides a source of acoustic stimuli containing patterns. Moreover, emotional states of the mother are not unrelated to patterns in her speech. Ostwald[10] has attempted to analyze speech~~, not for content, but~~ for such attributes as loudness and timbre, and to relate these to mental states. Rubenstein[11] ~~has~~ found that tones hummed by subjects had a frequency pattern which varied diurnally. Thus, at the very least, diurnal changes in the mother's voice would accompany changes in other factors which also vary diurnally, and which affect the fetus.

Next consider patterns formed by the combined pulsing of the hearts of the mother and that of the fetus, and the relation of such patterns to the emotional states and breathing of the mother. Contractions of the heart muscle of the fetus begin within a month following conception, and become audible to the naked ear at the end of the fourth month. The fetal heart normally beats at a rate of 120 to 160 per minute, about twice the rate of the mother's heart. The combined ~~sounds~~ pulsations of the ~~heart and the fetus~~ fetal and maternal hearts establish a definite rhythmical pattern which depends on the frequency and relative phase of the two ~~beats~~ pulsations (see Figs. 1 and 2). Any departure from the 2 to 1 ratio of fetal and maternal heart rates changes the relationships contained in this pattern. It is known that the heart rate of an adult varies with changes in physical activity, emotions,

Fig. 1.—Normal fetal electrocardiogram from three different subjects, with the fetus in vertex presentation. Longitudinal leads. Maternal complex is seen to be directed down, and the fetal complexes are directed upward and occur at a faster rate.

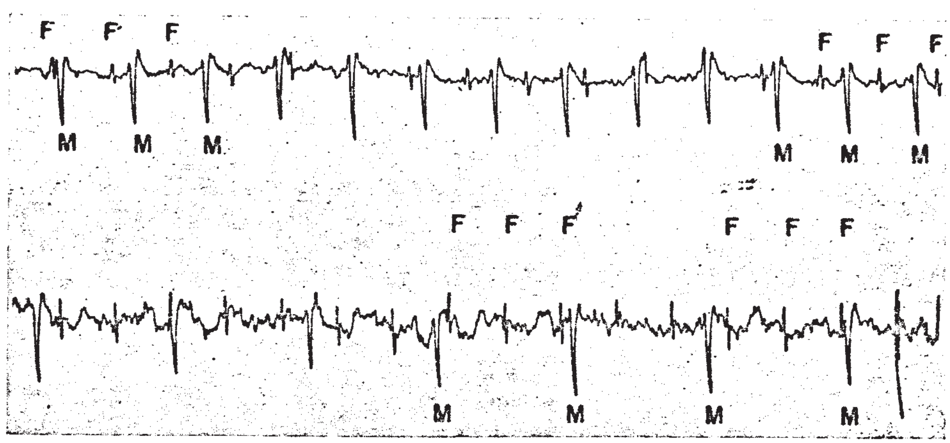

Fig. 2.—Appearance of the fetal electrocardiogram with differing relative fetal-maternal rates. Upper tracing shows fetal and maternal rates which are similar, largely because of a fast maternal rate. Lower tracing shows appearance with a slow maternal rate. On occasion, three fetal complexes can be seen in the interval between two maternal complexes

[From S.D. Larks and K. Dasgupta, Fetal Electrocardiography, with Special Reference to Early Pregnancy. Am. Heart J., 56: 701-14, 1958.]

or breathing. Even in the absence of these changes, the heart rate of a normal individual alternately increases and decreases. This is termed the sinus arrhythmia. The increased rate usually occurs with respiratory inspiration, and the decreased rate with expiration. The fetal heart rate also undergoes a pattern of variation. ~~Sontag reports that~~ These fetal variations are affected by external stimuli in the form of pressure, vibration, or chemical changes in the blood[13], but ~~that~~ the pattern of variation appears to be independent of the maternal sinus arrhythmia.[14] Thus in the absence of sudden changes in maternal emotions, activity, and breathing, and in the pertinent stimuli to the fetus, the combined pulsations of the hearts of the fetus and the mother produce a slowly varying rhythmic pattern (see Figs. 1 and 2). The sudden experiencing of an emotion by the mother~~, for example,~~ would be accompanied by an immediate relatively large increase in her heart rate and the pressure of the pulsation. However, the fetus would not be immediately subjected to any chemical changes, and its heart rate would not be immediately affected. Thus, there would be an abrupt change in the combined rhythm (compare Fig. 1 to Fig. 2). This abrupt rhythm change would later be followed by chemical changes in the blood supplied to the fetus.

We therefore consider the evidence that patterns in the fetal environment act on the fetus in a manner that can be characterized as learning. The most promising evidence that fetuses are capable of learning has been reported by Spelt.[15] Spelt, in

Thus there is an opportunity for the fetus to learn to adjust to the chemical changes before they come, rather than having them come as an unexpected jolt.

an experiment with 16 women in the last two months of pregnancy, conditioned the fetuses to respond to a vibrotactile stimulus. Initially the vibrotactile stimulus alone did not produce a response. Next, the fetuses were exposed simultaneously to both the vibrotactile stimulus and a loud sound which, alone, did produce a response. After 15 to 20 such paired stimulations, the fetuses were conditioned to the point at which 3 or 4 successive responses to the vibrotactile stimulus alone could be expected. Additional conditioning raised the number of successive conditioned responses to as high as 11. Spelt's experiment adds considerable plausibility to the idea that the fetus may learn responses to patterns inherent in prenatal stimuli. Greene[15] suggests that oxygen, water, carbon dioxide, glucose, or their concentrations, or combinations, represent a kind of object for the fetus' perception at one stage of development. While not rejecting the possibility that the mother's vocal utterances are constituents of an object, Greene additionally proposes that vibrations, pulsations, and pressures incident to the mother's physiologic activities, chiefly vascular and pulmonary, become an object during the later stages of fetal experience. Thus the consistent recurrence of these objects, and the physiological and neuro-hormonal response of the fetus to them, may constitute a sort of learning process. For example, during the last 8 months of development, the fetus would be subjected to of the order of a billion repetitions of alternating strong and weak cardiovascular pulsations. The minimum we can expect is that such stimuli leave a lasting imprint on the fetus. If so, the psychological phenomenon of grouping sounds would seem to have its roots in the cardiovascular elements of prenatal experience, as has been suggested by Lourie.[16] There is experimental evidence that the cardiovascular prenatal stimuli leave such an imprint. Salk[17] has demonstrated that when a newborn child is exposed to the amplified sound of a normal heartbeat, he is quieter, healthier, and gains weight faster than when he is not. This work by Salk has been replicated by Tulloch et al.[18]

Specifically, let us attempt to picture the stimuli provided to the fetus by laughter on the part of the pregnant mother. Laughter, which involves rhythmical contractions of the abdominal muscles and diaphragm, accompanied by high-pitched staccato vocal utterances, would constitute a definite climax to the pattern of speech sounds which evoked the laughter. These speech sounds would consist of phrases, repeated with gradual changes in words, intonation, and emphasis, characteristic of humor. For the mother, the laughter would be accompanied by an exultant feeling state, changes in heart rate and breathing, and changes in concentrations in her blood, of oxygen and hormones which may affect the fetus. These patterns involve a climactic change of acoustic and tactile stimuli, and chemical stimuli associated with a state of maternal well-being. If such patterns are repeated with sufficient frequency, they may become an object for ~~the fetus~~ fetal learning. According to this picture, the learning faculties of the fetus are not dormant until some definite moment when they suddenly become active, but rather continuously grow. The difference between before and after birth may be more in the nature of the stimuli than in the degree to which learning may occur.

After Birth

After the child is born, it is by contrast exposed to cold, hunger, and harsh forces. We consider whether stimuli are now present which resemble those of the womb, for such stimuli could evoke neuro-hormonal states paralleling those before birth. In the case of an adult, such states would now be accompanied by the experiencing of certain emotions. (We note that no assumption is made concerning the experiencing of emotions on the part of the fetus. The hormones need only be produced as a reflex to certain patterns in prenatal stimuli. This distinction is clarified by Ashley-Montagu[20] in discussing the mechanism of action of the mother's adverse emotional states on the fetus.) After the child has learned to speak, the sound of the mother talking, for example, would not be expected to resemble prenatal stimuli, for now the mother's voice has communicative meaning, and possibly a different sound. To evoke prenatal modes of brain activity, an auditory stimulus should (in this example) sound to an adult as did human speech before birth, ~~when the notion of communication was absent.~~ Moreover, stimuli of a random nature, although resembling a large portion of prenatal stimuli, would not be expected to **evoke pleasurable feelings** of prenatal origin, because pattern recognition would be impossible.

Let us examine the hypothesis that music is an organized pattern of sounds constituting a ~~simulated reconstruction~~ synthesis of prenatal stimuli, and that recognition of these patterns revives modes of neuro-hormonal activity corresponding to that produced by prenatal stimuli. In the case of an adult, ~~these modes~~ this activity would be experienced as emotions.

Music

In almost all music there is a strong beat at a rate within a range approximately equal to that of the maternal heart rate. During a musical performance the tempo (the rate of the strong beat) is not constant but is varied in the context of the music in a manner analagous to the variation of the maternal heart rate with breathing, and with changing emotions and physical activity. Moreover, in much music, this beat, which is produced by an instrument such as a drum or a plucked bass viol, has a sound which resembles that of a pulsing heart. In addition to the strong beat, music contains weaker, but faster beats. The weaker beats are sensed by the listener as being grouped within the stronger ones. The particular pattern of grouping is called meter. For example, the meters which are formed by the main components of the combined maternal-fetal electrocardiograms in Fig. 2 are that of duple time (upper), triple time (lower 1st, 2nd, 3rd, and 5th groups), and quadruple time (lower 4th and 6th groups). The pattern determined by the time intervals separating the beats of a group (or measure) constitutes one type of rhythm. (Another type of rhythm is that established by the duration of tones.) We note that in each of the electrocardiograms shown in Figs. 1 and 2 the rhythm changes with time. Rhythmic change is absent only if the ratio of the fetal and maternal heart rates r_F and r_M, respectively, is an integer. If $r_F/r_M = m/n$, where m and n are integers, then the rhythmic pattern repeats itself every n measures. Most of the time $r_F \approx 2r_M$, and the rhythm is slowly changing. A period of maternal emotional stress would be accompanied by a relatively large increase in r_M, and consequently correspondingly fast changes in rhythm. These changes would be accentuated by a greater intensity in the maternal pulsations. If heart rhythm ~~rate~~ patterns and the following hormonal and chemical changes constitute an object for ~~the fetus~~ fetal learning, then changes in r_M and in rhythm would be expected to act as signals which precede chemical and hormonal changes. Thus, increases in r_M, and fast changes in rhythm would be expected to produce in the fetus a state which is the prenatal analogue of emotional tension. This tension would be further increased by an intensification ~~increase in the intensity~~ of the maternal pulsation. These mechanisms agree well with the mechanisms by which music produces emotional tension formulated by composer-conductor, Howard Hanson.[21] According to Hanson, an increase in tempo, or changes in rhythm produce such tension in the listener, and the rhythmic effect is increased by an increase in dynamic intensity.

We note that more complicated ~~complex~~ rhythmic patterns are actually present in prenatal stimuli if we consider the weaker components of both the maternal and fetal complexes. These components would become more prominent under stress. Further, present knowledge does not establish whether the cardiovascular stimuli are most appropriately considered to be primarily acoustic, vibratory, or even possibly electric ~~electromagnetic~~ in nature. In any case it appears that after birth acoustic and vibratory stimuli can act as a satisfactory analogue of the prenatal cariovascular stimuli.

Tonal Patterns in Music

Music contains non-random tonal patterns of sound vaguely resembling the rising and falling inflections and intonations, and the syllabic articulations of human utterances. Some music involves the singing of words, the presence of which suggests that music is closely related to human speech. It would seem that words provide added insurance that melodic phrases conform to the structure of spoken language.

Feelings Evoked by Music

Some of the feelings evoked by music are a sense of buoyancy, a sensation of bathing in a warm fluid, an ecstatic swell of emotion or excitement, and an impulse to move in a manner related to the musical patterns, with a corresponding increase in pleasure when we obey this impulse. Considering these in turn, the first two of the above sensations are highly descriptive of the womb. The ecstatic swell of emotion or excitement can be interpreted in terms of the conditioning influence on the fetus of maternal hormones associated with a state of well-being. We may picture the composer as one who possesses the ability to create patterns of sound which when recognized by the listener will produce in him a succession of feelings, the totality of which constitutes an experience he will desire to repeat. If these feelings result from learned responses to prenatal stimuli, then the composer is gifted to the extent that he is in touch with his own prenatal experience.

The impulse to dance or move to music can be explained as follows: Speech involves breathing and gesturing by the speaker in a manner related to the utterances. This is partly involuntary, and partly an aid to expression for the speaker. The speech of a pregnant mother would therefore be accompanied by changes in pressure and force on the fetus, causing it to be moved in patterns related to that speech. Thus, supplying this motion ourselves intensifies the suggestion of the prenatal state.

The Ear and Harmony

If the ears of a normal adult are subjected to a pure sinusoidal acoustic frequency f, as the intensity is increased he will successively begin to hear the additional frequencies 2f, 3f, 4f, ... This phenomenon, called harmonic generation, is known to result from the inherent nonlinearity of the ear. If f is the frequency of the musical tone C, then the first 16 terms in the harmonic series f, 2f, 3f, ... correspond to the musical tones C, c, g, c', e', g', b♭', c", d", e", f#", g", a", b♭", b", and c"', respectively. The octave, the interval f-2f formed from the first two frequencies of the harmonic series, is found in the musical scale of every culture. The next two intervals, 2f-3f and 3f-4f, known as the fifth and fourth, respectively, are found in most primitive scales. (we note that certain instruments, such as the valveless trumpet, naturally resonate at frequencies which form a harmonic series.)

An interesting type of music is that of the Tibetan lamas. ~~This music~~ Intentionally incorporated in this music are sounds associated with bodily processes such as heartbeat, circulating blood, and even the ringing noise experienced during periods of silence. Tibetan music is designed to evoke, in the hearer and performer alike, a ~~mood of deep concentration~~ reproduction of what the lamas hear during meditation. In certain Tibetan monasteries, the lamas chant in a manner which results in the impression that each lama is singing a chord. Smith, Stevens, and Tomlinson[20] have analyzed the spectrum of the voice of a single individual during this chanting, and found that the fifth and tenth harmonics are highly accentuated. This incorporation of musical intervals in a single singing voice ~~leads to~~ suggests the following hypothesis: The hearing of the fetus, although sufficiently developed to respond to acoustic stimuli, may involve more effects of harmonic generation than the hearing of an adult. Three possible mechanisms for this seem worthy of consideration. (1) The amniotic fluid, which contacts the fetal eardrum on both sides, may increase the inherent nonlinearity of the eardrum. (2) A greater nonlinearity may result from incomplete development of structures in the fetal ear. (3) After birth the brain may learn to compensate for inherent distortion in the ear in such a manner as to raise thresholds for the subjective experience of hearing harmonics generated in the ear.

As a result of increased effects of harmonic generation, the fetus would "hear" a correspondingly greater proportion of higher harmonics than an adult subjected to a pure tone of the same loudness. (For a fetus the term "loudness" might be defined in terms of a neurological, rather than a subjective parameter.) Roughly speaking, for the fetus, pure tones may sound like chords. Thus, it appears that the inclusion of harmony in music may have its roots in prenatal stimuli.

Dissonance

Historically, music has shown a trend toward the inclusion of increasingly higher order terms of the harmonic series, resulting in increasing dissonance. Bartholomew[21], in discussing this trend, states that "...it seems to be more than a historical coincidence that the order in which intervals have been accepted for use in music performed in parts parallels as closely as it does the order in which they occur in the harmonic series. The supposition is that, since most tones are complex, man's ear had unconsciously been absorbing the sound of these intervals in the harmonic series of many of the tones he heard; and when he desired to use intervals for their own sake, they naturally appeared in musical history in the order of their appearance (and loudness) in the harmonic series." The hypothesis concerning the increased effects of harmonic generation in fetal hearing may be extended to account for this unconscious absorption: Consider the possible effects of music acting as a stimulus on successive generations of composers while in the fetal state. Each generation would be exposed to acoustic stimuli of a given degree of dissonance. This dissonance would be amplified by the presumed large effects of harmonic generation in the hearing of the fetus. When these fetuses grew up to be composers, they would naturally tend to make use of a higher degree of dissonance in their musical compositions. Thus, over the years, music would evolve in a direction of increasing dissonance.

It is tempting to apply this hypothesis to the question of why "too much" dissonance is disagreeable. In the womb, the highest degrees of dissonance were associated with the loudest sounds; and we know that loud sounds can produce a startle response in a fetus. Thus, highly dissonant sound, even if not loud, may evoke an echo of this response.

Summary and Conclusion

There exists ample evidence that the human fetus reacts to a wide variety of stimuli. Although the fetus would not be expected to have a conscious awareness of these stimuli, the results of the experiments of Spelt and Salk, which we have cited, indicate that the fetus is capable of learning, at least on some rudimentary level. If the recognition of patterns of an order of complexity comparable to those of music has as its origin a similar recognition of the patterns in the vibrational, chemical, and physiological processes of the womb, then the fetus is capable of learning to an extent hitherto thought impossible. ~~The fact~~ That the patterns in music bear such close similarity to patterns in prenatal stimuli suggests that experimentation is needed to cast light on the following questions:

1. Can patterns in music be more definitely linked to patterns in prenatal stimuli?
2. To what extent does the fetus hear, and what is the qualitative nature of any inherent differences in hearing before and after birth?
3. To what extent is the fetus capable of learning?
4. What are the prenatal effects of the ~~electromagnetic fields~~ maternal cardiovascular potentials to which the fetus is normally subjected?

The results of such experimentation could have a far reaching effect on theories of learning, especially where such theories pertain to the learning of speech.

References

1. Hooker, D.: The Research Publications of the Association for Research in Nervous & Mental Diseases, 19: 237, 1939.

2. Schmeidler, G. R.: The Relation of Fetal Activity to the Activity of the Mother. Child Developm., 12: 63, 1941.

3. Newberry Norman, H. Fetal Hiccups, J. Comp. Psych. 34: 65, 1941.

4. Peiper, A.: Sinnesempfindungen des Kindes vor seiner Geburt. Monatsch. f. Kinderh., xxix: 236, 1925.

5. Forbes, H. S. and Forbes, H. B.: Fetal Sense Reaction: Hearing. J. Comp. Psychol., 7: 353-355, 1927.

6. Ray, W. S.: A Preliminary Report of a Study of Fetal Conditioning. Child Developm., 3: 175, 1932.

7. Sontag, L. W.: Implications of Fetal Behavior and Environment for Adult Personalities. Ann. N. Y. Acad. Sci., 134: 782-786, 1966.

10. Sontag, L. W.: The Significance of Fetal Environmental Differences. Am. J. Obstet. & Gynec., 42: 996-1003, 1941.

8. Bernard, J. and Sontag, L. W.: Fetal Reactivity to Tonal Stimulation: A Preliminary Report. J. Genetic Psych., 70: 205-210, 1947.

9. Gordon, ?. ?.: Ohio State Med. J. 32 540, 1936

11 ~~9.~~ Ostwald, P. F.: Acoustic Methods in Psychiatry. Scientific Am. 212: 82-91, Mar 1965.

12 ~~10.~~ Rubenstein, L.: Humming: A vocal standard with a diurnal variation. Science 134: 1519-20, Nov. 1961

~~11.~~ Sontag, L. W. and Richards, T. W.: Monogr. Soc. Res. Child, Wash, D.C., Developm., 3, 1938, vol. 3, no. 4, serial no. 17.

14. Sontag, L. W.: Individual Differences in Heart Rate Variability in the Human Fetus. Am. J. Obstet. & Gynec., 98: -61, 1967.

13 Sontag, L. W. and Newberry, H., Incidence and Nature of Fetal Arrythmias. Am. J. Dis. Child. 62: 991-9, 1941.

15. Spelt, D. K.: The Conditioning of the Human Fetus in Utero. J. Exper. Psychol., 38: 338-346, 1948.

16. Greene, W.A., Jr.: Early Object Relations, Somatic, and Personal. J. Nerv. & Ment. Dis. 126: 225-253, 1958.

20. Montagu, A.: Prenatal Influences, Chas. C. Thomas, Springfield, Ill., 1962. pp. 192-198.

18. Salk, L.: Effects of the Normal Heartbeat Sound on the Behavior of the Newly-Born Infant: Implications for Mental Health. World Mental Health, 12: 168, 1960.

22. Smith, H., Stevens, K. N., and Tomlinson, R. S.: On an Unusual Mode of Chanting by Certain Tibetan Lamas. J. Acoust. Soc. Am. 41: 1262-1264, 1967.

23. Bartholomew, W. T.: Acoustics of Music, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1942, pp. 164-5.

21. Hanson, H.: Some objective Studies of Rhythm in Music. Am. J. Psychiat., 101: 364, 1944.

19. Tulloch, J.D., Brown, B.S, Jacobs, H.L., Prugh, D.G. and Greene W.A.: Normal Heartbeat Sound and the Behavior of Newborn Infants – A replication Study. Pschosomatic Med., 26: 661-670, 1964.

Jeans, Sir James Science & Music Dover Publications, Inc 1968 (reprinted from the Cambridge University press Edition, 1937).

17 Lowrie, R.S.: The Role of Rhythmic Patterns in Childhood. Am. J. Psychiat. 105: 653-60, 1949.