Effects of harmonic context on pitch perception

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Abstract

This paper presents an empirical investigation of the effects of harmonic context on pitch perception. Participants performed a same/different discrimination task on two tones —a reference tone (RT) and a comparison tone (CT) — that were embedded within a single melody with clearly implied harmonies. The experimental design consisted of three factors: pitch (same/different); harmony (same/different harmonic context for CT and RT); and harmonic stability (equal/unequal, i.e., either CT and RT were consonant members of their respective harmonies or one tone was consonant and the other dissonant).The results revealed significantly better discrimination of same than different tones, better pitch discrimination for nonchanging than for changing harmonic contexts, and better pitch sensitivity in unequal compared to equal harmonic-stability conditions. In addition, the discrimination of same pitches was better for equal than for unequal harmonic stability, whereas the reverse was true for different pitches. Further, in the unequal harmonic-stability condition (i.e., when one tone was consonant and the other dissonant), pitch discrimination was equally accurate for same and different tones. Altogether, these findings suggest that tones belonging to different and adjacent harmonic functions tend to be perceived as equal in pitch, particularly when they are consonant members of their contextual harmony.

Resumen

Este trabajo presenta una investigación empírica de la influencia del contexto armónico en la percepción de altura. Los participantes compararon dos notas musicales— una nota de referencia (RT) con una de comparación (CT) — indicando si eran iguales o diferentes. Las dos notas formaban parte de una melodía con una clara progresión armónica (implicada). El diseño experimental abarcó los factores altura (igual/diferente), armonía (no-cambiante/cambiante), y estabilidad armónica (equivalente/no-equivalente, es decir, CT y RT eran ambas consonantes en sus respectivas armonías, o una nota era consonante y la otra disonante).Los resultados indicaron mejor discriminación para alturas iguales que diferentes, mejor discriminación de altura en armonías no-cambiantes que cambiantes, y sensibilidad superior para alturas de estabilidad armónica dispar que para alturas equivalentemente estables armónicamente. Además, la discriminación de alturas iguales fue mejor en situaciones de estabilidad armónica equivalente que no-equivalente, mientras que lo contrario ocurrió con la discriminación de alturas diferentes. Más aún, en situaciones de estabilidad armónica no-equivalente, los participantes identificaron igualmente bien notas diferentes e iguales. Estos resultados sugieren que las notas que pertenecen a funciones armónicas diferentes y adyacentes tienden a ser percibidas como iguales en altura, especialmente cuando son miembros consonantes de sus respectivos contextos armónicos.

Resumo

Este trabalho apresenta uma investigação empírica dos efeitos do contexto harmônico na percepção do tom. Os participantes realizaram uma tarefa de julgamento igual-diferente para dois tons —um tom de referência (RT) e um tom de comparação (CT) —ambos incorporados em uma única melodia com harmonias implícitas. O design experimental consistiu de três fatores: tom (igual-diferente); harmonia (contexto harmônico igual-diferente para o RT e o CT); e estabilidade harmônica (igual-diferente, i.e., ambos CT e RT eram membros consonantes de suas respectivas harmonias ou um tom era consonante e o outro dissonante). Os resultados revelaram uma distinção significativamente melhor para tons iguais, uma distinção melhor do tom em contextos harmônicos que não mudavam, e uma sensibilidade tonal melhor em condições de harmonia e estabilidade desiguais. Adicionalmente, houve melhor distinção entre tons iguais em estabilidades harmônicas iguais, ocorrendo o contrário para tons diferentes. Enfim, na condição de harmonia e estabilidade desiguais (i.e., quando um tom era consonante e o outro dissonante), houve uma distinção do tom igualmente precisa para tons diferentes e iguais. Estes resultados sugerem que tons pertencentes a funções harmônicas diferentes e adjacentes tendem a ser percebidos como iguais em altura, especialmente quando são membros consonantes de seu contexto harmônico.

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Introduction

Music is a complex phenomenon in which many aspects (e.g., pitch, harmony, rhythm, timbre) interact, defining the musical context. It is known that our perception of one particular musical factor, such as pitch or rhythm, is often dependent on the musical context (i.e., on other factors). Research has shown that the perception of pitches and chords is highly dependent on the intervallic context. In certain situations, we tend to hear two instances of the same pitch as two different pitches and vice versa. Empirical evidence has indicated that when two melodic or harmonic dyads are presented successively, the [melodic or harmonic] intervallic context interferes with our ability to accurately discriminate the individual pitch components of each dyad. Specifically, when two equal pitches are preceded or accompanied by different pitches, so that they form a pair of dissimilar melodic or harmonic intervals, non musicians tend to hear the equal pitches as different. Similarly, when two different pitches are presented within equal [melodic or harmonic] intervallic contexts, we often perceive the different pitches as equal (Deutsch, 1999, 1982, 1974).

Pitch and harmony are greatly responsible for creating the sense of motion and directionality that characterizes tonal music. The degree of stability of individual notes in tonal music changes with the harmonic setting (e.g., scale degree ^4 is more stable within a IV harmony than within a V7 harmony). It seems then reasonable to expect that harmonic context influences the way we hear pitches. Whereas numerous theoretical, behavioral, and scientific studies have illuminated cognitive aspects of pitch and harmony (e.g., Krumhansl 1990; Deutsch, 1999; Cross, 2007; Cook, 2009; Yeary, 2011), the experimental research examining the perceptual processes involved in the interaction of pitch and harmony is notably scarce. Aimed to contribute to our understanding of the interaction between pitch and harmony at the cognitive level, and motivated by the important role that harmony plays in the definition of tonality, this paper presents an empirical investigation of the effects of harmonic context on pitch perception.

Methodology

Nonmusicians performed a same/different discrimination task on two tones —a reference tone (RT) and a comparison tone (CT) — that were embedded within a single melody with clearly implied harmonies. One hundred and twenty musical examples were composed by the experimenter. Visual cues facilitated the identification of the two tones. Colored numbers appeared on a black computer screen. Each target tone (i.e., CT and RT) was synchronized with the last number of a regressive count from two to zero (the regressive count occurred twice, once for each target tone in each musical example). The final number of the regressive count (zero) was different in color and size from the preceding numbers. An example of the stimuli can be seen at http://www.youtube.com/watch?v=gxHAP0_pnNo. A pilot survey was do neto determine the distance between the two target tones, tempo and other parametrical aspects of the stimuli, ensuring that the level of difficulty of the task was appropriate for non musicians. Three different melodic patterns were chosen from the pilot study and used in the actual experiment. The most typical harmonic progressions in western classical music were equally represented in each of the patterns: I-IV, I-V, ii-V, ii-vi, iii-vi, IV-I, IV-V, V-I, vi-ii, vii-iii. Weak progressions were excluded, because they do not imply a change in harmonic function (tonic vs. subdominant vs. dominant). In addition, incorporating weak harmonic progressions would have added considerable problems to the composition of the musical examples, due to note-repetition limitations.

Three experimental factors were considered: pitch (same/different, i.e., RT=CT/RT≠CT); harmony (same/different harmonic context for CT and RT); and harmonic stability (equal/unequal, i.e., either CT and RT were consonant members of their respective harmonies or one tone was consonant and the other tone was dissonant). Due to the impossibility to compose musical examples that would allow us to address these factors and, at the same time, to carefully control for confounding effects, two separate experiments were completed (60 stimuli per experiment). The first experiment was designed to study the effects of pitch and harmonic stability (and their interaction) in situations in which CT and RT were presented in different harmonic contexts under highly controlled conditions. Controlled factors included intervallic context, number of intervening pitches between CT and RT, number of different pitches between CT and RT, scale degree, and chroma. The second experiment addressed the factor harmony, by comparing situations in which CT and RT were presented within an unchanging harmonic context with those in which the two tones were supported by different harmonies (as in Experiment 1).

Results

The data of the first experiment was analyzed using a two-factor repeated-measures ANOVA (*n* = 363nonmusicians, age 18-33), with percentage of correct responses as dependent variable and *c* (measure of response bias) as covariate. The results revealed significantly better discrimination of same than different tones [$F(1,361) = 44.31$, p(adjusted Huynh-Feldt)< 0.001, $\eta 2 = .109$, see Figure 1], and better pitch sensitivity in unequal compared to equal harmonic-stability conditions [$F(1,361) = 5.955$, p (adjusted Huynh-Feldt) $= 0.015$, $\eta 2 = .016$, Figure 2].

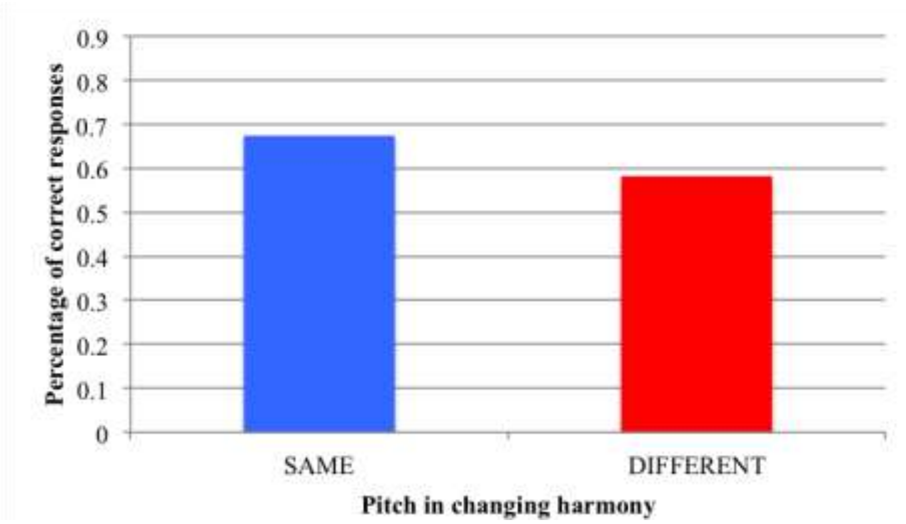

Figure 1: Significantly better discrimination of same than different tones.

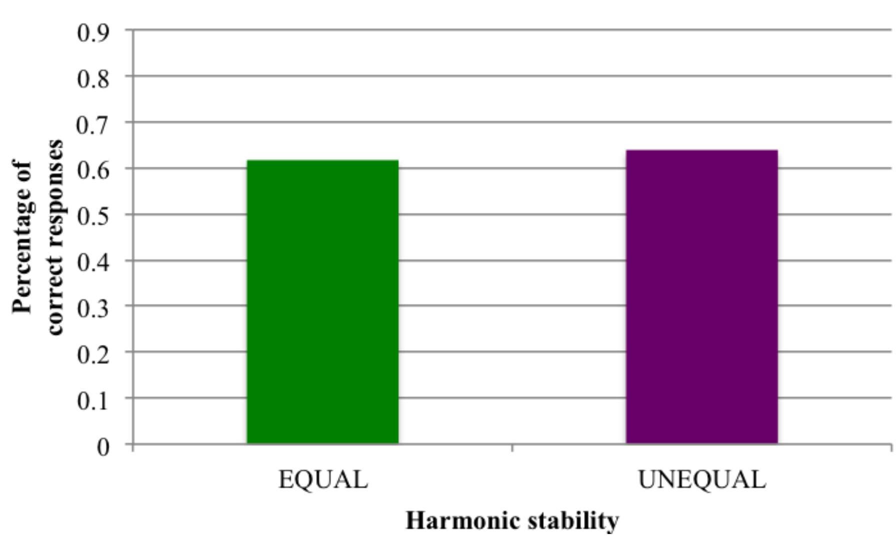

Figure 2: Better pitch sensitivity in unequal compared to equal harmonic-stability conditions.

In addition, the discrimination of same pitches was better for equal than for unequal harmonic stability, whereas the reverse was true for different pitches [$F(1,361) = 158.568$, p(adjusted Huynh-Feldt)< 0.001 , $\eta 2 = .305$, see Figure 3]. Further, in the unequal harmonic-stability condition (i.e., when one tone was consonant and the other dissonant), pitch discrimination was equally accurate for same and different tones, suggesting a marked influence of harmonic stability on pitch representation.The data of the second experiment was analyzed using one-way between-subjects ANOVA (*n* = 636nonmusicians, age 18-49), with d-prime as dependent variable. The results showed that pitch discrimination seemed to be more disturbed in changing- than nonchanging-harmony conditions [$F(1, 634) = 195.389$; $p < 0.001$, $\eta 2 = .235$],further confirming the findings of the first experiment. Even more importantly, post-hoc analyses combining the data from both experiments implied that the effects of harmonic stability on pitch perception might be larger than those of intervallic context. Two ANOVAs were performed and contrasted. The first ANOVA compared the data corresponding to the nonchanging-harmony condition (60 stimuli corresponding to Experiment 2) with that corresponding to those stimuli from the changing-harmony condition that paralleled the nonchanging-harmony examples in terms of intervallic context (16 stimuli taken from Experiment 1). This analysis controlled for intervallic context, but it was greatly unbalanced in terms of harmonic stability: the totality of the musical examples from the changing-harmony condition in which equal tones were approached by the same interval corresponded (unavoidably) to the unequal harmonic-stability situation, whereas the opposite was the case for the musical examples from the nonchanging-harmony condition. The analysis revealed a significant effect of harmony [$F(1,634) = 268.456$, $p < 0.001$] with an effect size of $\eta^2 = .297$. The second ANOVA compared the nonchanging-harmony condition (60 stimuli from Experiment 2) with only those stimuli from the changing-harmony condition that paralleled the nonchanging-harmony examples in terms of harmonic stability (30 stimuli from Experiment 1). In contrast to the previous ANOVA, this analysis controlledfor harmonic stability, but it was greatly unbalanced in terms of intervallic context: the totality of the examples from the changing-harmony condition in whichequal tones were presented under equivalent harmonic-stability situations, corresponded to conditions of different intervallic approach for CT and RT.

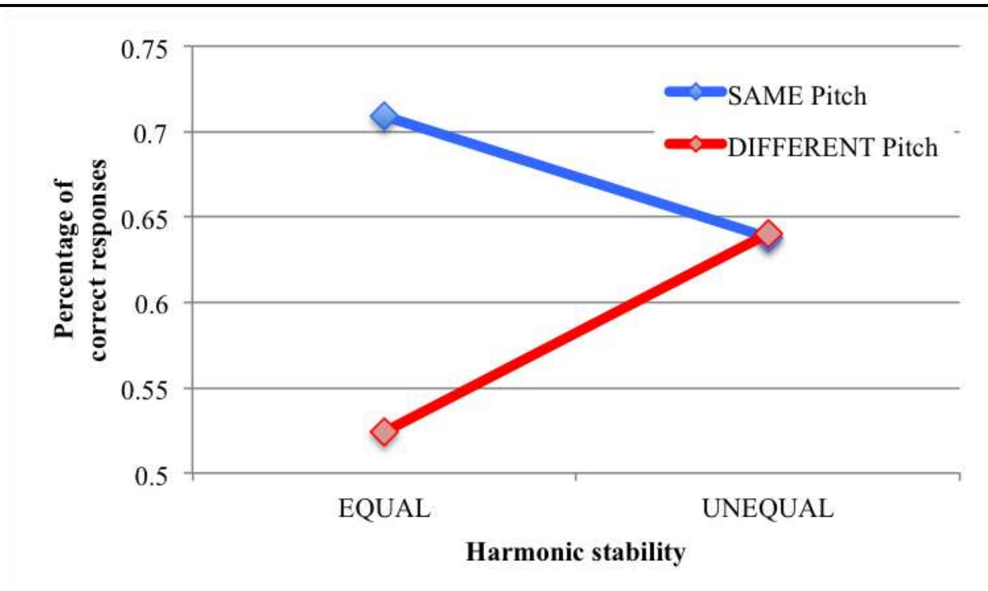

Figure 3: The discrimination of same pitches for equal and for unequal harmonic stability.

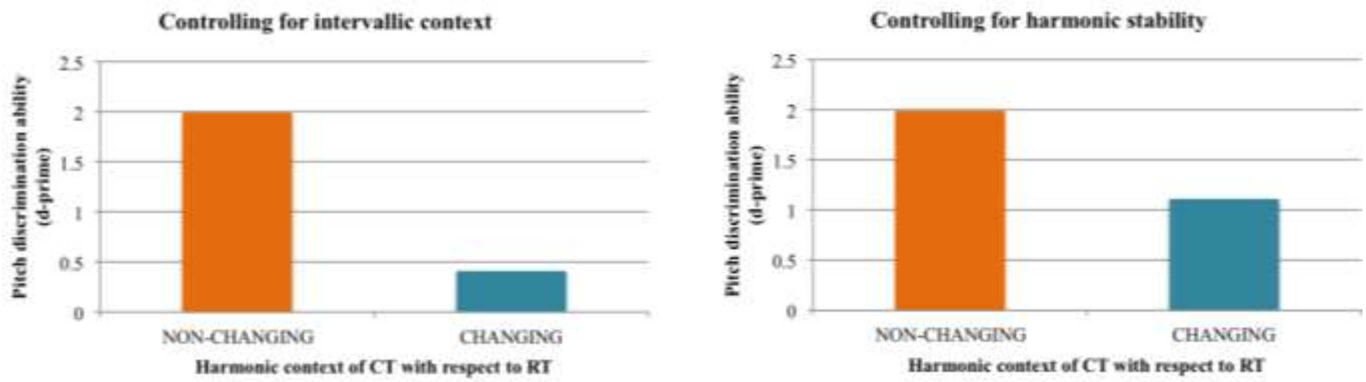

Figure 4: Effects of intervallic context and harmonic stability.

The second ANOVA revealed an strikingly smaller effect of harmony [$F(1,634) = 84.951$, $p < 0.001$, $\eta 2 = .118$] than the first ANOVA, suggesting that the effects of harmonic stability might be larger than those of intervallic context (see Figure 4). These findings are especially relevant because, whereas previous investigations have demonstrated and emphasized the influence of intervallic context on pitch discrimination, the study of the relationship between harmonic stability and pitch perception seems to be have been overlooked in the experimental literature.

Discussion

Altogether, the results of the two experiments presented here suggest that tones belonging to different and adjacent harmonic functions tend to be perceived as the same in pitch, particularly when they are consonant members of their contextual harmony. Possibilities for future studies include the investigation of pitch perception in modulating harmonic contexts, non-adjacent changing harmonies, and harmonic contexts presented chordally rather than melodically.

This paper contributes to the field of music cognition by illuminating our understanding of the perceptual mechanisms involved in the interaction of pitch and harmony, proposing an alternative methodological approach that aims to improve the control of confounding effects in contextual studies of pitch perception, and emphasizing problems that underlie the study of contextual aspects of music. Finally, it is hoped that the methodology and results presented in this paper will motivate further experimental research on the interaction of different aspects of music.

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