Absolute pitch correlates with high performance on musical dictation

Kevin Dooley and Diana Deutsch[a)]
Department of Psychology, University of California, San Diego, La Jolla, California 92093

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Absolute pitch (AP)—the ability to name a musical note in the absence of a reference note—is a rare ability whose relevance to musical proficiency has so far been unclear. Sixty trained musicians—thirty who self-reported AP and thirty with equivalent age of onset and duration of musical training—were administered a test for AP and also a musical dictation test not requiring AP. Performance on both types of test were highly correlated ($r=.81$, $p<.001$). When subjects were divided into three groups based on their performance on the AP test, highly significant differences between the groups emerged. Those who clearly possessed AP showed remarkably high performance on the musical dictation test, the scores of those without AP varied widely, and the performance of the intermediate group of borderline AP possessors fell between that of clear AP possessors and clear nonpossessors. The findings support the hypothesis that AP is associated with proficiency in performing other musical tasks, and run counter to the claim that it confers a disadvantage in the processing of relative pitch.
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I. INTRODUCTION

Absolute pitch (AP) is defined as the ability to name a musical note in the absence of a reference note, and its prevalence in Western cultures is estimated at less than one in 10,000 (Bachem, 1955). While the subject of much informal speculation, the relationship between AP and musical proficiency has so far been little investigated. On one hand, many distinguished musicians have, at least anecdotally, been credited with possessing AP (c.f. Bachem, 1955), and many other musicians seek to develop this skill. In addition, certain advantages of AP possession have been shown in psychoacoustic tasks involving identification of pitches (Hsieh and Saberi, 2007, 2008a, 2009). However, AP possessors have been found to be subject to a Stroop-like interference effect (Hsieh and Saberi, 2008b; Miyazaki and Rakowski, 2002), and generalizing from this, some researchers have claimed that AP is musically disadvantageous or irrelevant to other aspects of musical processing (cf. Levitin and Rogers, 2005). Furthermore, the potential correlation of AP with the ability to perform various musical tasks is complicated by its association with age of onset of musical training. For example, Miyazaki and Rakowski (2002) have pointed out that to the extent that AP possessors enjoy an advantage in performing musical tasks, this may be due to earlier onset of musical training, longer duration of musical training, or both of these factors.

The present study was designed to test the hypothesis that AP is advantageous in musical contexts beyond the identification of isolated tones, controlling for age of onset and years of musical training. To this end, 60 musically trained subjects were recruited: 30 who self-reported having AP, and 30 who were equivalent in terms of age of onset and duration of musical training. All subjects were given a test of AP, together with a musical dictation test modeled after the placement examination given to all entering music majors at a prestigious music conservatory (the USC Thornton School of Music). The relative contributions to performance level on the musical dictation test of AP possession, age of onset, and duration of musical training were assessed.

II. METHOD

A. Subjects

There were 60 subjects in this study. These were 30 males and 30 females; average age 22.7 years (range 18–30). 30 subjects were recruited who self-reported AP; 30 matched controls were then recruited with equivalent onsets and durations of musical training. Of those who scored more than 80% correct on the AP test ($n=30$, 13 male, 17 female), average age was 22.1 years (range 18–30), average age of onset of musical training was 4.6 years (range 3–8) and average number of years of formal musical training was 15.8 (range 11–25); of those who scored less than 20% correct on the AP test ($n=22$, 13 male, 9 female), average age was 23.3 years (range 18–30), average age of onset of musical training was 4.9 years (range 1–8) and average number of years of training was 15.8 (range 10–28); of those who scored between 20% and 80% correct on the AP test ($n=8$, 4 male, 4 female), average age was 23.0 years (range 19–30), average age of onset of musical training was 4.4 years (range 3–6), and average number of years of training was 14.4 (range 3–27). All subjects self-reported normal hearing.

B. Procedure

All subjects were individually tested. They were first given the test for AP that had been employed in the studies

[a)]Author to whom correspondence should be addressed. Electronic mail: kdooley@ucsd.edu; ddeutsch@ucsd.edu

FIG. 1. The three musical passages presented for the musical dictation test. The first note of each passage was given for the melodic dictation passages, and the highest and lowest notes of the four-part harmony passage.

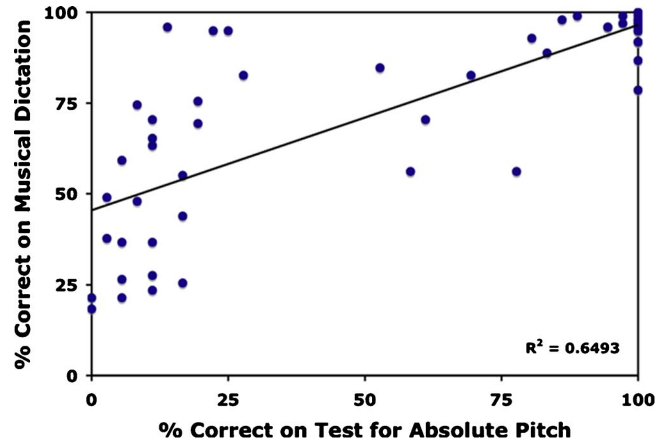

FIG. 2. (Color online) Overall percentage correct on the musical dictation test, as a function of percentage correct on the test for absolute pitch. A least-squares linear regression trendline has been fitted to the data.

by Deutsch *et al.* (2006, 2009). This test consisted of successive presentations of the 36 tones spanning three octaves from C_3 (131 Hz) to B_5 (988 Hz), and subjects were asked to write down the name of each tone (C, F#, E; and so on) after they heard it. All tones were separated from temporally adjacent tones by an interval larger than an octave, in order to minimize the use of relative pitch in making judgments. The tones were piano tones of 500 ms duration, with 4.25-s inter-onset intervals; these were presented in three 12-tone blocks, with 39-s pauses between blocks. A practice block of four successive tones preceded the three test blocks. No feedback was provided at any time during the test.

For the second test, the subjects were presented with three short musical passages (Fig. 1), and in each case were asked to notate what they heard. They were informed that they would be presented aurally with each passage four times in succession, and were provided with blank staff paper on which was given the starting note (or notes, in the case of the third passage) for each passage. They began notating each passage at their own discretion, and continued notating during all four presentations.[1] The experimenter played each new passage, and each presentation of the passage, when the subjects indicated their readiness to hear it.

The first two passages each consisted of a single 32-note melodic line. The tempo of the first passage was 64 bpm (i.e., 937 ms per dotted quarter note). The tempo of the second passage was 88 bpm (i.e., 682 ms per quarter note). The third passage consisted of four-part harmony; for this passage, the first note was given for the soprano (top) and bass (bottom) lines, consisting of 18 and 16 notes respectively, and subjects were instructed to notate only these two lines. The tempo of this passage was 48 bpm (i.e., 1250 ms per quarter note). The passages were composed in accordance with the conventions of Western tonal music, and the entire test, including the approximate level of difficulty and administration procedure, was closely modeled after the musical placement exam given to entering music majors at the USC Thornton School of Music.

Following the tests, the subjects filled out a questionnaire regarding the onset and duration of their music education, and demographic information.

C. Instrumentation

For both types of test, the stimuli were piano tones, generated on a Kurzweil K2000 synthesizer tuned to $A_4 = 440$ Hz. They were recorded onto a Zoom H2 digital audio recorder and were presented to subjects from this recorder via Sony MDR-7506 dynamic stereo headphones, at a level of approximately 72 dB SPL.

III. RESULTS

Figure 2 shows, for each subject, and across all three passages, the percentage of tones that were correctly notated in their correct serial positions, as a function of percentage correct on the test for AP. As can be seen, there was a strong positive relationship between performance on the AP test on the one hand and the musical dictation test on the other ($r=.81$, $p<.001$).[2] This correlation remained equally strong when controlling for age of onset and years of musical training ($r=.81$, $p<.001$). Neither age of onset ($r=-.23$, $p>.05$) nor duration ($r=.19$, $p>.05$) of musical training correlated significantly with the dictation scores.

These trends persisted when each passage was analyzed separately. Indeed, performance was highly consistent across passages, with high correlations between dictation scores on passages 1 and 2 ($r=.84$, $p<.001$), 2 and 3 ($r=.81$, $p<.001$), and 1 and 3 ($r=.82$, $p<.001$). Performance on the AP and musical dictation tests were strongly and significantly correlated taking each passage separately (passage 1 ($r=.76$, $p<.001$), passage 2 ($r=.82$, $p<.001$), and passage 3 ($r=.78$, $p<.001$); again, these correlations remained just as high when controlling for onset and duration of music training ($r=.75$, $p<.001$; $r=.83$, $p<.001$; $r=.78$, $p<.001$, for passage 1, 2, and 3 respectively). As with the overall dictation score, neither age of onset ($r=-.19$, $p>.05$; $r=$

−.06, $p>.05$; $r=-.23$, $p>.05$, respectively) nor duration of musical training ($r=.21$, $p>.05$; $r=.17$, $p>.05$; $r=.23$, $p>.05$, respectively) were significantly correlated with performance on any of the individual passages.

To quantify the extent to which each of these factors predicted overall performance on the dictation test, a multiple regression was performed with percentage correct on the AP test, age of onset of musical training, and years of musical training as predictor variables. AP score alone accounted for nearly two-thirds of all the variance in scores on the musical dictation test ($\beta=.81$, $R^2_{adj}=.66$, $F(1,58)=113.08$, $p<.001$). In fact, including age of onset of training ($\beta=-.04$) and years of training ($\beta=.07$) in the overall regression model accounted for only an additional 1% of the variance in musical dictation scores (R^2_{adj} change=.01, $F(2,56)<1$).

It can also be seen (Fig. 2) that the subjects were divisible into three groups: those who were clear AP possessors (>80% correct on the AP test), all of whom displayed remarkably high performance on the dictation test; those who were clear AP non-possessors (<20% correct), whose dictation scores varied widely; and those who were borderline AP possessors (scoring between *20%–80%* correct), whose dictation scores correspondingly fell between those of the other two groups. (For reference, chance performance on the AP test—based on a 1/12 chance across 36 trials—averages 8.33% correct, and the probability of guessing over 20% correctly is less than 0.01.) This trichotomous categorization of AP ability is consistent with findings from other studies (cf. Temperley and Marvin, 2008; Miyazaki and Ogawa, 2006).

To analyze these between-group differences in the musical dictation scores while controlling for duration and age of onset of musical training, an ANCOVA was performed, with AP category (<20%, *20%–80%*, >80% correct on the AP test) as the grouping variable, and age of onset and years of training as covariates. Age of onset was nonsignificant ($F<1$), as was years of training ($F<1$), and even while controlling for these, the main effect of AP score was highly significant and accounted for most of the variance in performance on the musical dictation test ($F(2,55)=66.04$, $p<.001$, $\eta^2=.71$), consistent with the overall regression analysis described above.

On post hoc comparisons, the performance level was significantly higher for *AP possessors* compared with *non-possessors* ($p<.001$); for *AP possessors* compared with *borderline possessors* ($p<.001$); and for *borderline possessors* compared with *non-possessors* ($p<.005$). Given that there were no significant differences between the groups in terms of age of onset of training ($F<1$) or years of training ($F<1$), these findings indicate strongly that the differences in performance levels between the groups were associated primarily with their differing degrees of AP possession.

IV. DISCUSSION

By considering the relevance of AP to performance on a musical dictation test not requiring AP, the present study adds to a broader, ongoing exploration of the correlates of AP. While it is outside the scope of this article to discuss the genesis of AP in detail, we note that it has been proposed to be genetic in origin (Theusch *et al.*, 2009). It has also been shown that AP possessors have an exaggerated leftwise asymmetry of the planum temporale compared with nonpossessor musicians (Keenan *et al.*, 2001; Schlaug *et al.*, 1995). In addition, it has been found that tone language speakers have a far higher prevalence of AP than do speakers of nontone languages, indicating a speech-related critical period in its genesis (Deutsch *et al.*, 2006, 2009). Related to this, tone language speakers show enhanced abilities to perceive and produce musical pitch (Pfordresher and Brown, 2009). Indeed, the potential for developing AP is evident very early in life (Saffran and Griepentrog, 2001). Incremental effects of early music education on the development of AP have also been documented (Miyazaki and Ogawa, 2006).

As Miyazaki and Rakowski (2002) have pointed out, it is important to distinguish the contributions of AP to musical ability from those of early musical training. In the experiment reported here, the strength of the relationship between AP and a test of musical ability holds, even controlling for age of onset and duration of musical training. Regardless of whether subjects were grouped into discrete categories of AP possession vs. partial possession vs. non-possession, or analyzed as a whole, the single factor of AP score alone accounted for the majority of all variance in performance on the musical dictation tests. Taken together, these results run contrary to the claim that AP is musically irrelevant or disadvantageous (cf. Levitin and Rogers, 2005) and instead strongly support the hypothesis that AP contributes to musical proficiency beyond the simple identification of isolated pitches. The AP possessors in this study uniformly showed very high performance on the musical dictation test, and so showed no evidence of impaired relative pitch processing, thus adding to the growing body of research documenting advantages of AP possession in musical and psychoacoustic tasks (Hsieh and Saberi, 2007, 2008a, 2009).

Our present findings are also related to those reported by Miyazaki and Rakowski (2002). These authors tested AP possessors and nonpossessors using a task that consisted of comparing auditory and visual presentations of melodies to make 'same' or 'different' judgments, for both tonal and atonal patterns, and for transposed as well as untransposed passages. Consistent with the present findings, the authors identified a significant AP advantage for accuracy in judgment of both tonal and atonal melodies when these were played to subjects in the correct key as written; however, they obtained a moderate negative correlation between AP score and judgment accuracy for the transposed melodies, although this correlation was significant only for the atonal melodies. A likely explanation for this apparent discrepancy is that AP possessors are subject to Stroop-like interference effects in artificial situations (Hsieh and Saberi, 2008b; Miyazaki and Rakowski, 2002; Takeuchi and Hulse, 1993).

Converging on a unanimous definition or operationalization of "musical ability" is, of course, a near-impossible task, certainly one outside the scope of the present paper. However, the extent to which the present findings can be considered to reflect overall musical ability depends in part on the external validity of the dictation test used. While the placement exam in the USC Thornton School of Music, upon which this musical dictation task was modeled, can no more capture musicality than any other single test, this task has at least stood the test of time as a practical measure for use by this music conservatory, whose faculty include many highly distinguished musicians. In the present experiment, its relevance to the common demands of music education and performance was further confirmed by a number of subjects who commented (unprompted) that the dictation task presented in this study was very similar to that required of them in various music courses.

While the overwhelmingly large role played by AP in predicting performance on the present dictation test was surprising relative to the comparatively small effects of onset and duration of musical training, we should note that conclusions drawn from this data are limited to the range of the characteristics of the subjects included in the study. Specifically, age of onset of musical training for all subjects ranged from age 1 to age 8, and duration of training ranged from 3 to 28 years; thus, these factors may play a larger role in predicting proficiency at musical dictation or other musical tasks for subject populations that include wider ranges of musical experience.

Although AP is often considered a dichotomous trait (cf. Theusch *et al.*, 2009), some research has found the distinction between AP and non-AP to be more blurred than commonly thought (Takeuchi and Hulse, 1993; Vitouch, 2003). It is worth noting that in the present study also, a substantial minority of subjects did not fall neatly into either the category of AP possessor or that of non-possessor; rather, their AP scores far exceeded chance performance while still falling well short of the level of consistency achieved by clear AP possessors. Furthermore, the musical dictation scores of subjects in this intermediate category fell between those of the AP possessors and non-possessors. The 'borderline' nature of their AP possession was also reflected in their self-awareness regarding AP: While 27 of the 30 clear AP possessors believed they had AP (the other three, when asked, responded 'don't know' to the question of whether or not they possessed AP) and 17 of the 22 non-possessors believed they did not possess AP (five of the non-possessors responded 'don't know'), the eight subjects in the borderline group were split between 3 'yes', 3 'no', and 2 'don't know'. It is also an open question what factors lead individuals to develop borderline AP; one which will likely have implications for the broader question of the genesis of AP in general.

It is also important to note that while all subjects whose AP scores exceeded chance levels performed well on the musical dictation test (an overall mean of 91.7% correct and no scores below 56%) and all clear AP possessors performed very well on the test (a mean of 95.4%, with no scores below 78%), some non-possessors also performed well (a mean of 47.5%, but one even scored above 80% correct). AP is therefore not required for successful performance on musical dictation tasks—and indeed many world-class musicians do not possess AP—however from our present findings this ability appears to confer a musical advantage rather than a disadvantage.

[1]As an exception, one AP possessor finished notating all three passages after only three listenings, declining the option to hear each one a fourth time, and scored 100%, 100%, and 97.1% correct on the three passages.

[2]Because normality assumptions were not met for the raw data based on the Shapiro-Wilk test for AP scores ($p < .001$), musical dictation scores ($p < .001$), years of musical training ($p < .005$), and age of onset of musical training ($p < .005$), all variables were rank-transformed, and all reported statistics are based on the rank-transformed data. Nonetheless, all patterns of significance for the raw data were nearly identical to those reported.

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