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ABSOLUTE PITCH: COMMON TRAITS IN MUSIC AND LANGUAGE

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Absolute pitch in music means an ability of long-term auditory memory to store pitch standards corresponding to within-octave musical pitch classes, based on a generally recognized reference pitch. Such an ability, extremely rare among Western musicians, appears much more commonly among musicians of Asiatic countries. Hypothetically, it is due to either the special forms and early beginnings of musical education (Japan), or to a sort of "preconditioning" of the pitch-memory system in infants and very young children, to treat pitch value as a meaningful element of speech communication (countries with tone languages). Similarities and differences between absolute pitch in music and the memory for pitch value in tone languages will be discussed in detail.

Keywords: pitch, chroma, absolute pitch, pitch memory.

1. Introduction

Absolute pitch is the ability to recognize or also to produce (e.g. vocally) without help of any reference tone the absolute value of musical pitch chroma, i.e. to name or to produce one of the musical-norm tones like C, C#, D, etc. Absolute pitch is a phenomenon of memory which occurs in Western musical culture very rarely.

The English term "absolute pitch" is misleading. It refers to the quality of pitch, saying that it is "absolute", rather than e.g. "relative" or somehow still different. But it should rather refer not to the sensation of pitch, but to the mechanism of hearing, or to some special features of auditory memory. Still more misleading is the term sometimes used alternatively: "perfect pitch". It replaces the previous descriptive expression with the expression of highly positive assessment, which changes the initial nonsense into a double one. British and American terminology has been rather alone in committing these mistakes, which were luckily omitted in German (*Absolutes Gehör*), French (*l'oreille absolue*), Russian (*absolutnyj sluch*), and in many other languages.

The unprecise formulation of a name for the popular phenomenon may be a source of ambiguity in more advanced technical discussions. This is what happens exactly with the term absolute pitch. We are now forced to admit that it has two different meanings. One referring to the properties of auditory memory, and the other one completely unrelated to memory. In this other meaning the term "absolute pitch" is just what it says, namely "absolute value of pitch"; in other words "pitch value" or "pitch level".

"To have absolute pitch" means to be able to identify (without external reference) the musical pitch as one of the 12 steps (chromas) of the within-octave musical scale. The above ability is called passive AP (TEPLOV, [27]). Its more difficult version called active AP means not only recognizing, but also producing vocally or with a tone generator a given musical note without the aid of a tuning fork. As may be seen from the above descriptions, detection of absolute pitch requires that its possessors have at least some elementary knowledge of music and know the names of the chromatic-scale steps of musical pitch. Of course it does not exclude the possibility that a hidden tendency to develop AP exists in some, musically not enlighted individuals.

The phenomenon of "having AP", definitely unusual among Western musicians (according to RÉVÉSZ, [23], it occurs only in about 3% of their population)[(1)] and, as found recently, much more common among the musicians of Asiatic origin (GREGERSEN *et al.*, [14, 15]; DEUTSCH *et al.*, [11–13]) has long been a subject of great interest of music theoreticians and psychologists. It seems to have been first noticed by STUMPF, [26] as a characteristic of particularly gifted composers. At the end of 19-th and beginning of 20-th century several other authors dedicated their time trying to describe and explain this fascinating phenomenon of musical memory. But rather than following their efforts, it will be more instructive to make a half century step forward and look at the influential paper by the American psychologist George Miller, entitled "The magical number seven plus or minus two" (MILLER, [18]). In that paper Miller referred to the informational capacity of human memory. He tried to find how many degrees of intensity of an unidimensional sensation can be recognized and identified in an absolute manner, i.e. without any external "anchor" for comparisons. He found there an intriguing universal constraint expressed in the title of his paper. Various unidimensional sensations, like brightness of light, intensity of some definite taste (like saltiness of water), loudness or pitch of a tone, can be remembered in an absolute manner only in a very limited number of categories of their strength, or perceived intensity. Miller's finding was based on numerous experiments performed by various authors. As far as the story goes with pitch,

[(1)] The pitch-naming test performed with 251 students of Chopin Academy of Music in Warsaw has shown that 13 of them (5.2%) could recognize musical names of all tones presented, 26 persons (10.4%) have recognized at least 83% of tones, 39 persons (15.5%) have recognized at least 65% of tones and 49 persons (19.5%) have named correctly at least 50% of tones. The test was constructed of 25 piano tones taken from 5 octaves and presented at time intervals of 6 seconds.

he referred to the investigations of another well known American psychologist, Irwin Pollack. POLLACK [21] found that in the frequency range 100–8000 Hz the human ear is able to recognize and identify perfectly only 5 distinct pitch values, that corresponds to absolute information transfer of 2.3 bits.

Miller, after making some corrections on Pollack's data estimates pitch information transfer as 2.5 bits and corresponding number of recognizable pitch values as 6. However, at the end of the appropriate part of his paper he makes a significant remark referring to the capacity of human memory for pitch (MILLER, [18], p. 86):

"Most people are surprised that the number is as small as six. Of course, there is evidence that a musically sophisticated person with absolute pitch can identify accurately any one of 50 or 60 different pitches. Fortunately, I do not have time to discuss these remarkable exceptions. I say it is fortunate because I do not know how to explain their superior performance. So I shall stick to the more pedestrian fact that most of us can identify about one out of only five or six pitches before we begin to get confused".

To start discussing the "superior performance" of AP possessors, that George Miller did not have time to bother with, we have to come back again to the turn of the century. Probably von BRENTANO, [8] was the first who turned attention to the very particular way of perceiving pitch in music. He noticed that there is an important difference between the natural, uniform sensation of pitch, a "tone height" that we perceive listening to every ambient sounds, and the sensation of various "tone colors" that we perceive hearing individual musical pitches, the separate units that serve like bricks in building musical constructions. The same view was later accepted and widespread by RÉVÉSZ, [23]. It also served Bachem, the most important early investigator of absolute pitch, in formulating his notion of a "chroma". In the first of his papers published in 1937 Bachem states: *"C-chroma shall refer to the common aspects of all the C's (C-ness), and the general term "tone chroma" shall point to the underlying quality of any tone and the tones in octave periodicity with it."* (BACHEM, [1], p. 147).

The double performance of pitch sensation in music, i.e. the parallel existence of natural pitch (tone height) and a within-octave scale of twelve tone chromas, constitutes the base for the formation of musical absolute pitch. It also explains the phenomenon that was a source of deep confusion for George Miller while writing his text in 1956. There is one way, and it seems – the only one way, how to reconcile the generality of the 7 ± 2 rule with the fact that an AP possessor can identify without a mistake as much as 60 different pitch values. This way is to recognize the fact that tone height (natural pitch) and tone chroma (a within-octave system of musical pitch classes based on a generally recognized pitch standard) constitute two independent, unidimensional scales of pitch sensation in music (RAKOWSKI, [22]).

The possessor of full and faultless absolute pitch who can recognize 12 pitch chromas in any of at least 5 octaves, makes the job of recognizing 60 pitches without any effort. In each singular task he makes 2 completely independent decisions: One while choosing the proper pitch name along the scale of 12 tone chromas, the other one along the scale of natural pitch, where he chooses the proper octave. The possessor of quasi absolute pitch (the term of Bachem; it might be replaced by the term "partial AP") may do the same job of identification, but his work will be done with greater effort and will take more time. The possessor of partial absolute pitch has in his long-term memory only one or two (rather than 12) permanently fixed musical pitch standards. Using these standards as points of reference, and operating well-memorized musical intervals, the partial AP possessor may identify any musical pitch desired.

There is still some doubt as to whether memorizing 12 steps of the tone-chroma scale may be somehow explained in view of the constructions of information transfer imposed on single-dimensional scales of sensation by the magical-number-seven rule. There may be two hypothetical solutions to this problem. First, as it will be shown later, acquisition of the full number of chromas seems to be a gradual process. The first group of tones recognized by a child represents most often a white-key scale. The remaining "chromatic steps" are acquired later and very often fixed in the memory less strongly. The other solution lies in a very specific form of perception of different chromas by an AP possessor. According to introspective relations of people having absolute pitch, the difference in perceiving various chromas is not only quantitative (how much higher or lower along the scale) but to some degree also qualitative. It is somehow similar to recognizing different colors (see the first remarks on this phenomenon by BRENTANO, [8]). This particular case of "quasi-multidimensionality" may be changing somehow the strict limitations of unidimensional perception.

2. Learning absolute pitch

In the previous section we have already made a remark that some people, young or old, also those without any musical education, may have latent predispositions for achieving some forms of absolute pitch. That will be broaderly discussed in the third section of this paper. But before that, it will be instructive to look at two very different cases, where people of different ages tried or were taught to acquire absolute pitch. The methods used in both cases were rather different, though had some unifying traits.

2.1. Learning absolute pitch by children in Yamaha music school

It is generally known that the percentage of AP possessors among the students of music departments in Japanese universities and colleges is greater than that among students of analogous schools in Europe. The most important (though perhaps not the only one) factor responsible for it is the great popularity in Japan of music schools for children, where great care is taken to train very young children in identifying the absolute pitch of musical tones. The most popular music schools for children run by Yamaha have their program carefully prepared and strictly executed. The age of children is usually, between 4 and 10 years. A two-year Primary Course begins with learning by children to use and to recognize a very limited, gradually increasing part of the diatonic scale. The method of "fixed do" is used throughout the course and continued in later years.

In the first semester only five chromas are used as pitches C4, D4, E4, F4, and G4, supplemented by the octave downward repetitions of C and G. The pitch names are always replaced by "fixed do" names do, re, mi, fa, sol, etc. Learning and singing begins with the simplest child tunes, like the melodies constructed only on three chromas: do, re, mi. The lessons (once a week, with many repetitions by parents at home) consist in singing a given song with solmization, playing it on a piano by the teacher, and singing it by a child while it is played on the piano. These simplest songs are played and sung in lessons during first 6 months. In later stages learning the diatonic material is completed and chromatic notes introduced gradually. Children make their first steps in beginning to play the piano and sing songs of various character. All the time, however, pitch of tones is demonstrated as being the part of a system of absolute pitch values. This is constantly enhanced by singing with "fixed do" solmization and by learning to recognize aurally every note played on a piano and every key of a song being played. At the Advanced Course (age 6–10) children have opportunities to play, compose, arrange and improvise music. They learn the pitch relations, such as intervals, chords and chord progressions. This is to strengthen their musical consciousness of pitch relations in the domain of relative pitch, while making them aware of the absolute-pitch character of the material in use.

In a recent publication, Ken'ichi Miyazaki and Yoko Ogawa report on their research conducted in Yamaha music school situated in Tokyo (MIYAZAKI and OGAWA, [19]). They performed there a series of regular individual tests on recognition of the chroma with 104 children in 6 reasonably equal age groups: 4 years, 5 years, 6 years, 7 years, 8 years, and 9 to 10 years. The results show a systematic growth in average percentage of correct responses in subsequent age groups, with dramatic increase between 6 an 7 years and with saturation at 8 years of age. The numbers are as follows (age/perc. corr.): 4/near chance, 5/27%, 6/49%, 7/78%, 8/84%, 9+10/85%. As can be seen, the averaged results of testing AP in consecutive classes of Yamaha music school show the improvement from random guessing up to the level corresponding to the demands of a full and nearly faultless absolute pitch. The type of research has some obvious flaws, because it does not show development in the same group of subjects. Nevertheless the conclusions are clear. Absolute pitch can be learned when (it is too early to say "if") two conditions are fulfilled: 1. The education starts early enough and lasts long enough. 2. It is begun by gradually imprinting in the long-term memory consecutive diatonic chromas, and by strengthening the imprints with musical activity.

There was yet another important output from Miyazaki and Ogawa's research; the one that concerned differences in the acquisition of the diatonic and chromatic steps of the scale ("white keys" vs. "black keys"). As it could be expected, through all the age groups the percentage of white-keys recognition overpassed the one of black keys. The largest difference occurred at the age of 6 (70% white vs. 17% black correctly identified). It diminishes after saturation, yet it was still present at the age 9–10 (94% white vs. 74% black). This phenomenon well illustrates the gradual form of AP acquisition.

2.2. Learning absolute pitch by adults

The first and so far the only one documented evidence for acquiring absolute pitch by an adult person through learning was that of BRADY, [7]. He adapted the method described by Lola Cuddy as "reference training", according to her experience superior to "series training" (CUDDY, [10]). The series training was a procedure of "absolute judgment with feedback", typical of associative-learning methods. In that procedure, during training each tone in a series was presented equally often. The subject was required to name a tone and was given a feedback – the right answer. In the experiments of CUDDY, [10] that procedure did not work, and the memory for musical pitches before and after training was practically equal.

In contrast to the above-mentioned behavioral method, the procedure of reference training (based on structural models of the musical pitch system) appeared effective. In this procedure tone A4 = 440 Hz was selected as a reference point. During training sessions this tone was presented frequently, with feedback, in various sequential combinations with other tones. Those other tones during training sessions were not identified. The pitch-naming test performed before and after training sessions showed a significant improvement of all subjects in musical pitch recognition. It should be mentioned that the subjects taking part in the above-described experiments were experienced in operating musical intervals (CUDDY, [10]). Unfortunately, the long-term persistence of the new skill of the subjects in identifying absolute pitch is unknown.

Brady, who performed the experiment on himself as the only subject, decided to modify the reference training method of CUDDY, [10] not only by changing the reference tone from A = 440 Hz to C = 523 Hz, but also by taking advantage of the possibility (which appeared during training) of fixing in his long-term memory not only a reference point (the single tone C), but also a highly organized structure – the scale C major.

The training sessions, like in Cuddy's experiment consisted in listening to series of various tones. Among those tones the reference tone C was presented at first more, then less frequently. This tone had to be identified, and feedback was given. However, in these training sessions, from the very beginning, Brady tried not only to recognize the reference tone but also, in relations to this tone, all other tones of the 12-tone chromatic system. This gave him a possibility to develop a perfect skill in operating musical intervals. Then, after some time, quite unexpectedly some new phenomenon appeared. Several tones became familiar not only as being at a definite pitch distance from the reference point, but simply being parts of the reference system themselves and identified as such. This reference system was the C-major scale. The author says: *"... concentrating on one scale only, each absolute note retained a unique chroma,... all notes were remembered strictly according to their position in the C-major scale... certain notes were simply remembered as such... "* (BRADY, [7], p. 885). From other descriptions we learn that Brady's reaction to pitches was instantaneous and generally not based on relative-pitch assessments.

The work done by Brady seems quite imposing. In his training sessions he used recorded series of pure tones with various frequency of occurrence of reference tone and with various reaction times imposed. He listened to these tapes for about 60 hours. After that training, a special pitch-naming test was performed. For 57 consecutive days, every morning he was presented with one piano tone, selected randomly along the chromatic scale of about 4 octaves, and had to name each chroma. The ratio of correct answers was 65%; according to WARD, [28] such an accuracy would correspond to a "nearly perfect" absolute pitch. It should be noted that Brady, following many authors, and against many others, states that recognition of musical pitch of pure tones or piano tones is of equal difficulty.

Since we know from published data that so far all other endeavors of adult persons to learn absolute pitch were fruitless (MEYER, [17]; MULL, [20]; WEDELL, [29]; HELLER and AUERBACH, [16]; RUSH, [24]) we might want to ask Dr Brady whether he retained this ability in later years. There seems to be very little evidence on this issue in the literature, however some information may be found in the informal Bulletine of Education Testing Service (CARROL, [9]). John B. Caroll published there the results of his experiments on absolute pitch. In those experiments P.T. Brady took part as one of the AP listeners (actually denoted as TAP – trained absolute pitch), and in the pitch-naming test of 127 stimuli obtained the percent-correct score of 67%. Unfortunately no exact date of performing that experiment was given.

3. Absolute pitch, speech prosody, and tone languages

The "classical" theory of absolute pitch in music was created by BACHEM [1–5]. Bachem was strongly convinced about the importance of genetic factors in acquiring absolute pitch, and was sure that acquiring it in adolescence by learning is impossible. Bachem invented the term "musical chroma", and he KNEW (being an AP possessor himself) that various chromas are qualitatively different from each other and preserve their identity across octaves. BACHEM, [1] introduced the first (and still valid to some degree) classification of various cases of absolute pitch. The basic category is formed by the notion of the genuine AP. Possessors of genuine AP remember chromas as discrete, quantitatively distinct aural phenomena. Quasi AP means having memorized only very limited number of chromas (typically one) and judging upon other musical pitch values by manipulating musical intervals. Pseudo AP means the ability to remember more or less accurately a given value of the tone height, without perceiving it as a chroma.

For a long time there were two theories explaining the genesis of AP. The first was the above-mentioned theory of heredity, with BACHEM, [5] and RÉVÉSZ, [23] as its advocates. In its most extreme form the theory of heredity was telling simply that there are two kinds of people, those that have, or may have AP as soon as appropriate situation arises, and those that have not and will never have this ability. The theory of heredity has been strongly opposed by the theory of learning. The theory of learning held a much more humanitarian view that all people are born equal and that anybody can learn anything at any age, at least as far as elementary capabilities are concerned. Many adherents of this theory have put a lot of effort and spent a lot of time trying to prove it. Unfortunately, nearly all of them in vain. It seems that the first was Max MEYER [17], and most recent ones are probably still working.

Some later developed theories tried to assume that even allowing for some elements of heredity, all new-born infants are generally sensitive rather to absolute than to relative values of the stimuli, so perceiving and remembering absolute pitch would be for them quite natural (see also SAFFRAN and GRIEPENTROG, [25]). However, the interaction of an infant with acoustic environment must have a detrimental effect on these primary tendencies. It may by hypothesized that particularly strong negative influence is that of the first endeavors of a child to communicate vocally with his mother. The patterns of a mother's voice prosody or, more exactly, the mother's special intonation while addressing the child is probably performed at various pitch levels. Also some very early child's vocalizations trying to imitate the mother's intonation, for obvious physiological reasons cannot be performed preserving the original absolute pitch. In both the above-mentioned cases speech prosody seems to be a factor strongly inhibiting the hypothetical, natural tendency of infants to preserve the ability of identifying and memorizing absolute pitch. And there are many other factors (e.g. musical) that later do the same job; nevertheless it should be remembered, that according to biological laws, the earlier in a child's life such an inhibition occurs, the stronger its influence.

According to such reasoning, learning absolute pitch means removing the effects of inhibition, the one that an infant's auditory system had experienced in very early days. This is connected with giving names to auditory stimuli – the musical norm tones (i.e. musical pitch values based on a recognized norm A = 440 Hz). The earlier in the child's life this work had begun, the more certain its positive results. The period of natural language acquisition seems to be a proper time for it. That conclusion perfectly agrees with the general opinion of music educators. Some time ago, in an interesting paper, Baharloo and his colleagues (BAHARLOO *et al.*, [6]) reported on the results of a large-scale survey in which 612 musicians, possessors or non-possessors of AP, were telling at what age their musical training had begun. The respondents were divided in five groups depending of that age, namely: less than 4, 4–6, 6–9, 9–12, and over 12 years of age. The percentage of AP possessors in each group was respectively 40, 27, 8, 4 and 2.7%.

Quite recently some evidence appeared indicating that speech phenomena, may also have some, quite positive influence on the ease of acquiring absolute pitch by children. That important evidence was gathered while conducting investigations on groups of speakers of tone languages. The tone languages use pitch to signal a difference in meaning between words. The same word may have a totally different meaning depending on whether it is pronounced high or low along the scale of absolute pitch value, and also whether the shape of intonation curve leads downward, upward, or along some definite curvature. So far there is not enough evidence, based on the exact measurements, concerning pitch of the words in tone languages.

In 1999, Diana Deutsch, Trevor Henthorn and Mark Dolson reported on an experiment in which they used a simplified method of estimating absolute-pitch values of single tone-language words (DEUTSCH *et al.*, [11]). Such representative mean values were obtained by averaging current frequency measurements taken along the utterance of a given word. Deutsch, Henthorn and Dolson's experiment was performed on two groups of tone-language speakers, 7 Vietnamese and 15 Chinese-Mandarin. The speakers were required to read out lists of their-language words on two different days, and for each speaker the correspondence between absolute-pitch values of the same word on different days was estimated. This correspondence appeared to be *"well within a semitone"*. The same data were shown by Deutsch, Henthorn, and Dolson five years later in a publication (DEUTSCH *et al.*, [12]) where it was compared with the data obtained from a group of 14 native speakers of a non-tone language, namely American English. In this last case absolute-pitch stability across days was much lower than in the case of tone-language speakers.

Diana Deutsch (DEUTSCH *et al.*, [13]) and Trevor Henthorn, accompanied by Elisabeth Marvin (Eastman School of Music) and HongShuai Xu (University in Beijing) continued the studies that had started in 1999 (DEUTSCH *et al.*, [11]). This time they compared the results of a pitch-naming piano-tone test of AP administered to two large groups of speakers, 88 students speaking Mandarin and 115 students speaking English. The subjects provided information about the age at which they had started their musical training. The results of testing were compared among two groups of subjects and relative to the age of beginning of the musical training. Three categories were specified according to the age of beginning musical training: 4–5, 6–7 and 8–9 years of age. Scoring over 85% correct in AP testing was considered as "having absolute pitch". Percentage of AP possessors among those that had started musical education very early (at 4-5 years of age) was about 60% in Chinese and about 14% in American group, among those that had started at 6-7 years the percentage was 55% in Chinese and 6% in American group, and among those that had started at 8–9 years 42% Chinese students met the criteria but no one from the American group did. Two general facts were noted. First, as is generally known, the earlier the music education starts, the better the chances for having AP. The second fact is: tone language speakers have absolute pitch much more frequently than the people speaking non-tone languages. This second observation based on actual measurements, confirms the results obtained by other authors in very large surveys GREGERSEN *et al.*, [14, 15]. Deutsch, Henthorn, Marwin and HongShuai Xu (DEUSTCH *et al.*, [13]) put forward the following hypothesis. Speakers of tone languages, who learn from the infancy to perceive absolute values of pitch in a linguistic mode, are later better than non-tone-language speakers prepared to learn musical absolute pitch. They take that learning somehow like "learning the second language" and get in it relatively good results.

As mentioned before, the research somehow similar to those of Deutsch and her colleagues were reported in 1999 and 2000. They were conducted by Gregersen and two other researchers from the North Shore University Hospital, Manhasset, NY, and accompanied by Elisabeth W. Marwin from Eastman School of Music, Rochester, NY, the same that later took part in the researches of Diana Deustch. GREGERSEN *et al.*, [14] had made a great survey of 2.707 music students from various universities and college music programs in the United States. They found a strong correlation between the prevalence of absolute pitch and the reported ethnic background of students as "Asian or Pacific islander". In fact, the percent of AP possessors in Asian students appeared to be 32.1%, while in non-Asian students it was only 7%.

In their second publication (GREGERSEN *et al.*, [15]) the authors reported on a survey of 1067 music students enrolled in music theory classes of 13 educational institutions in the U.S. This time in a questionnaire, among others, they had included the question on the age of the respondents at the beginning of their musical education. The overall rate of AP in the whole population of those students was 12.2% and was markedly increased in the group of 80 students of Asian origin (47.5%). In three subgroups of Asian students the percentage of AP possessors was following: Japanese 26%, Korean 37% and Chinese 65% AP possessors. According to the authors, one of the possible explanations for the high prevalence of AP in Asian students may be the early musical training (before the age of 7). It appears from the data provided in questionnaires that this training in Asian students was performed most frequently with the "fixed do" technique. However, even those students that had reported the absence of early music training differed markedly in the possession of AP depending on the Asian or non-Asian ethic background. The rate of AP in that group was estimated as 20% in Asian and 3% in non-Asian students.

The results of a survey conducted by GREGERSEN *et al.*, [14, 15], as well as the data obtained from the direct, on-site testing performed comparatively on Chinese and American students of music (DEUTSCH *et al.*, [13]) demonstrate the greater prevalence of AP in Asian subjects, independently of the onset of musical training in the groups compared. Two concepts have been formulated to explain that obvious phenomenon. The first one refers to possible genetic differences. It is put forward by GREGERSEN *et al.*, ([15], p. 282) in following words: *"The most reasonable view of the existing data is that certain early childhood musical exposures increase the probability of AP in genetically susceptible individuals"*.

The other view tries to connect greater susceptibility to AP in some Asian students with particular properties of their languages, namely the tone languages (DEUTSCH *et al.*, [13]). According to that concept *"... the potential for acquiring absolute pitch is universal at birth"*. From this universal beginning the infants become more and more attuned to the characteristics of the language, that surrounds them. In case of the tone languages the infants' attention is driven towards the lexical meaning of both the pitch variations and pitch absolute values. This is like including the phenomenon of absolute pitch into the set of tools necessary for speech communication. From that inclusion the way to acceptance and learning musical absolute pitch is not very far.

Commenting on that view we may add the following.

1. The presence of an ambient language has a deep influence on the formation of the auditory system of an infant. The infant's first attempts to tie a voice communication with his mother may play a particularly strong part in that process.
2. The prosody of any ambient language must have a strong inhibitory effect on the natural tendency of an infant to perceive and remember rather absolute than relative values of pitch. This inhibitory effect may appear less strong when the ambient language is a tone language rather than when it is a non-tone language.

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