

# Music Identification from Harmony

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**Abstract**—Earlier studies seem to indicate that harmony plays a relatively unimportant role in music identification tasks. However, identifying music from its harmony, although a difficult task, can inform our understanding of how listeners mentally represent and remember harmony. The present study is the first to examine the ability of listeners with varying musical expertise to identify well-known classical and pop/rock pieces from their chords. In this study, well-known classical and pop/rock pieces selected in a pilot were used instead of traditional tunes because their chord progressions tend to be more distinctive and their different renditions often preserve the original harmony with little or no modifications. One hundred participants, divided into four groups according to musical expertise, listened to chord progressions of representative passages from 12 pieces and were asked to identify them. Two ways of modifying pitch information in the chord progressions were explored: (1) The progressions were played with piano tones and shepard tones, the latter diminishing the effect of melodic cues. (2) The progressions were played on six transpositional levels. In the second part of the experiment, the participants heard commercial recordings of the same pieces and were asked to identify them. The study showed that music identification from harmony in an open-set task is possible, even when melodic and rhythmic cues are largely missing. Additionally, both the timbre with which the chord progressions were played and the expertise of the participants were statistically significant factors for identification; the professionals being best. We found that stimuli using shepard tones were more difficult to identify than those using piano tones, and that the major part of the difference was explained by the downgrading of melodic cues, not by timbral associations. The differences between transpositions were not statistically significant.

**Keywords**—harmony, memory for harmony, music memory, tune identification.

## I. INTRODUCTION

WHEREAS the effects of pitch and rhythmic information on tune identification have been studied extensively [1], the effect of harmony for tune identification has seldom been examined [2], [3]. There are several reasons that could explain why the effect of harmony on tune identification has not been studied more often. First, listeners can easily identify a song or piece of music based on the pitch and rhythmic features of its melody alone, without hearing its harmonic accompaniment [1]. Second, the chords that accompany a well-known melody can be changed without altering the identity of a tune [2]. Third, many tunes imply or are typically accompanied by the same or similar chord progressions, and this one-to-many correspondence can weaken the association between a chord

progression and a specific tune [4], [5]. Additionally, it is difficult to measure the effect of harmony independent of the effect of melody and rhythm since a chord progression cannot be instantiated without also creating some degree of melodic motion and rhythmic activity. Reference [3] found that adding chords to a single-pitch rhythmic version of well-known tunes made identification more difficult, and it is likely that the melodic line created by the highest notes of each of the chords in the progression provided participants with a wrong melody that misled them in their process of tune identification. One way to avoid the problem of incorrect melodic cues is to voice the chords in such a way that the highest note of each chord in the progression corresponds to the most representative pitch of the melody during that time-span. The use of this type of harmonic reductions to summarize the underlying structure of music dates at least as far back as the mid-19<sup>th</sup> century [6], and formal musical training usually involves the study of harmonic reductions [7], [8]. Empirical evidence also suggests that listeners can distinguish between correct and incorrect harmonic reductions of a musical passage [9], [10]. Until the present study, however, the ability to identify music from harmonic reductions has not been empirically tested.

## II. PILOT STUDY

Forty pieces, 20 popular songs and 20 pieces of classical music, were selected for the pilot based on their inclusion in recent publications: studies on tune identification [11]–[13], a study on implicit absolute pitch [14], a corpus analysis [15], a CD compilation of popular classical pieces [16], as well as because of their popularity among undergraduate music theory students at the University of Pittsburgh, who were surveyed between the years 2010 and 2014. Classical and pop/rock pieces were used instead of traditional tunes because their chord progressions tend to be more distinctive and their different renditions often preserve the original harmony with little or no modifications. In the pilot study, we tested 18 participants' ability to identify the 40 pieces from harmonic reductions played with a digital grand piano sound. Harmonic reductions consisted of six, seven, or eight chords from the initial phrase, initial period, or another representative section of the pieces and every chord lasted 2 seconds. Most harmonic reductions had four voices, and all voices had only one note per chord. Since the excerpts chosen for this pilot were the initial phrases of relatively simple pieces and songs, durational accents provided a straightforward criterion for choosing most of the notes. Harmonic reductions preserved both the contour of the different voices and chordal inversions from the original excerpts. Pitches were verified using Sonic Visualiser software. The test was administered online.

After listening to each harmonic reduction, listeners were asked to select the name of the piece from a list of the 40

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pieces. The difficulty of the identification task and the high number of items in the list reduced the likelihood that listeners would identify pieces by process of elimination. The twelve pieces that were most often identified in the pilot study were selected for the main experiment: The Animals, *House of the Rising Sun*; The Beatles, *Let it Be*; Capital Cities, *Safe and Sound*; Coldplay, *Clocks*; Coldplay, *Viva La Vida*; Daft Punk, *Get Lucky*; Elgar, *Pomp and Circumstance*; Led Zeppelin, *Stairway to Heaven*; Nirvana, *Smells like Teen Spirit*; Pachelbel, *Canon in D Major*; Red Hot Chili Peppers, *Snow (Hey Oh)*; Tchaikovsky, *Dance of the Sugar Plum Fairy*.

### III. MAIN EXPERIMENT

#### A. Participants

There were one hundred participants in this experiment. Two participants were rejected since they had very limited familiarity with Western popular music. Eighty-seven participants were undergraduate students enrolled in one or more music classes at the University of Pittsburgh. Of the other eleven participants, five were composition doctoral or master students, two were music theorists, two were instrument instructors, one was a professional musician and one was an amateur musician. The participants were divided into four groups according to their musical background. In the first group, labeled *professionals* (N = 17; 13 male), the participants were professional musicians or professional music students. In the second group, labeled *serious amateur musicians* (N = 16; 7 male), the participants had no professional musical training but had had private instrument lessons for more than five years. The third group, labeled *amateur musicians* (N = 40; 23 male), consisted of participants with no professional musical training but who had had 5 years or less of private instrument lessons or had played an instrument for more than 5 years. The participants in the fourth group, labeled *non-musicians* (N = 25, 15 male), had not studied music nor did they actively play any instrument.

#### B. Stimuli

The chord sequences were first composed using Finale 2007 software. The harmonic reductions were composed so that each new harmony of the original commercial recording was composed into a chord. The specific notes for each chord in the reductions were chosen according to the same criteria used in the pilot experiment. For the nine harmonic reductions taken from popular songs, the duration of the chords matched the original duration in the most viewed version of the song on YouTube. For the three harmonic reductions taken from classical pieces, the duration of the chords was determined by averaging the duration of every chord in the ten most viewed versions of the piece on YouTube.

Both piano tones and shepard tones were used in the harmonic reductions. Shepard tones are vague in terms of pitch register, which greatly reduces the clarity of melodic gestures, voicing, and chordal inversions. For this reason shepard tones have been used regularly in experiments where researchers want to minimize the effects of melodic cues in tasks that aim to examine participants' responses to harmony [17]-[21]. Audio excerpts for the second part of the

experiment were extracted from commercial recordings of the twelve pieces used in the experiment. Excerpts lasted 15 seconds and contained the harmonic reductions used in the first part of the experiment. Most excerpts from songs included vocals but no excerpt contained words from the title of the song

#### C. Transposition

Although most listeners can identify familiar melodies when transposed to a different key based on relative pitch information (e.g., Happy Birthday), we predicted that for pieces that are usually performed at the same pitch level, the presence of absolute pitch cues (i.e., hearing the music at its most typical pitch level) would be an important factor in the identification of a piece from harmonic reduction, that is, in the absence of important rhythmic, timbral, and textural cues. Thus, we expected that playing harmonic reductions in atypical keys would make identification more difficult. Six different pitch levels were used for the main experiment: original, one semitone down, one semitone up, two semitones down, two semitones up, and tritone.

#### D. Procedure

In the first part of the experiment, the 12 harmonic reductions representing the 12 pieces were presented using either piano tones or shepard tones. After hearing each reduction, the participants were asked to respond either with the name of the piece, some words of the lyrics or some description of the piece if they could not recall the exact name or lyrics. In the second part of the experiment, the tunes were presented as commercial recordings, and the participants were asked to name the pieces as well. Participants were also asked how often they had heard the piece or if they had played the piece themselves.

#### E. Results

The scores were summarized for each timbre and each group of participants. If a participant did not identify a piece from the commercial recording, all his/her responses for harmonic reductions of the piece were omitted from analysis. There were a few instances where participants mentioned a piece that was not in our list but that matched the chord progressions featured in the harmonic reduction. Based on that scarcity and the fact that our harmonic reductions had a less direct musical connection to those pieces than to the pieces in our list, we decided to exclude those pieces from our main analysis. Fig.1 shows the percentages of identified harmonic reductions played using two timbres for the four groups of participants. The figure shows that the professionals identified more pieces from their harmonic reductions than did the other participants.

The difference between professionals and other participants was relatively large, but the differences between the three other subgroups were small, especially when the reductions were played using shepard tones. As can also be seen, the reductions played using shepard tones were generally more difficult to identify than the reductions played using piano tones. A two-factor ANOVA analysis was made using two

timbres of the reductions and the musical background of the participants as experimental variables. The analysis confirmed the results: both the timbre ( $F(1, 97) = 10.031, p = .002$ ) and the musical training of participants ( $F(3, 291) = 24.798, p < .001$ ) were statistically significant factors in explaining the responses. The group \* timbre interaction was not statistically significant ( $p = .545$ ). The Bonferroni post-hoc test confirmed that the subgroup of professional musicians differed from other participant subgroups ( $p < .001$ ) and that there was no difference between the other participant subgroups. Since the subgroup of professionals differed from the other participant subgroups, and since the responses of the other three subgroups did not differ, the three subgroups were merged into one group of non-professionals, and the rest of the analyses were made using data from only two groups of participants labeled as professionals and non-professionals.

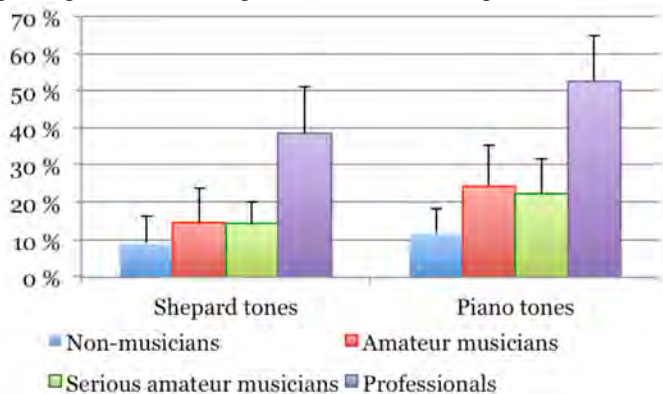


Fig. 1 Responses from four participant subgroups. Identification of music from harmonic reductions. Error bars show standard deviations

Identification rates for piano-tone and shepard-tone chordal reductions were the most dissimilar for *The House of the Rising Sun* and *Pomp and Circumstance*. The piano-tone version of the chords of *The House of the Rising Sun* was identified more often (57%) than its shepard-tone counterpart (21%). The advantage of piano over shepard tones in the case of *The House of the Rising Sun* is likely a consequence of a prominent 8-7-#6-6 melodic line that can be heard in the shepard-tone version, which is not a prominent gesture in the original song or the piano reduction. More evidence of the importance of the minimization of melodic cues in shepard-tone reductions comes from the identification of *Pomp and Circumstance* (61% for piano first and 4% for shepard first). The shepard-tone version of *Pomp and Circumstance* was most often mistakenly identified as being Pachelbel’s Canon, while the piano-tone version was not. The mistake was not a consequence of the “church” association triggered by the organ-like sound of shepard tones, if that were the case, such an association would have also made Pachelbel’s reduction more easily identifiable from Shepard tones than piano tones, which was not the case. A more plausible explanation for why our participants heard Pachelbel’s reduction in the shepard-tone version of *Pomp and Circumstance* but not its piano-tone version is that in the shepard-tone version, the ascending bass and the chordal inversion of the original are most likely lost, and listeners are likely to hear instead the roots of the chords

that create a pattern similar to that of the bass in Pachelbel’s Canon.

The effect of transposition on music identification was also analyzed. Fig 2. shows the percentages of pieces identified from the six transpositional levels, done separately for professionals and non-professionals. ANOVA analysis showed that the effect of transpositions was statistically significant neither for the non-professionals ( $F(5,400) = 1.127, p < .345$ ) nor for the professionals ( $F(5,80) = 1.750, p = .131$ ).

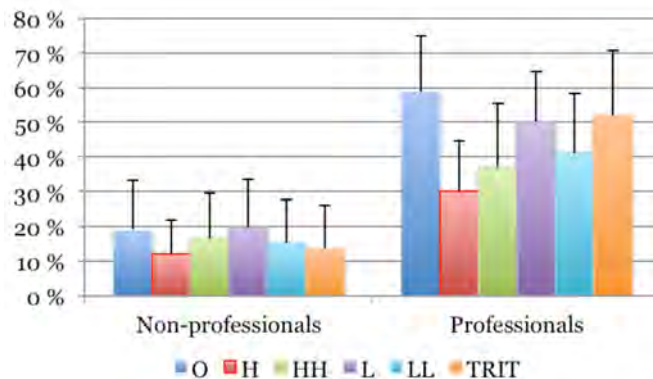


Fig 2. Effect of transposition. Correct identifications (vertical axis). O = original transposition; H = one semitone up; HH = two semitones up; L = one semitone down; LL = two semitones down; TRIT = tritone. Error bars show standard deviations.

The role of rhythmic resemblance between the original piece and the harmonic reduction on music identification was also examined. Although rhythmic resemblance is a complex topic because there are many possible considerations [22]-[24], we opted for an approach to calculating rhythmic similarity that only takes into account rhythmic density and syncopation, two aspects of rhythm that exhibited a high degree of variability in our group of 12 pieces. We calculated correlations between rhythmic similarity and the average percentages of hits vs. misses for the two participant subgroups, separately for shepard tones and piano tones, and found that there was a statistically significant correlation for both participant subgroups in the piano-tones condition ( $R(12) = .759, p = .004$  for professionals;  $R(12) = .641, p = .025$  for non-professionals), but not in the shepard-tone condition ( $R(12) = .567, p = .055$  for professionals;  $R(12) = .478, p = .116$  for non-professionals). The responses for piano-tone stimuli are consistent with the idea that rhythmic similarity does indeed facilitate identification from harmonic reductions.

#### IV. DISCUSSION

Results suggest that listeners with extensive musical training are significantly better than other listeners at identifying music from its harmony. These results are in line with previous research showing that musical training increases sensitivity to harmony [25]-[29]. Our study, however, showed that neither previous musical training nor playing an instrument was necessary for identifying pieces from harmonic reductions. Results from our experiment also provide evidence of the crucial role of melodic and rhythmic cues in the identification of pieces from harmonic reductions. Pachelbel’s *Canon in D* was by far the most often identified piece from harmonic reduction in our study. Although its

extra-musical associations (e.g., weddings, graduations, Christmas), pervasive presence in popular culture, and distinctive sequential pattern may have facilitated its identification, the rhythmic resemblance between the block-chords in our stimuli and the beginning of Pachelbel's piece is likely to have simplified the process of identification as well. It is important to note that for most of the pieces we selected for our experiment, deviation from the slow, regular rhythm of our block-chord stimuli also meant deviation in terms of melodic content. That is, the more rhythmically dense the original excerpts were, the more melodic gestures were omitted in the harmonic reduction. The correlations between rhythmic similarity and identification rates for individual pieces from piano chordal reductions are consistent with the idea that rhythmic similarity does indeed facilitate identification from harmonic reductions. The role that melodic and rhythmic cues played in the identification of music from harmonic reductions in the present study provides further evidence of their influence on the mental representation of harmonic activity.

In addition to testing the influence of musical training in the identification of music from harmony, our experiment also tested the influence of transposition. Although music was most often identified from harmonic reductions played at their typical pitch level in our experiment, we found no significant effect of transposition on music identification.

## V. CONCLUSIONS AND FUTURE WORK

This study showed that music identification from harmonic reductions is possible, yet there are many factors affecting the identification process. It appears that the use of harmonic information in identification is easiest for professional musicians, especially composers and theorists. Melodic and rhythmic cues are important, and they are always present in chord progressions and harmonic reductions. The association of a harmonic reduction with a specific song is just one way that the interaction of harmony and episodic memory can influence our perception of music, suggesting that the seemingly idiosyncratic task of explicitly identifying music from harmonic reductions can improve our general understanding of how listeners make sense of music. Future research on music identification from harmony is needed to clarify whether the association of harmony with episodic memory occurs implicitly or not as well as how such unconscious associations impact our experiences with music.

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## REFERENCES

[1] A. R. Halpern and J. C. Bartlett, "Memory for melodies." in *Music perception*. Springer, New York, 2010, pp. 233-258.  
 [2] D.J. Povel and R. Van Egmond, "The function of accompanying chords in the recognition of melodic fragments," *Music Perception*, vol. 11, pp. 101-115, 1993.

[3] T. Kuusi, "Tune recognition from melody, rhythm and harmony," in *Proc. 7th Triennial Conference of European Society for the Cognitive Sciences of Music (ESCOM)*, Jyväskylä, Finland, 2009.  
 [4] R. J. Scott, *Money Chords: A Songwriter's Sourcebook of Popular Chord Progressions*. Bloomington, IN: iUniverse, 2000.  
 [5] N. Stoia, "The common stock of schemes in early blues and country music," *Music Theory Spectrum*, vol. 35, pp. 194-234, 2013.  
 [6] C. Czerny, *School of Practical Composition: Complete Treatise on the Composition of All Kinds of Music* (J. Beshop, Trans.). New York: Da Capo Press, 1979 [Reprinted from *Die Schule der Praktischen Tonsetzkunst*, Bonn: Simrock, 1849].  
 [7] E. Aldwell, C. Schachter, and A. C. Cadwallader, *Harmony & Voice Leading*, 4th ed. Boston, MA: Schirmer/Cengage Learning, 2011.  
 [8] J. P. Clendinning, and E. W. Marvin, *The Musician's Guide to Theory and Analysis*, 2nd ed. New York: W.W. Norton, 2011.  
 [9] M. L. Serafine, N. Glassman, and C. Overbeeke, "The cognitive reality of hierarchic structure in music," *Music Perception*, vol. 6, pp. 397-430, 1989.  
 [10] N. Dibben, "The cognitive reality of hierarchic structure in tonal and atonal music," *Music Perception*, vol. 12, pp. 1-25, 1994.  
 [11] C. L. Krumhansl, "Plink: 'thin slices' of music," *Music Perception*, vol. 27, no. 5, pp. 337-354, 2010.  
 [12] K. VanWeelden, "Classical music as popular music: adolescents' recognition of Western art music," *Applications of Research in Music Education*, vol. 31, pp. 1-11, 2012.  
 [13] K. VanWeelden, "Preservice music teachers' recognition of Western art music found in popular culture," *Journal of Music Teacher Education*, vol. 24, pp. 65-75, 2014.  
 [14] K. Frieler, T. Fischinger, K. Schlemmer, K. Lothwesen, K. Jakubowski and D. Müllensiefen, "Absolute memory for pitch: A comparative replication of Levitin's 1994 study in six European labs," *Musicae Scientiae*, vol. 17, pp. 334-349, 2013.  
 [15] T. deClercq and D. Temperley, "A corpus analysis of rock harmony," *Popular Music*, vol. 30, pp. 47-70, 2011.  
 [16] D. Parry, *The 50 Greatest Pieces of Classical Music*. London Philharmonic Orchestra. X5 Music Group. ASIN: B002WMP162, 2009.  
 [17] J. J. Bharucha, "Anchoring effects in music: The resolution of dissonance," *Cognitive Psychology*, vol. 16, pp. 485-518, 1984.  
 [18] J. J. Bharucha and K. Stoelkig, "Reaction time and musical expectancy: Priming of chords," *Journal of Experimental Psychology: Human Perception and Performance*, vol. 12, pp. 403-410, 1986.  
 [19] É. A. Firmino, J. L. O. Bueno, and E. Bigand, "Travelling through pitch space speeds up musical time," *Music Perception*, vol. 26, pp. 205-209, 2009.  
 [20] T. Kuusi, "Interval-class and order of presentation affect interval discrimination," *Journal of New Music Research*, vol. 36, pp. 95-104, 2007.  
 [21] C. L. Krumhansl, J. J. Bharucha, and E. J. Kessler, "Perceived harmonic structure of chords in three related musical keys," *Journal of Experimental Psychology: Human Perception and Performance*, vol. 8, pp. 24-36, 1982.  
 [22] E. Cao, M. Lotstein, and P. N. Johnson-Laird, "Similarity and Families of Musical Rhythms," *Music Perception*, vol. 31, pp. 444-469, 2014.  
 [23] J. Forth, *Cognitively-motivated Geometric Methods of Pattern Discovery and Models of Similarity in Music*. PhD Dissertation, Goldsmiths University London, 2012.  
 [24] G. T. Toussaint, *The Geometry of Musical Rhythm: What Makes a "Good" Rhythm Good?*. Boca Raton, FL: CRC Press, Taylor & Francis Group, 2013.  
 [25] M. M. Farbood, "A parametric, temporal model of musical tension," *Music Perception*, vol. 29, pp. 387-428, 2012.  
 [26] R. Kopiez and F. Platz, "The role of listening expertise, attention, and musical style in the perception of clash of keys," *Music Perception*, vol. 26, no. 4, pp. 321-334, 2009.  
 [27] D. Sears, W. E. Caplin, and S. McAdams, "Perceiving the Classical cadence," *Music Perception*, vol. 31, no. 5, pp. 397-417, 2014.  
 [28] L. R. Williams, *The Effect of Musical Training and Musical Complexity on Focus of Attention to Melody or Harmony*. Unpublished doctoral dissertation, Florida State University, Tallahassee, FL., 2004.  
 [29] R. S. Wolpert, "Attention to key in a non-directed music listening task: Musicians vs. nonmusicians," *Music Perception*, vol. 18, pp. 225-230, 2000.