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Letter to the Editor

Early Childhood Music Education and Predisposition to Absolute Pitch: Teasing Apart Genes and Environment

To the Editor:

Twelve years ago in this journal, Profita and Bidder [1988] reported the first evidence for familial aggregation of a rare cognitive phenotype known commonly as "perfect pitch", also designated "absolute pitch." Since that report, several studies [Baharloo et al., 1998; Gregersen et al., 1999] provided evidence for genetic and environmental effects in predisposing to the development of absolute pitch (AP). Absolute pitch is a relatively uncommon cognitive ability possessed by a minority of professional and amateur musicians, characterized by their ability to identify pitch names, or to recall specific pitches, without benefit of a reference pitch; this is usually accomplished in a relatively effortless and instantaneous fashion [Ward and Burns, 1982; Gregersen, 1998]. The prevalence of AP in the general population is unknown because it cannot be ascertained in subjects unless they possess at least a minimum amount of musical education. The prevalence of AP in populations of students in professional level music schools or in the personnel of major orchestras is in the range of 10–15% [Baharloo et al., 1998; Gregersen et al., 1999]. This is in contrast to the prevalence estimate of 1/1,500 in amateur music students reported previously [Profita and Bidder, 1988]. A history of formal musical training before age 7 is widely acknowledged to predispose to AP; however, such training is neither necessary nor sufficient in most persons. As noted above, substantial familial aggregation of AP occurs, although it is unclear to what degree this reflects genetic factors [Baharloo et al., 1998; Gregersen et al., 1999].

We report the results of a survey of 1067 music students who were enrolled in music theory classes in one of 13 educational institutions in the United States. In addition to questions concerning AP ability and family history, we attempted to establish the nature of the musical training that these students received before the age of 7. Some types of early childhood education are designed with the express purpose of developing AP ability. These include the Yamaha method, the Royal College method, and other methods termed "fixed do." "Fixed do" pedagogy expressly associates solfége syllables (do-re-mi, etc.) with particular standard pitches: for example "do" is always C, "sol" is always G. Other types of training are more geared to the development of overall musicality, and emphasize the development of relative pitch ability, with minimal if any attempt to train for absolute pitch recognition. These include the Suzuki method, and other "moveable do" techniques. "Moveable do" pedagogy associates solfége syllables with a scalar function within a key, so that "do" can associate with different pitches, depending on the key being utilized for the training exercise. Instrumental music lessons generally place no emphasis on absolute pitch ability, and we did not categorize them as part of "fixed do" pedagogy, although of course, practice on most instruments does reinforce the association of particular note names with specific pitches. We also asked about other forms of exposure to music, such as the presence of a parent or sib who either studied or taught music in the home. Respondents were specifically asked to indicate which of these types of exposure to music they had received before the age of 7.

The overall rate of AP in this population was 12.2%. Similar to results we reported previously [Gregersen et al., 1999], there was a markedly increased rate of AP among Asian students (42/80; 47.5%) compared with Caucasian students (75/834; 9.0%). The relatively higher rate in Asians was present among all the major ethnic subgroups - Japanese (26% AP+), Korean (37% AP+) and Chinese (65% AP+). One possible explanation for this difference might be that early childhood music exposure is more frequent in Asian students. There was no significant difference, however, between these two ethnic groups, with 80% of Asians and 71% of Caucasians reporting early music exposure of at least some type ($P = 0.09$). When the type of early childhood music training was compared, however, Asians were significantly more likely to have been exposed to early training based on "fixed do" techniques compared with Caucasians (29% vs. 6.0%, $P = 0.001$).

We also performed a logistic regression using different types of early childhood music training among

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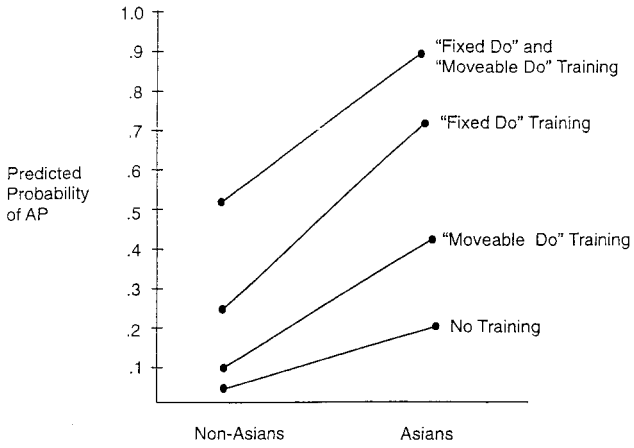

Fig. 1. Results of a logistic regression analysis to examine the role of race (Asian vs. non-Asian) and early childhood music exposureon the probability of developing AP. Musical exposure/training was divided into three types: 1) No training before age 7; 2) exposure or training that predominantly emphasize "moveable do" methods and the development of relative pitch, and 3) training that emphasizes the development of absolute pitch skills based on "fixed do" methods.

individuals with and without AP, also taking account of ethnic background (Asian vs. non-Asian). We considered separately students without any training at all before age 7, those who received training based on "moveable do" (including instrument instruction or exposure to relatives teaching or studying music in the home), and those whose training included "fixed do" methods. The results are shown in Figure 1. Note that for all childhood training environments, the probability of AP in Asians exceeds that for non-Asians. Furthermore, the predicted AP rate is greater in the setting of more early training, especially training based on "fixed do" methods. This emphasizes that early childhood music training has a major impact on the development of AP. Nevertheless, the logistic regression analysis also predicts that even in the absence of musical training or exposure before age 7, the predicted probability of Asian music students having AP is 0.20; among non-Asians, this probability is 0.03. Thus, early childhood training substantially enhances the probability of AP, but is not an absolute requirement for its development.

The lack of an absolute requirement for early training is also shown by the fact that among Asians with AP, 15.8% of our sample reported no early music exposure or training; this figure was 6.7% in Caucasians with AP. In addition, high levels of training do not guarantee the development of absolute pitch. For example, among students without AP, 4.7% reported early childhood training using both fixed and moveable do techniques before age 7.

We have previously provided an estimate of λ_s (relative risk to sibs) for AP, by comparing the rate of AP in the sibs of AP+ and AP− index cases [Gregersen et al., 1999] Using this new set of data, we again calculate a significant overall λ_s=12.2. This figure is calculated as follows:

$$\frac{\text{Rate of AP in sibs of music students with AP}(15.9\%)}{\text{Rate of AP in sibs of music students without AP}(1.3\%)}$$

Because the denominator in this λ_s calculation utilizes the AP rate in sibs of music students without AP, we have argued previously that this corrects somewhat for the role of environment [Gregersen et al., 1999]. This is based on the supposition that most music students and their sibs have some degree of exposure to music when growing up, and are at least more similar to one another in this regard when compared to the general population. Clearly, if the traditional means of calculating λ_s were utilized, that uses overall population prevalence in the denominator [Risch, 1990], the resulting λ_s value would be extremely high. This is because AP in the general population is probably at least an order of magnitude lower than in sibs of AP− music students [Profita and Bidder, 1988], and in any case is unmeasurable.

The current study allows us at least to partially address the role of environment in the contribution to this estimate of λ_s. Thus, we have also examined the rate of AP in various groups of sibs, stratified by the amount of early childhood exposure reported by the index cases (either AP+ or AP− music students). These figures are shown in Table I for 8 different groups of

TABLE I. Sib Recurrence Rates for AP in Various Subsets of Music Students*

Sib group	Sibling population	Sibs with AP n (%)
1	Sibs (n=182) of AP + music students	29 (15.9)
2	Sibs (n=1448) of AP− music students	19 (1.3)
3	Sibs (n=726) of AP− music students who had training (any type) before age 7	13 (1.8)
4	Sibs (n=722) of AP− music students who did not have training (any type) before age 7	6 (0.8)
5	Sibs (n=157) of AP+ music students who had training (any type) before age 7	25 (15.9)
6	Sibs (n=25) of AP+ music students who did not have training (any type) before age 7	4 (16)
7	Sibs (n=35) of AP+ music students who had "fixed do" training before age 7	8 (22.9)
8	Sibs (n=86) of AP− music students who had "fixed do" training before age 7	1 (1.2)

*Group 1 vs. Group 2 ($P < 0.001$); Group 1 vs. Group 3 ($P < 0.001$); Group 3 vs. Group 4 (P=NS); Group 5 vs. Group 6 (P=NS); Group 7 vs. Group 8 ($P < 0.001$).

sibs. Groups 1 and 2 give the overall sib AP rates, as discussed above. There is no significant difference in the rate of AP in the sibs of AP− students who had (Group 3), or did not have (Group 4) early childhood training ($P = 0.11$). Furthermore, early childhood training also does not appear to influence AP rates in the sibs of propositi with AP (Group 5 vs. Group 6). Perhaps most compelling is the significant difference between Group 7 and Group 8. These two groups contain sibs of students who all underwent "fixed do" training before age 7. Note that in Group 7 (sibs of AP+ propositi) the sib recurrence rate for AP is 22.9%. In contrast, in Group 8, where the index cases are all AP−, the sib rate of AP is only 1.2%. Thus, if early childhood "fixed do" training in the index cases is treated as a surrogate indicator for a generally predisposing environment in the family, the data indicate that this has no impact on the extent of familial aggregation.

In summary, we suggest that AP provides a unique opportunity to investigate the role of gene–environment interactions on a relatively "clean" cognitive phenotype [Miyazaki, 1980; Baharloo et al., 1998]. 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 size and complexity of the genetic effect are unknown, although a recent analysis [Baharloo et al., 2000] indicates the presence of major locus effects in AP. As in other complex phenotypes, it is likely that combination of genetic mapping approaches will be required to definitively demonstrate the role of genetic factors [Risch, 2000].

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