Recognition of notated melodies by possessors and non-possessors of absolute-pitch

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Running head: ABSOLUTE PITCH AND MELODY RECOGNITION

Musically trained listeners compared a notated melody displayed visually and a comparison melody presented auditorily, and responded whether they were exactly the same or not with respect to relative pitch. Listeners having absolute pitch showed the poorest performance for melodies transposed to different pitch levels from the notated melodies, whereas they exhibited the highest performance for untransposed melodies. By comparison, the performance of melody recognition by listeners not having absolute pitch was not influenced by the actual pitch level at which melodies were played. These results suggest that absolute-pitch listeners tend to rely on absolute pitch even in recognizing transposed melodies for which the absolute-pitch strategy is not useful.

Absolute pitch (AP) is defined as an ability to name single pitches with no reference tone given or to produce pitches corresponding to designated pitch names or musical-note symbols. It has been commonly believed that people with AP are extremely rare (Takeuchi & Hulse, 1993; Ward, 1999). In the musical score, i.e., in the conventionally used musical notation system, the vertical position of the note head on the five-line staff represents absolute pitch. Thus, only people having AP, given a musical score, are able to read out absolute pitch of notes and to have an exact pitch representation of a musical passage just as written in the score. This does not mean that a much greater proportion of people not having AP are not able to read the score. Musically literate people, even those not having AP, are able to read the score, from which they can extract musically meaningful information about pitch relations. Thus, for those people, the musical score represents relative pitch information with any arbitrary pitch as reference. Given a reference pitch, they are able to realize a musical passage exactly as written in the score by using the relative pitch sense. Moreover, even when no reference pitch is given and no support of accompanying instruments is available, musically literate people may be able to sing a melody accurately in relative pitch. Except for cases of people who have AP, people may sing the melody starting at an arbitrary pitch, and hence the pitch level of the melody sung may be often more or less different from that notated in the score. Nevertheless, this singing is musically acceptable so far as pitch relations in the sung melody are exactly reproduced as those described in the score. This is because, in our musical systems, melodies have Gestalt-like properties and are transposable in effect to any different pitch positions with its identity preserved.

By contrast, people who have absolute pitch are able to sing the song with its pitches exactly as notated, even if the reference pitch is not given. However, in spite of such a remarkable ability, there is a possibility that AP possessors may have difficulty when they are required to sing notated melodies in the transposed key (at pitch levels different from the notation), if they realize the melody strictly on the basis of AP. The primary concern of the present experiment is this possible drawback of AP in dealing with pitch relations in melodies.

It is obvious that musical pitch is intrinsically context-dependent. Essential musical information such as melodic and harmonic characteristics of musical passages is conveyed by means of the pitch configuration in certain tonal contexts. The ability to deal with such pitch configurations is called relative pitch. By contrast, absolute pitch is not so essential to music; it may be relevant to music at most when musicians have to tune their instruments or voices to a standard reference pitch before beginning performance.

Thus, previous investigations on music perception have mainly focused on the relational aspect of musical pitch not on absolute pitch (Krumhansl, 2000, for a recent review). For instance, typical experiments on melody recognition have used the delayed comparison procedure, in which listeners hear a standard melody followed by a transposed comparison melody and attempt to judge whether the two melodies are the same or different on the basis of pitch relations (a sequence of musical intervals) regardless of absolute pitch (Bartlett & Dowling, 1980; Cuddy & Cohen, 1976; Dowling, 1978). In experiments investigating the tonal hierarchy using the probe-tone technique (see, e.g., Krumhansl & Kessler, 1982; Krumhansl, 1990, for a comprehensive review), participants hear a probe tone preceded by context stimuli for establishing a particular tonal context and attempt to rate how stable the probe tone sounds in the tonal context. In this type of experiment, typically, the major or minor key context has been established on different tonal centers by providing a diatonic scale or a cadential sequence of chords at different pitch levels; as a consequence, tonal profile obtained from this procedure reflects the tonal hierarchy based on the pitch relations, again, independent of absolute pitch. Listeners with AP are purposefully excluded from the subject pools for these experiments, because it is suspected that AP listeners may use peculiar strategies and provide results quite different from those who have no AP. AP listeners have been usually called for as participants exclusively for experiments focusing on absolute pitch processing. Therefore, it still remains unclear how AP listeners respond in recognizing melodies and rating tonal hierarchies. Due to the exclusion of AP listeners from those experiments of perception of melodies and the tonal hierarchy, these problems until recently have escaped investigation.

Tentatively, AP listeners are expected to provide higher performance in recognizing tonal patterns because AP may anyway facilitate identification of musical pitch. This prediction is consistent with a view that AP is an important component of musical ability. However, considering that AP is musically irrelevant and sometimes even incompatible with relative pitch that is far more essential than AP in music, an alternative challenging hypothesis could be raised that AP listeners may have some disadvantages in certain tasks that require strategies incompatible with those based on absolute pitch.

In order to test this hypothesis, the ability to identify musical pitch relations (i.e., naming relative pitch) was investigated in the previous series of experiments with listeners having AP and those not having AP as participants, both groups having approximately equal degree of musical experience (Miyazaki, 1993, 1995). The participants heard a pair of successive tones forming a differently sized melodic interval and attempted to name the pitch of the second tone relative to the first tone as a reference using relative pitch names, i.e., sol-fa names in the *movable-do* system (for example, "*re*," "*mi*," and so on). The results indicated that both AP listeners and no-AP listeners performed equally well when musical intervals to be identified began with the C note; the listeners of both groups had been extensively trained in music, and so identifying musical intervals beginning with the C note should be very easy for the AP listeners probably by using either AP or relative pitch, and should be so also for the no-AP listeners solely by using relative pitch. In contrast, the AP listeners performed significantly worse when the musical intervals began with the F sharp or out-of-tune E flat note; as a consequence, the performance of the AP listeners was significantly lower than the no-AP listeners in these cases. These results are interpreted to reflect an inevitable tendency AP listeners have developed to rely on AP in processing musical pitches. Presumably, the strategy to rely on AP was indeed effective for the AP listeners in identifying pitch relative to C, because they were highly accustomed to name relative pitch on the basis of the fixed-do system naming C as "*do*" and, hence, the relative-pitch naming task with the C reference turned into an AP naming task, a straightforward and easy task for the AP listeners. However, they had more difficulties in identifying relative pitch with the non-C reference, because here they had to use the relative pitch strategy that is poorly practiced for them, or they would inappropriately stick to the AP strategy and take great effort to transpose the pitch interval to be identified to their home position with the fixed C reference.

However, these results are not so straightforward as directly evidencing the disadvantage of AP, because the performance decline of the AP listeners may be accounted for, at least partially, by the naming system the AP listeners used for responding. The musical-interval identification task in the previous experiments required the participants to name musical intervals using the sol-fa naming system. For no-AP listeners, the sol-fa labels are used as relative pitch names based on the *movable-do* system in which any tone can be *do* according to the current tonal context. However, AP listeners typically use the sol-fa labels as the absolute-pitch names based on the *fixed-do* system in which the C note is always *do* regardless of the key context. Hence, the AP listeners probably had a conflict between relative pitch to be identified and the labels to be used in responding. This type of conflict could be regarded as an auditory analog to the Stroop interference typically observed in the visual domain, i.e., an interference in naming the color in which a letter string is displayed when the letter string is happened to be the name of an incongruent color word. This conflict is supposed to cause the performance decline when the relative pitch name and absolute pitch name are incongruent.

To further investigate the possible disadvantage of AP in identifying musical pitch in a tonal context as suggested in the previous experiments, the present experiment employed a melody comparison task, which did not use pitch labels and hence could escape from the problem caused by the conflict between relative-pitch and absolute-pitch names. The purpose of the present experiment was to examine whether AP listeners had similar difficulties in recognizing transposed melodies as they had in recognizing transposed intervals. In each trial, a simple melody constructed for the experimental purpose was presented visually in a form of musical notation as a standard stimulus; then participants heard a comparison melody that was either at the same pitch level as the notated standard melody or transposed to different pitch levels. The comparison melody was either the same or different from the standard melody with respect to relative pitch irrespective of absolute-pitch levels; the same comparison melody was exactly the same as the standard and the different comparison melody included one note shifted upward or downward by one or two semitones with the constraint that the melodic contour did not change. The participants were engaged in the same-different discrimination task, in which they tried to judge as fast as possible whether the comparison melody was exactly the same or not as the standard melody.

This procedure is different from the typical procedures for investigating melody recognition. In previous experiments of melody recognition, the procedure typically employed was that of delayed comparisons in which both the standard and the comparison melodies were presented auditorily, and subjects attempted to judge whether they were the same or different. In such experiments the comparison melodies must be transposed to different pitch levels (different keys) from the standard to reliably examine melody recognition (e.g., Bartlett & Dowling, 1980). If the comparison melody were presented at the same pitch level as the standard, the task in effect would have turned into a simple direct pitch-comparison task, which would be quite easy not only for AP listeners but also for no-AP listeners by use of short-term memory of absolute pitch so far as the time delay would not be too long. However, presenting the standard melody in a notation as in the present experiment would allow to examine melody recognition for untransposed melodies as well as for transposed melodies.

If the AP listeners have the disadvantage in identifying musical pitch relations, as demonstrated in the previous experiments, it is assumed that they have the same difficulty in recognizing transposed melodies compared with untransposed melodies. In recognizing transposed melodies, they are required to process musical intervals and tonal characteristics in a context of a musical scale. If the AP listeners do show the disadvantage in the present task, this result would serve as a further evidence supporting the view that AP listeners have a strong tendency to stick to use the AP strategy even when it is inadequate for recognizing pitch relations as musical intervals or melodies.

METHOD

Stimulus. In total, 120 standard melodies were composed, each of which had seven notes of equal duration. Half of the standard melodies were tonal and the other half were atonal. The tonal melodies were constructed from diatonic scale tones of the major mode, suggesting definitely a major key, while the atonal melodies contained several non-diatonic tones, implying no definite key. The melodies differed in the number of reversals of melodic contour (the melodic shape complexity), from the simplest (one reversal) to the most complex (five reversals). The melodies always began with the central C, and moved around in the range from the lower G (G3) to the central A (A4). The standard melody was displayed on a computer monitor in a musical notation format consisting of a sequence of crotchets placed on the musical staff with a treble clef.

Comparison melodies were presented auditorily at three different pitch levels. In some trials, the comparison melody was played at the same pitch level as the notation of the corresponding standard melody, beginning with the central C (the untransposed condition). In the other trials, the comparison melody was transposed 4 semitones lower than the notated standard beginning with the lower G#, or 6 semitones higher beginning with the F# in the central octave (the transposed condition).

The combination of 2 levels of tonality (tonal vs. atonal) and three levels of amount of transposition (0, -4, and 6 semitones) made six experimental conditions, to which 20 melodies were assigned. Care was taken to equalize the melodic complexity among these conditions by making the number of reversals of pitch-contour equally distributed (one-reversal, 2; two-reversals, 6; three-reversals, 6; four-reversals, 4; five-reversals, 2). The melodic interval between adjacent tones in a melody ranged from 1 semitone to an octave, and the average of intervals in each melody was from 2.17 to 6.33 semitones. The distribution of the size of melodic intervals was roughly equivalent among the six experimental conditions (averages were 3.32 - 3.66 semitones).

The comparison melody was either the same or different from the corresponding standard; the same comparison melody was identical to the notated standard with respect to pitch relations, whereas the different comparison melody had one of the central five notes changed 1 or 2 semitones upward or downward, with the restriction that the melodic contour was not violated by this change. For tonal melodies, the changed note shifted one step higher or lower on the diatonic scale, so the amount of the pitch change was dependent on the direction of the change and the position of the changed note in the diatonic scale. For melodies in the atonal conditions, the amount of pitch change was equalized so as to correspond to the tonal conditions. Of 20 melodies in each experimental condition, 8 were the same ones and 12 were the different ones (4 melodies with a 1-semitone pitch change and 8 melodies with a 2-semitones pitch change), and the temporal position of the changed note was equally distributed among all the conditions. Figure 1 illustrates examples of pairs of the tonal standard melody and its corresponding comparison melody in the different transposition conditions.

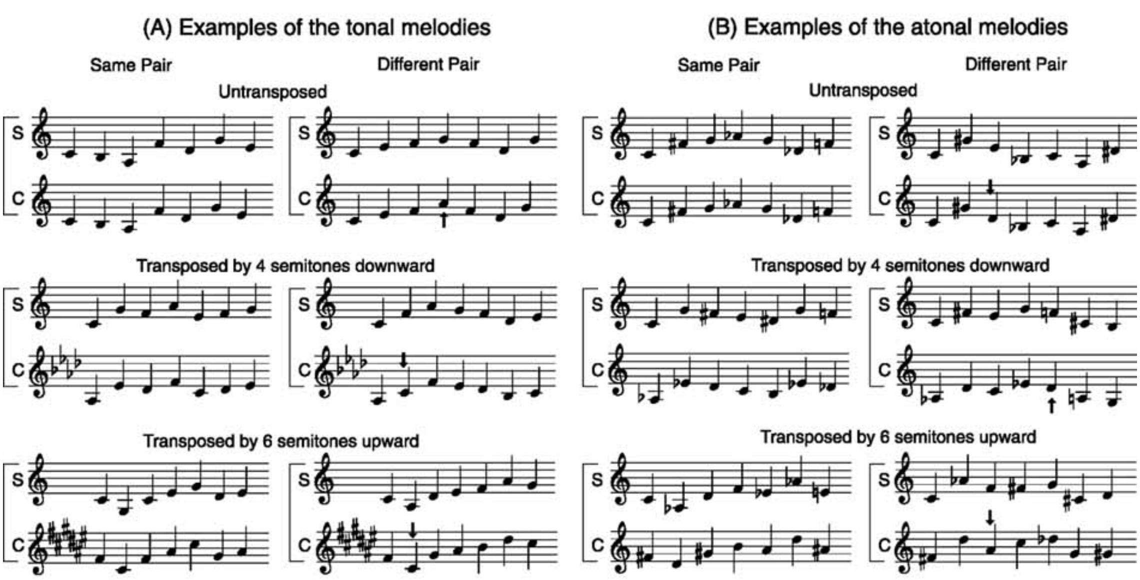

Figure 1. Examples of standard melodies (S) and comparison melodies (C) in the tonal (A) and atonal (B) condition. Standard melodies were displayed visually in a format of musical notation always in the C major key, and comparison melodies were presented auditorily either at the same pitch level (untransposed) as standard melodies or in different key (transposed by 4 semitones downward or 6 semitones upward). Note that the comparison melodies in the same pairs are exactly the same in relative pitch, and those in the different pairs include one tone shifted upward or downward by one or two semitones; the shifted tone is marked by an upward or downward arrow.

The comparison melodies were preceded by a two-chord sequence, which formed the conventional cadence (V7-I) of the major key having the initial note of the comparison melody as the tonic. This chord sequence was introduced to enable the subjects to anticipate the key of the tonal comparison melody or the beginning note of the atonal comparison melody. Each chord was 640-ms in duration and there was a 640-ms silent interval between the last chord and the first note of the comparison melody. Constituent tones of the comparison melody were about 280 ms in duration, and the onset-to-onset time intervals were 320-ms.

The chord sequence started at the same time as the display of the notated standard melody, which remained until the participants responded. All the notes were presented in timbre of the sampled piano in moderate loudness.

Apparatus. Generating and presenting stimulus melodies, and registering participants' responses were carried out by a computer (Apple, Macintosh PowerBook 170) and a MIDI system interfaced to the computer with an Apple MIDI interface. Musical notation of the standard melody was displayed in the center of the computer display in front of the participant. The sound of the comparison melody and the preceding chord sequence was generated from a tone generator module (Roland, SC-88) and presented to participants through headphones binaurally. The participant made a response by pressing one of designated keys on a musical keyboard (Korg). A HyperCard software (Apple) and a programming language HyperTalk were used for controlling the experimental setup, and HyperMIDI external commands (EarLevel Engineering) were used for controlling the MIDI system (Miyazaki, 1998).

Procedure. Each experimental trial began with the presentation of a musical score of a standard melody in the center of the computer display and a chord sequence followed by a comparison melody. The participants' task was to determine whether the comparison melody was exactly the same as the notated standard or contained a modified pitch in terms of relative pitch without regard to the difference in absolute pitch. The participants were instructed to make a keypress as quickly as possible. Six consecutive white keys in the center of the keyboard were used for responding and labeled as "D3," "D2," "D1," "S1," "S2," "S3" in this order from left to right. The participants were instructed that they should press one of the three "D" keys when they judged the comparison melody different from the notated standard, and should press one of the three "S" keys when they judged the heard melody was the same as the standard. The number following "D" or "S" represented the degree of confidence of judgments; thus, the keys as a whole corresponded to a 6-point scale with "surely different (D3)" and "surely the same (S3)" as the outer extremes. The participants allowed to make a response before the comparison melody came to an end when they detected the difference between the heard melody and the notated standard.

After a participant made a response, the window displaying the notated standard was replaced by a feedback window, which provided participant a feedback concerning the response correctness and a response delay time after the onset of the last tone; in addition, there was a response history box in which a small open circle was added when a participant made a correct response (the same response to the same trial or the different response to the different trial) and a small closed circle was added when the response was incorrect (the same response to the different trial or the different response to the same trial). A participant was encouraged to get as many open circles (success symbols) as possible avoiding closed circles (failure symbols), and response time as shorter as possible. In this manner, it was expected that participants' motivation could be kept high. Apparently, participants found the task a sort of game. The experiment proceeded at participant's pace; when participants pressed any key again after a response, the next trial began with a delay of 1 sec.

There were three experimental sessions, each of which contained 120 trials (2 tonality conditions x 3 transposition conditions, with 20 different melody set each) and took approximately 25 minutes; thus a participant carried out, in total, 360 experimental trials. Actually, there were 20 uncounted warming-up trials prior to the experimental trials in each session. The experiment was done on two separate days; the first two sessions were given on the first day and the last session on the second day. In a session, tonal and atonal conditions were arranged randomly, and the transposition conditions changed in every trial in an unpredictable manner. The three sessions had different orders of trials.

Before the melody recognition test on the second day, the participants had carried out the absolute pitch test, in which 60 notes of the chromatic scale based on equal temperament were presented over the central 5 octaves. The AP test was constructed of the same sampled piano tones as used in the melody test. The fundamental frequencies ranged from C2 (65.4 Hz) through B6 (1975.5 Hz), with the pitch standard of 440 Hz as A4. Subjects heard test tones presented one by one in isolation and tried to identify each pitch class by pressing a corresponding key within a restricted octave range on a keyboard. Octave locations were not considered. The test tones were presented in a pseudo-random order, with the constraint that tones of consecutive trials differed by more than one octave and differed by more than 3 steps in the pitch-class circle to prevent the subjects from relying on relative judgments from previously presented tones. There was a 3-sec intertrial interval between the occurrence of the response and the onset of the next tone. The same apparatus as in the main experiment was used.

Participants. The participants were 31 students recruited from the classes of solfege at the Department of Sound Engineering in the Chopin Academy of Music, Warsaw. According to the results of the AP test, the 9 AP listeners (correct responses: 60% - 100%) and 18 no-AP listeners (less than 50 %) were identified. Other 4 participants failed to take the AP test because they were absent from the second-day session. There were 7 participants who began music training in early childhood (3 - 6 years old), all of them in the AP group. The participants were paid for their participation.

RESULTS

Of 31 participants, 5 were excluded from data analysis because 4 failed to complete all three sessions and the AP test and one no-AP listener came across a trouble in the experimental setup.

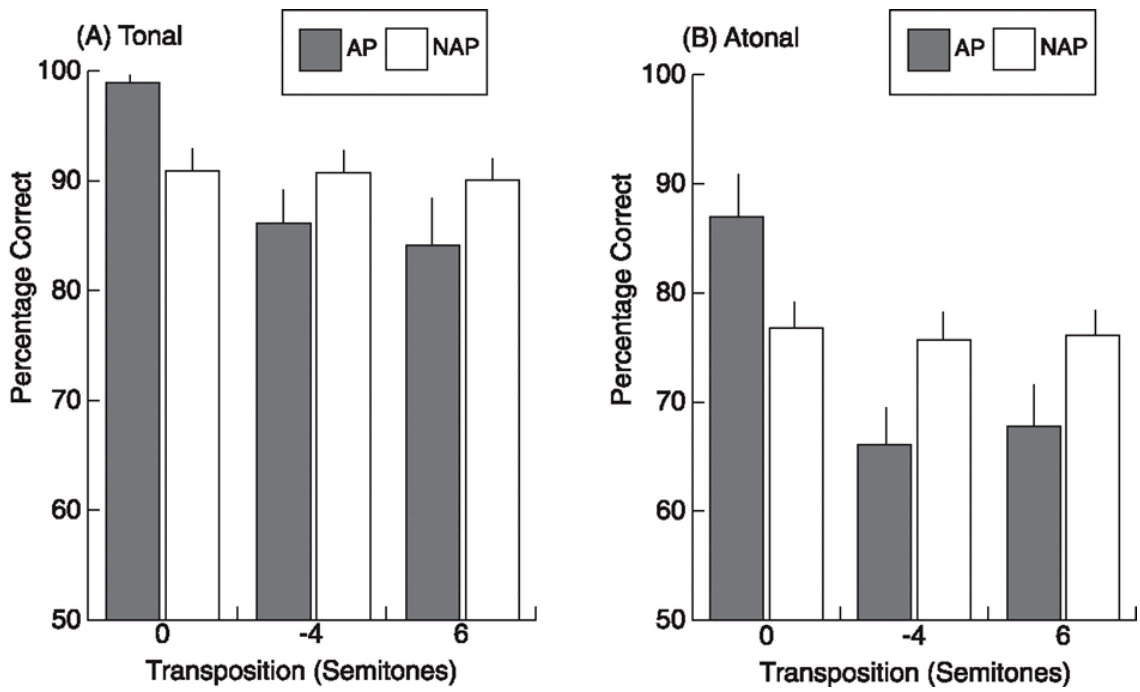

Figure 2. Averaged percentage correct responses as a function of the amount of transposition for the absolute-pitch listeners (AP) and the no-absolute-pitch listeners (NAP). (A) for tonal melodies, and (B) for atonal melodies. Bars show standard errors.

In this experiments, participants were asked to decide whether the standard and comparison melodies were the same or different using a 6-point confidence rating scale. However, most participants did not use the entire range of this scale, but in most cases used the extreme categories, i.e., "surely the same" and "surely different." Therefore, the 6 rating categories were collapsed into 2 response categories, the same and different, from which percentages of correct responses were calculated. Figure 2 shows the averaged percentage of correct responses of the AP listeners (the AP group) and no-AP listeners (the NAP group) as a function of the amount of transposition for the tonal and the atonal melodies separately. A 3-factor analysis of variance (ANOVA) of mixed-design, including AP (AP vs. NAP) as a between-subjects factor and Transposition (no-transposition, 4-semitones downward, and 6-semitones upward) and Tonality (atonal vs. tonal) as within-subjects factors, was performed on the percentage correct data with the Greenhouse-Geisser correction for inhomogeneity of variance applied whenever appropriate. The main effect of Tonality was significant [$F(1, 24) = 163.91$, $MSe = 50.00$, $p<.001$], indicating that, as expected, overall performance was reliably higher for tonal melodies than for atonal melodies. The interactions of Tonality by AP [$F(1, 24) = 0.48$, $MSe = 50.00$] and of Tonality by Transposition [$F(2, 48) = 2.78$, $MSe = 15.62$, $p<.1$] were not significant (though the latter was marginal), reflecting that the advantage of tonal melodies over atonal melodies was common for both AP and NAP groups and across transposition conditions.

The main effect of Transposition was significant [$F(2, 48) = 30.37$, $MSe = 40.68$, $p<.001$] indicating that, on the whole, the percentage of correct responses was higher in the untransposed condition than in the transposed conditions in which the notated standard melodies had to be compared with the comparison melodies transposed by 4 semitones lower or 6 semitones higher.

The main effect of AP was not significant but the interaction between Transposition and AP was significant [$F(2, 48) = 25.55$, $MSe = 40.68$, $p<.001$], which reflected the most important aspect of the results that the effect of Transposition differs between the AP group and the NAP group. More specifically, the AP group showed higher performance in the untransposed condition than in the transposed conditions, whereas the performance of the NAP group was almost equal irrespective of whether the comparison melodies were transposed or not. The source of the interaction was examined by additional analyses which revealed that the simple effect of Transposition was significant for the AP group [$F(2, 48) = 55.88$, $MSe = 40.68$, $p<.001$] but not for the NAP group. Post-hoc multiple comparisons (Tukey's HSD test) for the AP group showed that the performance for the untransposed melodies was reliably higher than for the two types of the transposed melodies ($p<.05$), while there was no reliable difference between the two types of the transposed melodies. It is particularly interesting that the simple effect of AP was significant for the untransposed melodies [$F(1,72) = 6.19$, $MSe = 157.97$, $p<.025$] and for the upward transposed melodies [$F(1, 72) = 4.53$, $MSe = 157.97$, $p<.05$], and was marginally significant for the downward transposed melodies [$F(1, 72) = 3.11$, $MSe = 157.97$, $p<.1$]. This indicates that the AP group was superior to the NAP group thanks to AP when recognizing untransposed melodies. On the contrary, the NAP group had the advantage over the AP group when recognizing the transposed melodies. The three-way interaction of Transposition by AP by Tonality was not significant, indicating that the interaction of Transposition by AP was observed across the tonal and atonal melodies.

There were large differences among participants in performance levels. Then, the percentages of correct responses for individual participants are presented in Figure 3. Different symbols connected solid lines in each panel illustrate the performance of each individual for untransposed and transposed melodies. As can be seen, the performance levels are widely dispersed, particularly for the atonal melodies where the percentage correct ranges from near chance (50%) to perfect. Most importantly, all AP participants except one (depicted by open triangles) showed a consistent decline in performance for the transposed melodies compared with the untransposed melodies. This trend is more pronounced for the atonal melodies (panel A) than the tonal melodies (panel B). In contrast, most participants in the NAP group showed no marked difference between transposed and untransposed melodies, although the performance level is widely varied among participants.

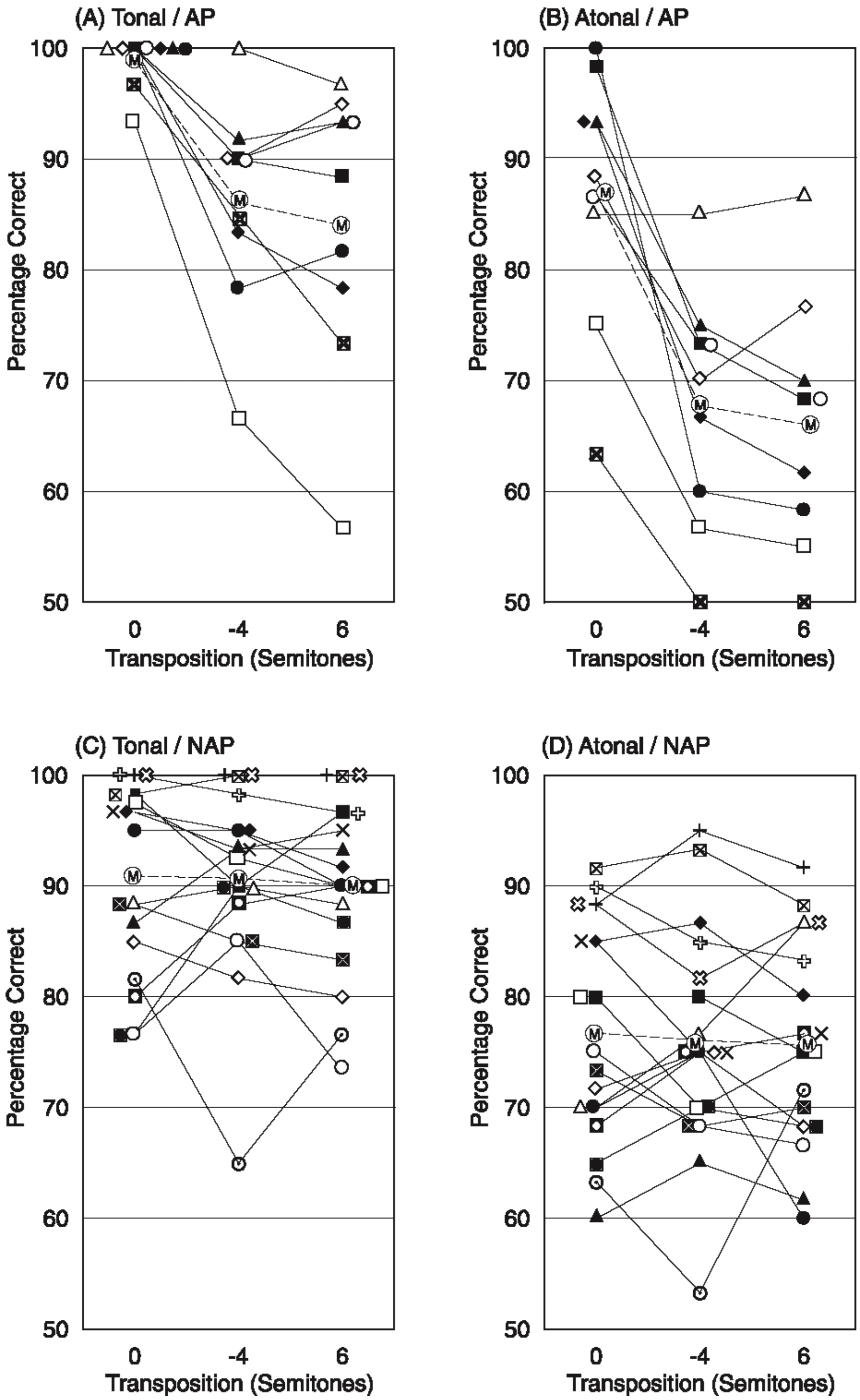

Figure 3. Percentage correct responses of individual listeners having absolute pitch (A and B) and those having no absolute pitch (C and D) for tonal melodies (A and C) and atonal melodies (B and D). Different symbols connected denote different listeners, and circled Ms connected by a dashed line represent group averages.

Next, further analysis was carried out to examine the correlation between the accuracy of the melody recognition (melody scores) and the accuracy of AP (AP scores). The results are graphically represented in Figure 4 as scatterplots for the transposed and untransposed melodies separately. Dots plotted in the scattergrams represent the individual participants whose melody scores are plotted on the ordinate and the AP scores on the abscissa. The scores for the untransposed melodies are plotted in the left panels (A and C) and the scores for the transposed melodies (collapsed across transpositions of -4 and 6 semitones) are plotted in the right panels (B and D). It is evident that, for the untransposed melodies, there was a significant positive correlation between the melody scores and the AP scores (r=.48, p<.05, for the tonal melodies, and r=.44, p<.05, for the atonal melodies). Notably, when the correlations are recalculated for 12 participants whose AP scores are more than 30%, the correlation coefficient rises to r=.85 for the atonal melodies and to r=.67 for the tonal melodies, although in the latter case the ceiling effect seems to appear. These positive correlations indicate that, in general, the more accurate the participants are in the AP test, the more accurate they are in recognizing untransposed melodies. By contrast, for the transposed melodies, negative correlations were found between the melody scores and the AP scores; the strength of correlation was of moderate size for the atonal melodies (r=.-45, p<.05), but negligible for the tonal melodies (r=.-24, n.s.).

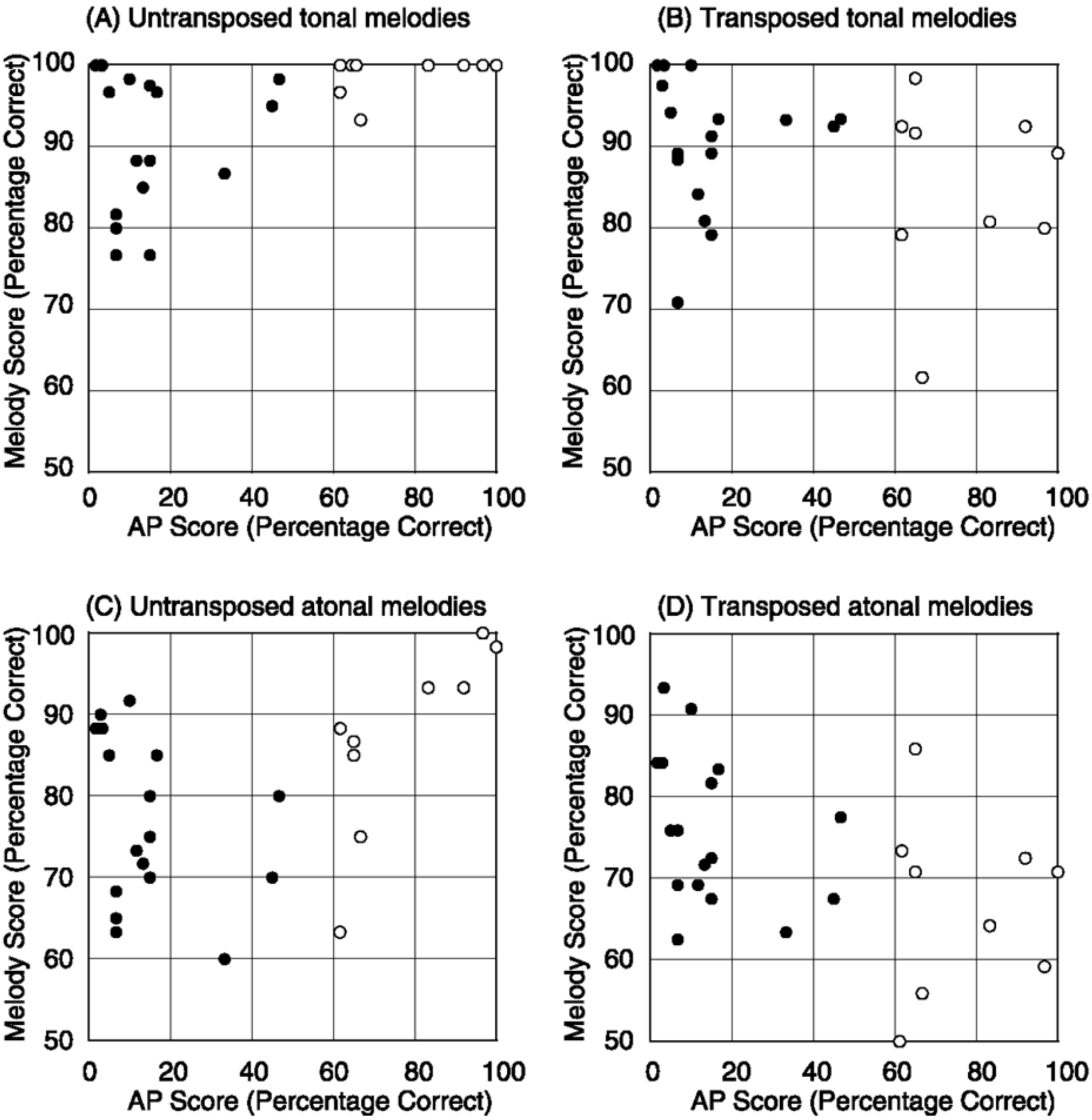

Figure 4. Scatterplot showing the correlation between the accuracy of melody recognition (abscissa) and absolute-pitch identification (ordinate). Open circles represent absolute-pitch listeners and closed circles represent no-absolute-pitch listeners.

To examine further how the difference in performance between the transposed and the untransposed melodies was related to the accuracy of AP, difference scores were calculated for individual participants by subtracting the melody scores (percentage correct) for the untransposed melodies from those for the transposed melodies. The difference scores were negatively related to the degree of accuracy of AP, i.e., the participants with more accurate AP tended to show larger decrements in recognizing transposed melodies relative to untransposed melodies; in contrast, the NAP participants had smaller difference scores. The correlation between the difference score and the AP score was $r = -.62$

(p<.005) for tonal melodies and r = -.81 (p<.005) for atonal melodies.

DISCUSSION

The results of the present experiment have shown that transposition of melodies differentially influenced the performance of the AP listeners and the NAP listeners in melody recognition. The NAP listeners exhibited equivalent performance regardless of whether or not the comparison melodies were transposed from the notated standard melodies, indicating that they read relative pitch information from the musical scores as opposed to absolute pitch information. In contrast, the AP listeners were strongly influenced by transposition; they exhibited the maximal level of performance for untransposed melodies, but showed the poorest performance for transposed melodies.

The equivalent performance of the NAP listeners across transposition conditions is consistent with the notion of the Gestalt tradition that stresses the invariance of melodic identity under transposition as an important Gestalt property, i.e., transposed melodic patterns are perceptually (and musically) equivalent in spite of the fact that all the tones of the melodies are changed in pitch by transposition so far as the exact pitch intervals among tones are maintained (see, Deutsch, 1986; Krumhansl, 1990).

The significant difference of the performance of the AP listeners between transposed and untransposed condition suggests costs and benefits of AP possession, which is evident when comparing the performance of the AP listeners with that of the NAP listeners. The benefits of AP, i.e., the facilitated performance in untransposed-melody recognition, is not surprising because AP should offer direct benefits to the AP listeners in comparing notated melodies with auditorily presented untransposed melodies. On the contrary, the AP listeners showed significantly poorer performance than the NAP listeners in transposed-melody recognition. This aspect of the cost of AP is contrary to the commonly accepted view on AP as a very useful musical ability and so should deserve more attention.

The cost of AP has already been demonstrated in the previous series of experiments (Miyazaki, 1993, 1995), in which AP listeners showed a significant performance decline in identifying musical intervals beginning at different pitch levels relative to those beginning at the C note. However, this finding is not so convincing because there is a possibility in these experiments that the AP listeners had a conflict between the relative-pitch name to be responded and the absolute-pitch name associated with the *fixed-do* naming system, as mentioned in the introduction. To rule out this possible conflict, the present experiment employed the melody comparison task in which participants were required to discriminate the standard melodies and the comparison melodies and to make simply same/different responses. Therefore, the converging evidence of the present experiment with the previous ones supports the hypothesis of the disadvantage of AP in the more musical situation of melody recognition.

Some caution might be exercised here, however, before claiming that AP has a disadvantageous aspect. The criterion adopted here for defining the AP group was rather arbitrary. The participants for the present experiment were recruited widely from music students, and so only 3 listeners had accurate AP (more than 90% correct in the AP test). Then, listeners whose AP scores were higher than 60% correct were classified into the AP group. It might be argued, therefore, that the AP group defined according to such a liberal criterion does not fairly represent AP possessors. It is true that there were a few inaccurate AP listeners who scored near chance for transposed atonal melodies, and these seemingly anomalous listeners reduced the average performance of the AP group for those melodies. However, in effect, there are varying degrees and qualitatively different types of AP. In one of the previous experiments, Miyazaki (1993) classified AP listeners as imprecise AP, partial AP (accurate only for white-key notes on the piano keyboard), and precise AP according to their AP scores, response patterns, and response speeds, and found that the partial and imprecise AP groups exhibited a more pronounced performance decrement in the relative pitch task than the precise AP group. In that experiment, too, there were a few partial- and imprecise-AP listeners who performed near chance in identifying musical intervals beginning with notes other than C. Therefore, a few of the AP listeners of the present experiment who showed a similar decline in performance for the transposed melodies as opposed to the untransposed melodies are not anomalous but rather represent noticeable characteristics of some AP listeners in a somewhat exaggerated manner. Moreover, it is worth noting that the precise AP listeners showed the similar pattern of performance decline (see Figure 4) and there was a negative correlation between the AP scores and the percent correct for the transposed melodies.

It may seem really counterintuitive to claim that AP is disadvantageous to music; superficially, it appears plausible that AP listeners are superior in recognizing tonal patterns, considering that absolute pitch facilitates anyway identification of musical pitch. This is associated with a commonly-accepted naïve conviction that absolute pitch is a highly valuable musical facility. The term "perfect pitch," an often used equivalent of absolute pitch though misleading, reflects such a view. In fact, it is quite easy to find support for this view; practically, there are a number of anecdotal reports of AP musicians who have achieved remarkable performance in many musical situations.

Indeed, AP is advantageous in music in two different aspects; first, AP allows its possessors to name pitches without any reference; second, it allows to have an auditory representation from a musical score. The first benefit of the AP ability, the advantage of naming pitch, may be most useful in the music dictation task in which one hears a musical passage and is required to write it on a staff. The purpose of the music dictation test in a proper musical sense should be to examine the ability to hear musical pitch relations in a certain tonal context, and so the tonic tone or chord is given prior to the test material for providing a reference pitch. However, this test would lose its validity when given to AP listeners, if they adopted a strategy based on absolute pitch instead of musical pitch relations. They are able to identify constituent tones of melodies presented and to place the corresponding notes on a musical staff. For extensively trained AP listeners, this process based on the AP strategy is supposed to be much easier than that based on the strategy of musical pitch relations, as evidenced by the remarks of one of the AP listeners that musical tones sound as if accompanied by their pitch labels. This might benefit very much AP listeners when given a dictation task including complicated tonal sequences difficult to perceive with relative pitch. It should be pointed out, however, that the improved performance achieved by using AP in the dictation test is irrelevant to music in that the performance does not reflect the ability to hear musical pitch relations to be assessed in the test, but simply does reflect the AP ability instead.

The second benefit of the AP ability, the advantage of having pitch representations from a score, may also benefit musicians with AP in playing music and reading a score, particularly in sight-reading. When given a score, the AP musicians would easily have internal representations of the sequences by producing representations of individual notes using AP, and then combining them into a melody representation. Thus, as in the dictation task, AP is highly useful for musicians who try to read music particularly when they read a complicated score including sequences difficult to recognize such as chromatic or dodecaphonic passages. Here again, however, it should be pointed out that the internal representation of the sequences formed with the aid of AP may not be a truly musical entity that is constructed from the musical pitch relations directly read from the score, but instead a secondary construct assembled from the representations of individual tones.

Although these advantages of AP seem to have no musical sense as argued above, at any rate, people with AP do exhibit actually higher performance in musical activities. However, the superiority AP listeners enjoy may come from extensive musical training they have received rather than from AP per se. Most of AP is a consequence of early musical training, and therefore musicians with AP generally have longer experience of musical training beginning from earlier ages than NAP musicians (Miyazaki, 1988). Thus, AP possession and the amount of musical training are usually confounded, making it difficult to differentiate between the contributions of these two factors to the higher performance of AP listeners in musical tasks. Therefore, it is unfair to compare simply AP listeners and NAP listeners; a fair comparison would require to keep the amount of musical experience equivalent between them. When the difference of the amount of musical experience between the AP and NAP groups is eliminated, the difference in performance observed between the groups could be taken as reliable evidence for the pure advantage and/or possible disadvantage of AP.

In the present experiment, the participants were classified into the AP group and the NAP group solely on the basis of the accuracy of the AP test without considering the amount of musical training they had received. Consequently, the participants of the AP group, independently of having absolute pitch, were such musicians who possibly had been trained in music more extensively than those of the NAP group. Because of this important difference, the AP listeners might be naturally expected to exhibit higher performance in general than the NAP listeners. Nevertheless, the results have shown that, opposite to what was predicted from the difference in musical experience, the performance of the AP group was lower than the NAP group in transposed melody recognition. It may be possible that the difference would have even been larger if the AP group and the NAP group were equalized in the amount of musical experience. Therefore, the performance decrement of the AP group observed in transposed melody recognition is taken as even stronger evidence for the characteristic disadvantage of AP listeners than its face value.

When recognizing transposed melodies, AP does not work and has even adverse effects. If AP were under voluntary control, the AP listeners could have suppressed AP and switched to an alternative strategy based on relative pitch in the transposed condition. The finding that the AP listeners performed worse than the NAP listeners in those conditions suggests that they have developed a strong tendency to rely on the AP strategy, and AP may be for them a sort of an involuntary, automatic listening strategy.

In conclusion, the present experiment has demonstrated the costs and benefits of AP. The benefits represent usefulness of AP and/or more extensive musical training the AP participants received. On the other hand, the cost of AP could raise important problems for musicians. This has been sometimes reported anecdotally by musicians. For example, some musicians with AP admit that they feel extremely uncomfortable when they hear a familiar piece of music played with instruments tuned to a historical pitch standard that is lower than the current one by nearly one semitone, complaining that it is in a wrong key or all the tones sound out-of-tune. Other musicians with AP sometimes confess that they are at a loss when they sing a song or play singers’ accompaniment in different keys from a score (see, Moore, 1971). Although most musicians with AP could successfully manage to deal with such problems by suppressing AP and instead using relative pitch, they might sometimes pay some cost in these situations resulting in declined performance in the transposed conditions. Moreover, the finding that there were a few AP listeners who exhibited considerably poor performance in recognizing transposed melodies suggests that there might be some inflexible AP possessors who stubbornly stuck to AP even when it might be disadvantageous.

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