Pitch Chromas and Scale-Degree Qualia:
Reconsidering Absolute Pitch and Relative Pitch

Ken'ichi Miyazaki*

Niigata University, 8050 Ikarashi-2-no-cho, Niigata, 950-2181 Japan

E-mail: miyazaki@human.niigata-u.ac.jp

Abstract Pitch chromas and scale-degree qualia are different qualitative aspects of musical pitch; the former are tone characters of absolute pitch categories perceived only by those having absolute pitch, while the latter are relative pitch categories perceived by almost everyone when listening to tonal music. The ability to perceive pitch chromas and scale-degree qualia was compared in a cross-cultural study with music students as participants. The results showed that, compared to the Western and Chinese students, Japanese students had an advantage in pitch chroma identification but had a disadvantage in scale-degree identification. Problems in music education and its socio-cultural background are discussed.

Keywords absolute pitch, relative pitch, pitch chroma, scale degree, qualia, music education

1. Qualitative aspects of musical pitch

In a tradition of pitch perception research, two different aspects of musical pitch are differentiated: a quantitative aspect that continuously changes with sound frequencies and a qualitative aspect that divides the pitch continuum into a limited number of pitch categories. The former represents a continuous pitch dimension called *pitch height,* and the latter a categorical and circular dimension called *pitch chroma.*

Pitch chroma, a term coined by Bachem (1937, 1950)[1,2], denotes tone quality that recurs at intervals of octaves. There are 12 pitch chromas within an octave in the chromatic scale, forming a chroma circle. Originally, Bachem envisioned pitch chroma as C-ness, D-ness, and so on, which is equivalent regardless of octave placement. Then, pitch chroma should be called precisely as *absolute-pitch chroma*, and it is not a universal perceptual attribute everyone can perceive, but an idiosyncratic one limited to persons having absolute pitch. Given pitch chroma as such, the definition of absolute pitch could be stated more precisely as "an ability to identify pitch chroma without relying on any reference pitch."

From the perspective of human music cognition, each musical tone in a diatonic scale has a distinctive musical quality depending on its location (scale degree) in the scale. Melodies and harmony are constructed solely on the basis of pitch relations (relative pitch), and therefore the musical pitch quality could be called as *relative-pitch chroma*. Huron (2006)[3] introduced the term *scale-degree qualia* by borrowing from philosophers[4,5] to denote the musical quality of relative pitches variously named so far as tone characters, tonality, tone quality, and so on. We adopt here the term *scale-degree qualia,* since it is now often used in music theory and music psychology[6, 7].

Pitch chroma of absolute pitch and scale-degree qualia of relative pitch are both subjective experiences, and are believed to be ineffable, a fundamental property of qualia[4,5]. Indeed, they are inherently unobservable; they are accessed only by introspection. Fortunately, as for scale-degree qualia, people with musical experience or perhaps even ordinary people without formal musical experience may share the same feelings (qualia) when hearing given scale-degree tones in a tonal context, just as most people presumably feel the same color quality for a given color stimulus. Huron (2006) conducted a qualia survey with musicians and found a remarkable level of agreement in characterizations of scale-degree qualia[3]. Arthur (2018) asked participants to rate the qualia of scale-degree tones in different harmonic contexts and found that musicians and even non-musicians were fairly consistent in their ratings of scale-degree qualia[7]. The empirical research on scale-degree qualia indicated a correlation with the tonal profile established by Krumhansl and Shepard[8,9]; as expected, the most salient scale-degree qualia are associated with the stability/tension, tendency, and movement, as exemplified by the most stable tonic (the tonal center) and the unstable leading-tone with a strong tendency toward a more stable tone.

In contrast to the scale-degree qualia, it is not known exactly what it is like to experience pitch chroma, because most people having no absolute pitch cannot recognize pitch chromas and there are no convincing reports on the nature of pitch chromas from the very few absolute pitch possessors. Throughout my research on absolute pitch, I often asked participants with absolute pitch what it is like to experience pitch chroma. They gave no informative answers except that many of them told that individual tones are always associated with the spoken sol-fa syllables; a pianist with absolute pitch said that individual piano tones sound as accompanied by spoken syllables, "do, re, mi"; it is just like five Japanese vowels sound as "a, i, u, e, o." This is strange because piano tones of C, D, and E have no spectral similarity with the spoken syllables, "do, re, mi." The association between absolute pitches and spoken sol-fa syllables presumably originate from repeated experience associating absolute pitches with fixed-*do* labels from early age, and as a result, the association is so strongly automatized that it is almost impossible to ignore the sol-fa syllables accompanying when hearing musical tones or even non-musical sounds in every-day life. Apart from the strong association with the sol-fa syllables, absolute pitch chromas seem to be only weak qualia.

2. Recognition of pitch chromas and scale-degree qualia: Cross-cultural comparisons

As discussed in the previous section, the most essential aspects of music, melody and harmony, are constructed almost completely on relative pitch, and the tonal meaning of music, including emotional expression, is based on scale-degree qualia. Then, absolute pitch is, logically by its definition, not relevant to music. However, there is a social belief, particularly in Japan, that absolute pitch is an important faculty for musicianship and most musicians have it. Furthermore, actually, some evidence suggests that absolute pitch is more prevalent among music students in East Asia than in North America and Europe[10-12]. It is interesting to compare recognition of pitch chroma (absolute pitch) and scale-degree qualia (relative pitch) cross-culturally between different countries from the East and the West.

* Emeritus professor

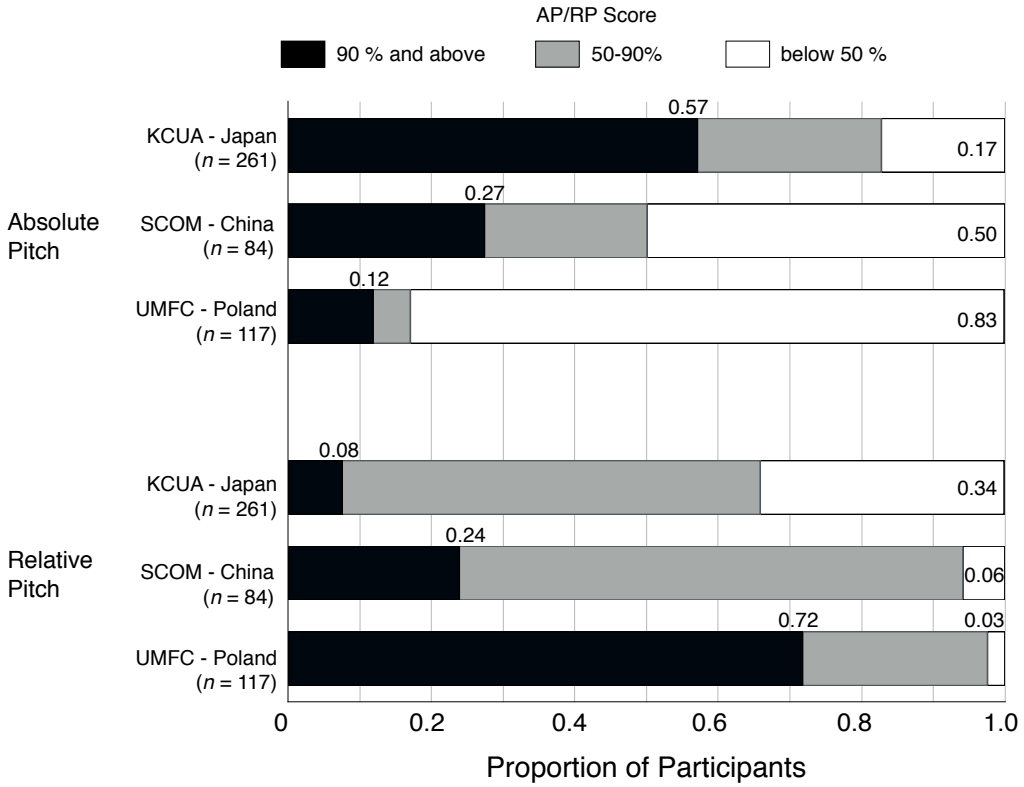

Figure 1. Proportion of the participants classified according to their AP/RP scores for selected conservatory level groups. Adapted from Miyazaki, et al., (2018)[13].

We carried out absolute pitch and relative tests on music students attending conservatories and departments of music or music education in universities in different countries (Japan, China, Poland, Germany, and USA)[13]. The participants were as follows:

- Department of Music, Kyoto City University of Arts (KCUA), Japan, $n = 261$
- Central Conservatory of Music (CCOM), Beijing, China, $n = 62$
- Shanghai Conservatory of Music (SCOM), Shanghai, China, $n = 103$
- Fryderyk Chopin University of Music (UMFC), Warsaw, Poland, $n = 117$
- Music Program of Faculty of Education, Niigata University (NGTU), Niigata, Japan, $n = 143$
- School of Music, Capital Normal University (CNU), Beijing, Chana, $n = 94$
- Institute of Music, Martin-Luther University (MLU), Halle-Wittenberg, Germany, $n = 57$
- School of Music, University of Minnesota (UMN), Minneapolis, USA, $n = 162$

In the absolute pitch test, test items were sixty tones in the chromatic scale over a 5-octave range (C_2–B_6). They were produced from a sampled piano tone generator, and presented in a nearly random order with an inter-tone interval of 3 s. Successive tones in adjacent trials were always different pitch classes separated by more than 14 or more semitones to make it difficult to use relative pitch. The participants were required to write down their musical pitch labels on a response sheet in the inter-tone interval.

In the relative pitch test, a stimulus presented in each trial was a sequence of a pair of chords forming an authentic cadence (the dominant seventh and the tonic chords) and a pair of successive tones; the first tone of the tone pair was always the tonic of the key established by the preceding cadence and the second tone (1- to 11-semitones higher than the first tone) was the test tone for which its scale-degree was to be identified. The key established by the chord sequence was varied from trial to trial among 4 different key conditions (C major, A flat major, F sharp major, and a major with a half-tone higher E as its tonic). The time interval between the onset of the test tone and the onset of the first chord of the next trial was 3.5 s. Participants recorded a sol-fa (relative pitch) name of the test tone relative to the tonic, a scale degree number (1-7 with + or –), or a musical interval name from the tonic. The instruction emphasized that the participants should identify the scale-degree of the test tone in the established key with the penultimate tone as the tonic.

Results of the absolute pitch test are presented in the upper part of Fig. 1. Here, the proportions of the participants classified according to their absolute pitch (AP) scores (percentage correct) are displayed for selected conservatory-level groups. At KCUA (Japan), more than half of participants had accurate absolute pitch (defined as 90% correct or above), and only a small minority were at the non-absolute-pitch level (less than 50% correct). Dividing the participants according to their major, those at the accurate level were almost all for piano majors, and more than two thirds for strings, conducting, and musicology majors, whereas they were about one third for wind instruments and singing majors. At SCOM (China), the proportion of participants at the accurate level was lower than in KCUA as a whole, but it was more than half for composition, conducting, and piano majors. In a striking contrast, at UMFC (Poland), students having accurate absolute pitch accounted for only about one tenth, and there were almost no absolute pitch students in other Western groups.

The distribution of relative pitch (RP) scores shown in the lower part of Fig. 1 revealed a quite opposite pattern. While the proportion of the participants at the accurate level exceeded two thirds at UMFC, it was less than one tenth at KCUA; remarkably, there were no accurate relative pitch students in singing majors in KCUA.

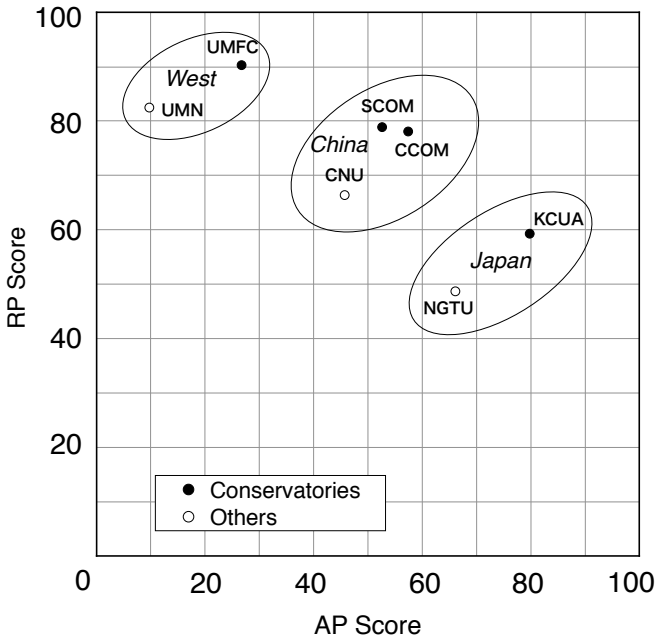

Figure 2. Scatterplot showing the relationship between AP and RP scores averaged across participants for each group. Adapted from Miyazaki, et al., (2018)[13].

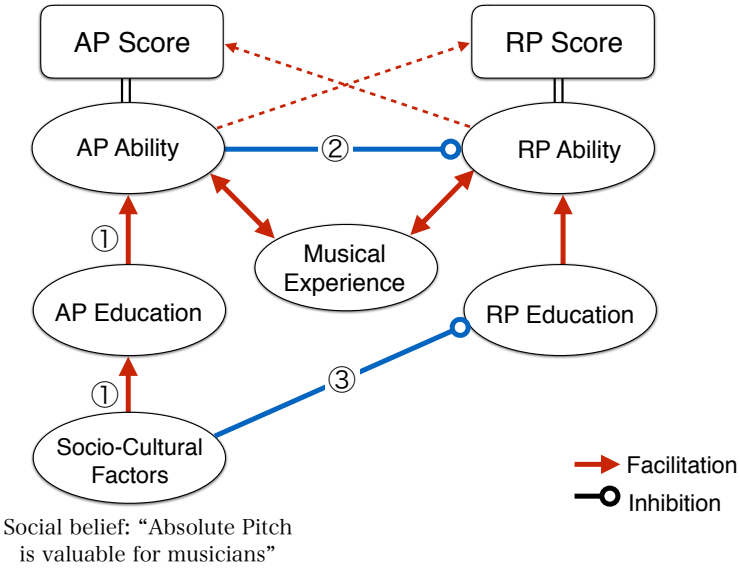

Figure 3. Hypothetical factors influencing on AP and RP scores. Adapted from Miyazaki (2019)[17].

Figure 2 shows a summary of the results showing the averaged AP and RP scores for individual groups of participants. The Japanese groups (KCUA and NGTU) showed high AP scores and low RP scores, while the Western groups (UMFC and UMN) showed low AP scores and high RP scores, with the Chinese groups (CCOM, SCOM, and CNU) in between.

What caused the difference in performance in absolute pitch and relative pitch among different cultures? Figure 3 illustrates a hypothetical causal relationship including factors influencing the AP and RP scores[14]. Factors that caused the peculiar pattern of performance of Japanese music students (excellent absolute pitch and poor relative pitch) are assumed to be the status quo in music education and its background socio-cultural condition in Japan. The higher prevalence and excellence in absolute pitch in Japanese music students is considered to come from early music training widespread in Japan that facilitates the development of absolute pitch, and an underlying socio-cultural situation in which a social belief that absolute pitch is valuable for musicians is popularly accepted. The socio-cultural factors are assumed to lead a particular type of music education that stresses the value of absolute pitch, producing a lot of children and music students having an excellent absolute pitch ability (Fig. 3①). on the other hand, these factors may interfere or distort the primary music education (Fig.3③), specifically the solfege (aural-skills) education, resulting in many Japanese music students who are weak in relative pitch. Furthermore, absolute pitch may suppress the development of the relative pitch ability (Fig.3②); the automatized association between absolute pitch and fixed-*do* labelling discussed above may

cause a cognitive conflict with the scale degree labels impeding effective aural-skills training based on the movable-*do* system. The hypothesized interference of absolute pitch with relative pitch processing is supported by findings obtained in a series of our previous studies[15-17].

The present finding that demonstrates the weakness of Japanese music students in recognizing scale-degree qualia suggests serious problems in the current state of music education in Japan[18]. Solutions to solve the problems may be found in reconsidering the methods of music education from the perspective of human cognition of music, and an urgent task is to find effective ways to develop a sense of scale-degree qualia for children and music students who have already acquired absolute pitch.

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