Striking Similarities: Toward a Quantitative Measure of Melodic Copyright Infringement

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In a well-publicized 2008 lawsuit, guitarist Joe Satriani accused the band Coldplay of misappropriating his musical materials.[1] The lawsuit, filed under the provisions of the United States Copyright Act, generated many news reports and even online videos comparing and contrasting the artists' songs.[2] Though the exploration in popular discourse of musical plagiarism[3] lawsuits seems to be a new phenomenon, musical plagiarism has appeared before American and other courts for well over a century. Such lawsuits are even somewhat common in the music industry; they are of particular interest to those people in musical careers, as the legal precedents of such lawsuits hold the potential to directly affect them. Yet, based on the paucity of discourse on the topic, musicians from outside the music industry, such as music theorists, appear to routinely ignore such proceedings.

They, too, should take an interest in such cases. Such lawsuits often address questions that are fundamental to the analytical study of music, and place these questions at the center of popular social and entertainment discourse. In court, prosecuting and defending attorneys alike seek to highlight similarities or differences between their clients' respective works; although legal professionals use

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[1] BBC News Online, "Guitarist Satriani Sues Coldplay" (London: BBC, December 5, 2008). Available online at: http://news.bbc.co.uk/2/hi/7766683.stm, accessed March 3, 2012.

[2] See, for example, a popular YouTube video titled "Coldplay vs. Joe Satriani," by user Fmbloxghost. Available online at: http://www.youtube.com/watch?v=UvB9Pj9Znsw, accessed March 3, 2012.

[3] Although "plagiarism" and "copyright infringement" are technically two different legal matters (with substantial overlap between them), these terms are used interchangeably in this study.

different terms and advocate to a different audience,[4] the questions they seek to answer in the courtroom are the same as those that many theorists place at the center of their own research: What is the design of this music? In what ways can this music be understood? How does this music relate to other music? By asking such questions, the legal system is answering an important legal query: what does it require for music to infringe upon the copyright of other music? As will be seen, the answers to these questions are anything but clear, due in part to the legal system's unfamiliarity with music and its approach to comparing musical works to one another.

At the same time, recent advances in music theory, musical psychology, and music informatics have allowed various scholars to quantify the differences between short musical works. Similarly to how audio technicians can quantify the intensity of sound via the decibel scale, these scholars are working to develop accurate systems for counting the number and measuring the significance of musical differences between two works.[5] This paper, therefore,

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[4] For an intriguing look at how legal professionals have sometimes presented such arguments and how these formulations differ from those commonly used in musical communities, see Maureen Baker, "Law - A Note to Follow So: Have We Forgotten the Federal Rules of Evidence in Music Plagiarism Cases?" (*Southern California Law Review*, Vol. 65, 1992, p.1583-1637), particularly 1596-1608.

[5] Members of the International Society for Music Information Retrieval (ISMIR) have especially been active in researching these issues at both the symbol- and signal-based levels (that is, both scores and recordings), using computer tools for most of their work. The Society's annual conference is thus one of the most important fora for the dissemination of work on similarity metrics. It is worth noting, however, that scholars in this area are primarily computer scientists with an interest in music, as opposed to music theorists *per se*. Beyond those that will be discussed in greater detail later, some notable studies attempting to quantify musical similarity include: J.-J. Aucouturier and F. Pachet, "Music Similarity Measures: What's the Use?" in *ISMIR 2002 Conference Proceedings: Third International Conference on Music Information Retrieval*, Michael Fingerhut, Ed. (Paris: IRCAM-Centre Pompidou, 2002); Jouni Paulus and Anssi Klapuri, "Measuring the Similarity of Rhythmic Patterns," in *ISMIR 2002 Conference Proceedings: Third International Conference on Music Information Retrieval*, Michael Fingerhut, Ed. (Paris: IRCAM-Centre Pompidou, 2002); Margaret Cahill and Donncha Ó Maidín, "Melodic Similarity Algorithms—Using Similarity Ratings for Development and Early Evaluation," in *ISMIR 2005: 6th International Conference on Music Information Retrieval: Proceedings*, Joshua Reiss and Geraint Wiggins, Eds. (London: Queen

joins these two areas of scholarship, *i.e.*, the nature of infringement in intellectual property law, and the music theoretical study of musical similarity. In doing so, the paper seeks to answer the following question, as it relates to musical plagiarism lawsuits in the United States: can copyright infringement be quantified and measured? Using the outcomes, findings and music from past musical plagiarism lawsuits, can some kind of numerical representation of the similarity between two musical works accurately represent the line between infringement and non-infringement? To answer this question, first, brief inquiries into both copyright law and musical similarity will be undertaken to identify a suitable context and approach for study. Second, the analytical methodology will be described and exemplified. Third, the results will be presented and trends therein discussed and further analyzed. In all, it will be demonstrated that, under some circumstances, quantifying the similarity of two musical works may indeed act as a good general indicator of the likelihood of a finding of copyright infringement.

Music and the Legal Context

To fully understand this study and its chosen methodology, it is necessary to understand a few key points about copyright law, as well as how music has interacted with copyright in the past. Copyright in the United States is governed by Title 17 of the *United States Code*,[6] which compiles the provisions of the various copyright bills passed by Congress from time to time (for instance, the *Copyright Act of 1976*, the *Copyright Term Extension Act*, and the *Digital*

Mary, University of London, 2005); Kurt Jacobson, "A Multifaceted Approach to Music Similarity," in *ISMIR 2006: 7th International Conference on Music Information Retrieval: Proceedings*, Roger Dannenberg, Kjell Lemström, and Adam Tindale, Eds. (Victoria, BC: University of Victoria, 2006); and Tim Pohle *et al.*, "Independent Component Analysis for Music Similarity Computation," in *ISMIR 2006: 7th International Conference on Music Information Retrieval: Proceedings*, Roger Dannenberg, Kjell Lemström, and Adam Tindale, Eds. (Victoria, BC: University of Victoria, 2006).

[6] *Copyrights*, 17 U.S.C. (2006).

Millennium Copyright Act).[7] One of copyright's purposes is to provide a rights holder with exclusive rights, e.g. make copies of the work or create new, derivative adaptations of the original work.[8] It is from the right to adapt the work that copyright claims are often initiated, as it is argued that a work featuring similar musical materials is indeed an unauthorized adaptation of the original work: the closer the similarities, the more likely the court will find copyright infringement.

This, of course, constitutes only copyright's basic legal outline. A substantial amount of music copyright law is derived from the case law of previously litigated instances of musical plagiarism. An essential component of common law systems is the reliance upon precedents to establish standards by which laws are interpreted and enforced, and to extend the law into areas clearly within its jurisdiction but where the law is silent on how to proceed in such matters. Title 17 does not list specific musical criteria to consider in establishing infringement in musical works; until the day such details might be legislated, they are provided by past court decisions, which have explained methods and rationales for deciding upon the standard of infringement, as described by the judges who worked through prior cases brought to the court.

While perhaps procedurally useful within the legal context, this methodology comes bundled with a few problems for this particular study. Because standards are only loosely codified and applied, music copyright infringement lawsuits feature uneven, and thus, unreliable precedents, as much in their methodologies as in their outcomes.[9] Given this, it is difficult to effectively predict the outcome of a given suit based solely on the musical works in question.[10] Such a consideration is important for this study, as some level of inconsistency should thus be expected in the results, given the problems the law faces in upholding reliable standards.

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[7] *Copyright Act of 1976*, 90 Stat. 2541 (1976); *Copyright Term Extension Act*, 112 Stat. 2827 (1998); *Digital Millennium Copyright Act*, 112 Stat. 2860 (1998).

[8] Simon Frith and Lee Marshall, "Making Sense of Copyright" in *Music and Copyright*, S. Frith and L. Marshall, Eds. (New York: Routledge, 2004), 7.

[9] Baker, 1584-5.

[10] *Ibid.*, 1585.

Still, from the precedents, there are some general principles that have emerged and are important in developing a suitable context for this study. The renowned legal scholar Alan Latman summarizes these principles into three key points:

1. The plaintiff must prove access by the defendant to his or her musical work, as independently composing a similar musical work is perfectly legal under copyright law.[11] As Jeffrey Sherman more succinctly puts it, if the defendant "had no access, he could not have copied the work, and if he did not in fact copy, there can be no infringement."[12] There is an exception, however, which will be discussed below.
2. The plaintiff's materials must be protected by a valid copyright.[13] Basically, one is not entitled to sue for infringement if one is not the owner of a copyright for the work involved in the dispute. This was admittedly more important prior to 1978, when copyright was granted only by registering a work with the Copyright Office. Since 1978, all works are automatically granted protection under copyright, whether registered or not.
3. The defendant must have copied a "substantial" amount of material.[14] Although "substantial" was originally understood in terms of quantity,[15] later decisions established that a "substantial" portion could be any prevalent feature of a musical work.[16] Yet "substantial" is itself a rather vague standard; as Melville Nimmer, the foremost copyright scholar of his day, points out, "[e]ven the measure of how

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[11] Alan Latman, "'Probative Similarity' as Proof of Copying: Toward Dispelling Some Myths in Copyright Infringement." (*Columbia Law Review*, Vol. 90, No. 5, 1990, p. 1187-1214), 1189.

[12] Jeffrey Sherman, "Musical Copyright Infringement: The Requirement of Substantial Similarity" (*Copyright Law Symposium*, Vol. 22, 1975, p. 81-146), 82.

[13] Latman, 1189.

[14] *Ibid.*, 1189.

[15] A good musical example of this occurred in *Marks v. Feist* (290 F. 959 (2d Cir. 1923)), where six bars of the defendant's work were found to be nearly identical to the plaintiff's work, yet the case was dismissed on the grounds that the infringing measures were not "substantial" within the defendant's 400-measure piece.

[16] Ronald Rosen, *Music and Copyright* (Oxford: Oxford University Press, 2008), see generally 16-19.

> substantial a 'substantial similarity" must be may vary according to circumstances."[17]

Finally, in somewhat of a contradiction to Latman's first principle, when dealing with musical works, if similarity is found to be "striking," i.e., to a significantly greater degree than "substantial," then access may be inferred even if the plaintiff is unable to prove access (as plaintiffs usually try to prove, as per the first principle).[18] As Maureen Baker puts it, "the tests between substantial and striking similarity determine how similar the material is, whether the similarities could possibly have been created independently, or whether they could only have come about through copying."[19]

These extra-musical considerations are important because they indicate that, in a study such as this one, it is not enough only to examine the music and outcomes in musical lawsuits to verify a correlation; one must carefully trace the legal reasoning which justifies the outcome to see if it is reached on substantive (*i.e.*, musical) or procedural grounds. A hypothetical lawsuit involving two identical songs could be dismissed on any of the above bases,

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[17] Melville Nimmer and David Nimmer, *Nimmer on Copyright* (New York: Bender, 1978), Vol. 4, Ch. 13, 35.

[18] Alice Kim, "Expert Testimony and Substantial Similarity: Facing the Music in (Music) Copyright Infringement Cases" (*Columbia-VLA Journal of Law and the Arts*, Vol. 19, 1995, p. 109-128), 111.

[19] Baker, 1592. Unfortunately, there appears to be little conclusive scholarship on the differences between substantial and striking similarity in music copyright infringement. Both Robert Osterberg's article (1983) on striking similarity in music and his book (2003, with Eric Osterberg) on the concept of similarity in copyright draw overly general conclusions on this point. John Autry (2002) analyzes various cases and proposes that striking similarity is first based upon the quantity of overlap between two works, and then on the similarities between the most unique musical features of the "original" and their alleged recurrences in the "copy." While his model appears plausible, Autry nonetheless remains rather vague about how much overlap constitutes striking overlap; this is large part a reflection of the challenge required to codify such understandings. See Robert Osterberg, "Striking Similarity and the Attempt to Prove Access and Copying in Music Plagiarism Cases" (*Journal of Copyright, Entertainment and Sports Law*, Vol. 2, No. 2, 1983, p. 85-104); Robert Osterberg and Eric Osterberg, *Substantial Similarity in Copyright Law* (New York: Practising Law Institute, 2003), particularly Chapter 9; John Autry, "Toward a Definition of Striking Similarity in Infringement Actions for Copyrighted Musical Works" (*Journal of Intellectual Property Law*, Vol.10, 2002, p. 113-141), especially 140-1.

yet a study searching for links between quantified musical similarity and findings of infringement would be at a loss to explain such an outcome on musical grounds alone. Surely to the dismay of many plaintiffs, the legal context and procedure often matter more than the musical work in musical plagiarism lawsuits. Still, such lawsuits pose problems for the study, since a judge, while dismissing a case on the basis of a technical requirement, may then expound upon the similarities or lack thereof between works—how should these comments be understood, in light of the procedural dismissal?

A final source of uncertainty in music plagiarism case law comes from the legal actors themselves. Obviously, in copyright law as in any other legal matter, judges are humans, and are on some level intuitively interpreting and applying legal standards codified in text by someone else.[20] One judge's "substantial" similarity might meet another's threshold for "striking" similarity, or perhaps not be enough at all and deemed unsubstantial copying. Some lawyers are better than others—this may yield a biased influence upon the outcome of an action. Additionally, jurors, when used in such trials, come from all walks of life. Most critically for musical plagiarism lawsuits is the lack of understanding of music and musical structures among judges, lawyers and jurors;[21] for them, that two works end on a sustained tonic chord could be perceived as substantial copying, as opposed to common musical practice. While expert testimony by trained musicians is often used in musical plagiarism proceedings (and one hopes these musicians would use the opportunity to correct any misunderstandings), it is

[20] No less a jurist than the esteemed Justice Learned Hand (1872-1961), a well-respected Manhattan District Court (and later, Appellate Court) judge, admitted that his judgments were intuitively based, claiming that in deciding a case he is "relying upon such musical sense as I have;" other judges followed suit. See *Haas v. Leo Feist* (234 F. 105 (S.D.N.Y. 1916)).

[21] An amusing yet revealing citation from case law sees the judge in *Northern Music v. King Record Distributing* (105 F. Supp. 393 (S.D.N.Y. 1952)) assert that "rhythm is simply the tempo in which the composition is written; it is the background for the melody" and that "there are only a limited amount of tempos." Of course, judges are not expected to be well-versed in music, just as musicians are not expected to be fluent in the law; still, such confusion points to the highly specialized nature of music copyright infringement, and the need for tools that can assist layperson judges in applying the law.

not at all clear how effective such experts are at conveying the essential similarities and dissimilarities in the works to the legal actors. [22] Even with such experts and assistance, judges' commentaries and various legal critiques suggest that most decisions remain rooted in intuition.[23]

Thus, there exist many barriers and variables that a study of infringement such as this one must consider in picking through its details. Certainly, the legal dichotomy of "guilty" and "not guilty" must be interpreted flexibly within the framework of a system that is almost rooted in inconsistency. Still, such fluctuations reveal the need for studies such as this one. Legal scholar Yvette Liebsman has specifically called for mathematical models that could be used to for parsing non-infringement from infringement and "substantial" similarity from "striking" similarity.[24] Maureen Baker, a musician and lawyer, describes making predictions in the current legal context on the outcome of a musical plagiarism lawsuit as "a game of Russian roulette."[25] The fact that most record labels are now required to take out insurance policies against infringement[26] and even occasionally hire expert musician-lawyers to comb through their works to remove possible bases for costly infringement lawsuits[27] speaks to the troubling levels of uncertainty

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[22] Fletcher Reynolds, *Music Analysis for Expert Testimony in Copyright Infringement Litigation* (Doctoral dissertation, University of Kansas. Ann Arbor: UMI, 1991), see generally chapter 9.

[23] See again the comments by Judge Learned Hand at footnote 20.

[24] Her proposed system for doing so through wave physics and sonograms appears rather problematic to this author, but her goal of introducing some quantifiable element into infringement disputes is well taken. See generally Yvette Liebsman, "Using Innovative Technologies to Analyze for Similarity Between Musical Works in Copyright Infringement Disputes" (*American Intellectual Property Law Association Quarterly Journal*, Vol. 35, No. 3, 2007, p. 331-62).

[25] Baker, 1585.

[26] *Ibid.*, 1587.

[27] Ronald Rosen, a musician and lawyer whose landmark book *Music and Copyright* (2008) was cited earlier at footnote 16, claims he regularly "assists clients in revising and rewriting musical scores to avoid infringing other works." See: TroyGould PC, "Ronald S. Rosen" (Los Angeles: TroyGould Attorneys, 2012), available online at http://www.troygould.com/index.cfm?fuseaction=people.personDetail&ID=10553, accessed March 3, 2012.

which exist in this legal area. All of this suggests that courts are failing in their duty to provide useful guidance to citizens beyond their halls on what is legally permissible and what is not. As a step toward developing ideas into solutions, a study of the applicability of mathematical formulae and similarity metrics to the field appears relevant and timely.

Measuring Musical Similarity

From the standpoint of music, similarity carries very different connotations than in the courtroom. The relatedness of musical features is a core theme within the study of composition, music theory and performance. Sets of variations from throughout music history, from Bach's to Beethoven's to Webern's and beyond, illustrate the compositional virtues and problems associated with musical similarity.[28] In stark contrast to what one might infer from contemporary copyright laws, composers borrowing from other composers was once a fairly normal practice: Bach borrowed from Vivaldi, Franz Liszt often wrote piano arrangements of orchestral works composed by his contemporaries and, more recently, Luciano Berio amalgamated themes written by others into his own works.[29] None were sued for copyright infringement or rebuked for borrowing musical materials in the absence of copyright laws, as musical similarity was so commonplace an idea that it was, until recently, mostly ignored as a topic. The list could go on, and is by no means limited to classical repertoire, although claims of infringement are more common outside classical music.[30] Of late,

[28] That is, how does one create a new variation that sounds different enough to maintain a listener's interest while still retaining a sufficiently referential quality to an identifiable original theme?

[29] I am thinking here of Bach's *Concerto for Four Harpsichords*, Liszt's adaptations of works by Schubert, Berlioz and Beethoven, and the third movement of Berio's *Sinfonia*. Berio in particular could have been sued by living composers from whom he borrowed poignant musical themes such as Pierre Boulez, Karlheinz Stockhausen and Igor Stravinsky, and/or the estates of then-recently deceased ones such as Paul Hindemith or Arnold Schoenberg.

[30] For example, Siva Vaidhyanathan examines musical borrowing and claims of copyright infringement in the history of blues music, and James Boyle reviews the

the study of similarity as an observable and quantifiable metric in music is a phenomenon associated with the advancements of musical psychology and computing in the late 20th century, and I will principally draw upon the work of researchers in these fields for my purposes. To be sure, many music theorists have also studied musical similarity, but their aims and areas of focus are not easy to reconcile with those of this study. Contour theory is a good example of similarity being examined from a different angle. As well-known articles by Michael Friedmann, Robert Morris and Ian Quinn (among many others) show,[31] generalizing short motives into contours allows for an examination of the many different forms that motives can take in a musical work, be that through the standard pc-set transformations, combinatorial methods, or other strict and/or fuzzy derivative methods; these methods can be applied to just about any musical parameter (pitch, dynamics, density, etc.), too. Contour theory, however, necessarily limits these analyses to single works at a time, or, at most, isolates one composer for study. Few of contour theory's many extensions have been applied to comparisons of two pieces by unrelated composers, since in many ways such an application goes against the theory's philosophical underpinnings as a mechanism for understanding transformations within a unified work. While transplanting this scholarship into the realm of popular songs could well bring some interesting observations, the kind of similarity discussed in contour theory is fundamentally not the same as that examined by the aforementioned scholars in music psychology and computing, resulting in vastly different conceptions of what

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history of one song used by Kanye West, Ray Charles and others, also relating claims of infringement (or the absence thereof) to the topic. See Siva Vaidhyanathan, *Copyrights & Copywrongs: The Rise of Intellectual Property and How It Threatens Creativity* (New York: NYU Press, 2001), at Chapter 4; and James Boyle, *The Public Domain: Enclosing the Commons of the Mind* (New Haven: Yale University Press, 2008), at Chapter 6.

31 Michael Friedmann, "A Methodology for the Discussion of Contour: Its Application to Schoenberg's Music" (*Journal of Music Theory*, Vol. 29, 1985, p. 223-48); Robert Morris, "New Directions in the Theory and Analysis of Musical Contour" (*Music Theory Spectrum*, Vol. 15, No. 2, 1993, p. 205-228); Ian Quinn, "Fuzzy Extensions to the Theory of Contour" (*Music Theory Spectrum*, Vol. 19, No. 2, 1997, p. 232-263).

comprise "similar" motives. To a contour theorist, two sound clips playing a motive and its retrograde inversion transposed by three semitones exhibit great similarity by the standards of her/his discipline; to a music psychologist, the theory behind how the two sound clips are related is less relevant, as the two excerpts sound nothing alike, and are thus not "similar" by the norms of his/her discipline. Moreover, contour theory's similarity is certainly not the type of similarity considered by judges and juries in the substantial similarity tests laid out earlier. The kind of similarity privileged in this study is therefore akin to the music psychologist's, requiring no understanding of retrogradation or pitch matrices. Here, similarity simply asks in which ways two songs by two composers may or may not "sound the same," in the most colloquial sense of the phrase. Because music psychologists and computer scientists are those that have most endeavored with this conception of similarity, their work is in general much more directly applicable to this study than that of music theorists.

This being said, some music theorists have published work relevant to this study due to their concern for copyright law, and their work bears surveying. Fletcher Reynolds' Ph.D. dissertation analyzes three musical plagiarism cases from the 1980's, and attempts to evaluate the role of musical experts in copyright infringement cases and such experts' levels of success at communicating musical similarities and differences to their laymen audiences.[32] Closer to the aims of this study is Charles Cronin's survey of the notion of melodic similarity in various U.S. copyright infringement lawsuits.[33] Cronin discusses several important cases and surveys the strategies used to compare melodies in trials; his article provides an excellent introduction to the issues in this study. Still, his study remains a qualitative one, as opposed to quantitative; while Cronin is very good at describing the differences and similarities in his chosen cases, he does not measure them

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[32] Reynolds, Fletcher. *Music Analysis for Expert Testimony in Copyright Infringement Litigation* (Doctoral dissertation, University of Kansas, Ann Arbor: UMI, 1991).

[33] Charles Cronin, "Concepts of Melodic Similarity in Music-Copyright Infringement Suits" in *Melodic Similarity: Concepts, Procedures, and Applications*. W. Hewlett and E. Selfridge-Field, Eds. (Computing in Musicology, 11. Cambridge, MA: MIT Press, 1998).

numerically. Moreover, he examines only a select few cases. Thus, while the existing literature provides guidance on some topics music researchers can consider within copyright law, it provides no concrete points of departure for the current study.

As mentioned earlier, several studies of similarity and its quantification have appeared, though most are by computer scientists working with music. A useful point of entry into this scholarship by someone with substantial musical training is the work of Ludger Hofmann-Engl. His 2005 paper, "An Evaluation of Melodic Similarity Models," [34] focuses on trends and methodologies developed in music informatics since 2000, and brings much-needed, musically-rooted criticism to many of the models advanced since that time. Hofmann-Engl identifies two basic trends in measuring similarity, one rooted in cognitive psychology, and the other emerging from computing. It quickly becomes apparent from his survey that the cognitive disciplines are interested in measuring general features, whereas computing deals with finer details; in Hofmann-Engl's survey, most of this latter work dates from 1996 to 2004. Because computer-based models attempt to quantify more subtle details, they present more interesting opportunities for this study in terms of quantifying the differences between allegedly similar musical works that are presented in music copyright infringement lawsuits.

The main models Hofmann-Engl surveys in the computational discipline are based on variations of edit distance or similar systems that quantify the amount of "work" that allows element A to be transformed into element B. In such models, "units of difference" of various musical parameters are individually quantified from the source scores.[35] More recent work further expands the parameters for considered and methods used for carrying out these kinds of

[34] Ludger Hofmann-Engl, "An Evaluation of Melodic Similarity Models" (London: Chameleongroup Online, 2005). Available online at http://www.chameleongroup.org.uk/research/evaluation.html, accessed March 3, 2012.

[35] That is, each of pitch, rhythm, harmony, and even tempo, dynamics, metrical stresses, articulations, etc. has its own metric as part of the calculation.

analyses.[36] In any case, all of these individual metrics—pitch, rhythm, range, etc., as the case may be—are then blended together into one number, intended to represent some final, quantified judgment about the similarity of two musical works. To take one of the simpler examples, music informatics expert Donncha Ó Maidín's formula for determining difference is as follows:[37]

Example 1.

$$\text{difference} = \sum_{k=1}^{n} \left| p_{1k} - p_{2k} \right| w_k ws_k$$

where

p_{1k}	is the pitch of the note from the final segment at the k^{th} window
p_{2k}	is the pitch of the note from the second segment at the k^{th} window
w_k	is the width of window k
ws_k	is the weight derived from metrical stress for window k

This particular formula emphasizes pitch and metric stresses; as mentioned, other formulae expand the number of variables. Regardless of the number of parameters a formula blends, however, this approach is problematic. Because in music informatics both the inputs and outputs are measured by the same metric and evaluated by computers (whatever the problem at

[36] Nicole Mitchell finds ways to incorporate range and generalized contours into her model. See Nicole Mitchell, *Music Similarity Metrics: Recognizing Tempo, Transposition, Ornamentation, and Accentuation Properties* (M.Sc. Thesis, Queen's University (Canada), 2007. ProQuest Digital Dissertations, accession number MR26511), see Chapters 4 and 5.

[37] "Difference" is Ó Maidín's term for the "numerical measure of melodic difference between segments of duration *r*," and in measuring this difference, a "window" is "the longest time for which both melodic segments have a uniform activity." Donncha Ó Maidín, "A Geometrical Algorithm for Melodic Difference" in *Melodic Similarity: Concepts, Procedures, and Applications*. W. Hewlett and E. Selfridge-Field, Eds. (Computing in Musicology, 11. Cambridge, MA: MIT Press, 1998), 66. The formula and descriptors (box) are excerpted from page 69.

hand), the blending of metrics into a single score may well be the most efficient mechanism for computers to perform this task. However, such metric blending does not hold true when using these formulae as tests against human intuitions about similarity, as "guilty" and "not guilty" remain inherently subjective human judgments. The main problem with metric blending is that it is difficult to assess how much dissimilarity in one parameter is perceptually equivalent to dissimilarity in another; as will be discussed later, a pitch difference of one semitone is understood differently from a rhythmic offset of one beat. In that case, the weightings of various musical elements could most definitely impact the validity of any metric representing the similarity of two works, given the difference between the mediums interpreting the same information. Essentially, because cognitive psychology does not yet understand the mind's balancing act when it assesses musical similarity, it is impossible to fully adjust the above formula (and others based on blending metrics) for our purposes.[38]

Still, for all the problems the current formulae pose, they also provide some solutions. All of them involve some mechanism for measuring the difference between Elements A and B, and for assessing the importance of all differences over as short or long a work as is desired. If, as Hofmann-Engl also maintains, the main issue the formulae present is that the weightings between the various musical elements are entirely arbitrary[39] and thus may or may not bear any semblance with human perception, then perhaps the best solution is simply to adapt such formulae to measure only one parameter (pitch, rhythm, etc.), and then to measure several parameters independently of one another. Through this system, one might also see which musical parameter is most likely to influence decisions in music infringement lawsuits, as well as the degree to which that influence informs court decisions. The most important advantage that single-parameter analyses bring, though,

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[38] For a more extended discussion of the differences between algorithmic and cognitive metrics for identifying similarity, see Daniel Müllensiefen and Klaus Frieler, "Measuring Melodic Similarity: Human vs. Algorithmic Judgments," in *Proceedings of the Conference on Interdisciplinary Musicology 2004*, R. Parncutt, A. Kessler & F. Zimmer, Eds. (Graz: Department of Musicology, Graz University, 2004).

[39] Hoffman-Engl, 13.

is that they allow analysts to compare the similarity of sets of melodies against one another on a uniform basis. Said otherwise, if set A (comprising melodies a and b) exhibits strong pitch-based similarity and set B (comprising melodies c and d) also shows strong pitch-based similarity, these formulae allow for a comparison of set A to set B. Thus, the analyst is able to identify in which of the two sets the pitch similarity is strongest. This kind of analysis can of course be extended to any number of parameters for any number of sets of melodies, and the similarity between the constituent melodies of every set ranked for every parameter. Through the analysis of a wide range of degrees of similarity and a scale far more nuanced than that which language can express through words, some approximation of where the line between substantial and insubstantial similarity (in the legal meanings of the terms) falls in music is possible, as is an evaluation of which parameters actually matter most in determining the threshold for meeting these standards.

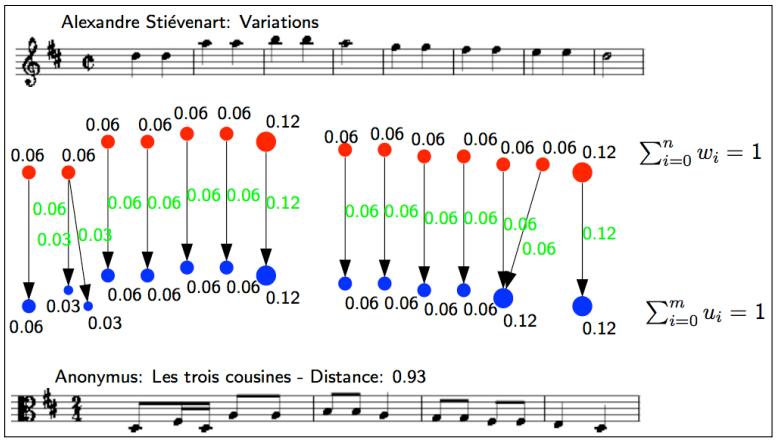
Following a review of the available options, the basic principles of the Proportional Transportation Distance (PTD) proposed by Typke *et al.* as part of a project related to music information retrieval[40] are retained as the main model for this study, while incorporating Ó Maidín's suggestion of using pitch and rhythm as the two separately quantified parameters.[41] The PTD will thus be

[40] Rainer Typke, Panos Giannopoulos, Remco Veltkamp, Frans Wiering, and René van Oostrum, "Using Transportation Distances for Measuring Melodic Similarity" in *ISMIR 2003: Proceedings of the Fourth International Conference on Music Information Retrieval*, Holger H. Hoos & David Bainbridge, Eds. (Baltimore: John Hopkins University, 2003), 110.

[41] Ó Maidín, 68. Note that pitch in this study is not absolute ("A 440"), but relative to key ("the fifth degree of D major"); to be precise, this study therefore compares scale degrees from one melody to scale degrees of another. Nor is "rhythm" a perfect term for all of the transformations included under the term "rhythmic differences;" the system accounts for both actual differences in rhythm (such as when a half note becomes two quarter notes), as well as the displacement of a particular rhythmic value to another position in the measure (that is, moving a quarter note from beat 2 to beat 3, much more akin to a metric shift than an actual rhythmic transformation). Thus, it is perhaps more accurate to say that rhythm here compares the number of onset events (i.e., pitches) and their locations in time as a proxy for rhythmic transformations as a whole; that one piece has significantly more or less onset events than another (or a relatively similar number

used to measure pitch differences between two musical works, and then used again to measure rhythmic differences. The main idea of the PTD is to map single, discrete elements of one melody to another discrete unit somewhere in the second melody, and then to measure the differences between the two linked elements. Typke *et al.* demonstrate this process using two similar melodies in Figure 1.[42]

Figure 1. Typke et al. exemplify the basic principles of the PTD by mapping the rhythm of the top work onto that of the bottom work. The numbers represent Typke's notation for rhythmic values only; pitch is not considered in this particular diagram. Note that the diagram is not perfectly centered; there is some horizontal offset between the notes of the staves and their corresponding mapping arrows. Reproduced by permission of Rainier Typke.



Here, Typke *et al.* map a phrase from Stiévenart's *Variations* onto the anonymous melody *Les trois cousines*. One of the objectives of a good mapping under the PTD is to minimize the overall amount of work required to transform the top melody into the bottom

but dispersed quite differently) suggests greater differences in the two pieces' rhythmic organization.

[42] Typke *et al.*, excerpted from Slide #30 from the presentation's visual aids. Reproduced by permission of Rainer Typke.

melody. As per this objective, the authors minimize the required "moving" by pairing notes in relatively similar positions in the selected excerpts; they certainly could have paired the first note of *Variations* with the last note of *Les trois cousines* or come up with some other creative mapping, but these systems would require much more "work" to "move" the notes, compared to the mapping shown above. The circles in the middle of the diagram represent the various rhythmic "weights" of each note; the bigger/longer the note, the heavier it is to move around, and more "work" is required to do so. The vertical position of the circles represents pitches: the higher the pitch, the higher the circle relative to the horizontal axis. In any case, for us, it is only the general idea of mapping elements onto one another that is of interest here.

The main takeaway from the above sketch of the PTD is that mapping is an easy way to understand how one work is "transformed" into another, and how this process may be accomplished by using greater or lesser amounts of work. For example, if the first note of one work is a D and the first note of the other is an E (and both works are in the same key, or transposed into the same key), one could map the D onto the E, and then measure the "work" required to transform D into E.[43] Under this study's system, such a transformation will accrue two penalty points to reflect the amount of "work" done, because the transformation required a move of two semitones; as a basic first step, one penalty point is assigned for each semitone of movement required to bring two pitches into a unison.[44] This first transformation should thus normally be less work (and thus acquire

[43] The idea of "work" in this context is perhaps best analogized to pushing boxes around in a large warehouse. Suppose a warehouse has twelve distinct shipping zones, named C, C♯, D, D♯, ... A♯, and B, like a piano keyboard. A warehouse worker who pushes a box from zone D to zone D♯ does less work than another who pushes a box from zone D to zone G. In Typke ***et al.***'s model, more "work" is performed to close a large interval compared to a small one. One goal of this model is to minimize the amount of "work" done in the overall conversion of one melody into another; an example will follow shortly.

[44] There are several exceptions and further complications to this rule, which will be explained later. For now, I only wish to introduce the concept of penalty points as the main metric by which the study evaluates mappings.

a smaller penalty) than mapping a D onto a G, and performing the same transformation again; that penalty is five points. Similarly, in the rhythmic dimension, if a D in the first work is mapped onto another D in a second work that occupies a metrically different place in the music, one could measure the "work" required to move the D to its new metric position. A note D that is only one quarter note away will accrue a smaller penalty than one that is three quarter notes away.[45] Thinking about these categories, pitch and rhythm, as individual dimensions on a plane in which "work" can be performed, one can then also measure the work required to transform a D on the downbeat of a measure into an E on an upbeat of a measure. Note, however, that since pitch and rhythmic placement are different parameters, the kind of work done in each dimension is unique; some given amount of work in one dimension (pitch transformation) is not necessarily equivalent to the same amount of work in another (rhythmic transformation).

While the measurement of work in both the pitch and rhythmic dimensions is straightforward, one of the main challenges of mapping is to find a system for any two pieces to be mapped onto one another that reasonably accommodates both dimensions in a single note-to-note mapping. The most efficient pitch mapping may thus bear little semblance to the most efficient rhythmic mapping, even for the same two pieces. At the same time, music is not experienced in a manner that pitch, rhythm, dynamics and all other metrics are considered separately; somewhere these are blended into one conceptual understanding of the music. Though we try to isolate these parameters wherever possible to measure their individual effect, doing so with complete disregard for the other parameters ignores the real experience of music (especially for non-expert listeners, who are unlikely to be analyzing pitch or rhythmic structure as the music flows). The main complexity of mapping, then, is to identify a common mapping of two complete melodies that minimizes the amount of "work" required overall for both pitch and rhythm. Strictly for the purposes of mapping two

[45] Penalty points also accrue for transformations in the rhythmic dimension, though due to the complexity of that system, I will introduce its application further in the paper, once the reader becomes familiar with the concept of the Basic Beat Unit (see below).

dimensions simultaneously so that the map might reasonably correspond to a listener's experience of the musical comparisons undertaken here, then, efficiency is defined in this study as that mapping which produces the least total amount of work for all dimensions measured. Although seemingly complex conceptually, in practice, this essentially means that music at the beginning of one excerpt is compared to music at the beginning of the other excerpt, middles are mapped onto middles, and ends onto ends. From these principles, the methodology for the entire study, a fine-tuning of Typke *et al.*'s formula and its subsequent application to legal precedents, can be elaborated.

Methodology of the current study

Having determined a suitable methodological starting point for this study, the other important aspects can be addressed. Of course, an important parameter is the case law. The website of the UCLA-Columbia Law School *Copyright Infringement Project*[46] has compiled an impressive number of decisions from music copyright infringement cases in the United States since 1900. Each case on the Copyright Infringement Project features its own web page, listing the court decision and musical excerpts of the works being litigated, often accompanied by scores and recordings of those works. Using this database, 57 cases involving litigation of music on grounds of copyright infringement from 1910 to 1990 in the United States of America were reviewed.[47] These cases were

[46] The UCLA-Columbia Law School *Copyright Infringement Project* can be found at http://cip.law.ucla.edu/cases/Pages/default.aspx (accessed March 3, 2012). I would like to express my heartfelt gratitude to the *Project*'s contributors for making their work publicly available online, without which this study would have been much more complicated and time-consuming, perhaps even impossible. I invite readers to visit the CIP's website in order to hear recordings and consult longer scores of the works discussed later in this paper.

[47] Note that, while copyright laws were amended from time to time during this period, revisions to the procedures for conducting infringement actions only minimally affect the conduct of the music infringement actions. Most music-specific procedures commonly used by courts in infringement actions are not grounded in statute (that is, Title 17 or other laws), but rather in common law

filtered for decisions that explicitly comment on musical features in the litigated works and draw some conclusion about the degree of musical similarity between the works in question. In line with the legal prerequisites described earlier, many cases were rejected on the basis on which the decision was reached. For example, all cases dismissed based on a lack of access by the defendant to the plaintiff's work (and without a finding of "striking similarity") were thrown out from the study. From this exercise, 31 cases were retained. Of these 31, some cases were further discarded based on the following two factors. First, the musical works featured in the cases were required to meet a two-phrase minimum threshold for length. This mostly eliminated lawsuits involving commercial jingles, which, at perhaps half a dozen notes each, are too short to be comparable to longer works. Given how the chosen similarity metric functions and the fact that most jingles are but a short rhythmic elaboration of an authentic cadence, it was judged that short jingles were indeed too short and archetypically standardized for meaningful differences between them to be accurately reflected by the PTD and for these to be measured by the same standard of infringement applied to longer works. Second, cases which did not feature melodic similarity as the main point of contention were rejected; as such, cases involving litigation based on musical features such as accompanimental figures or even the movement of inner voices in a choral texture were discarded.[48]

In all, eighteen cases were retained for study, more than any other music copyright study this author has encountered. In keeping with Cronin's observation that the "typical plaintiff in a music infringement suit is a songwriter of modest means who asserts that a lucrative hit by [...] a popular musician is based on musical expression from an earlier work by the plaintiff,"[49] these eighteen cases almost all involve songs written in a popular style.

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precedents (that is, by using past decisions as the basis for how to proceed in present matters). This ensures that the framework for the judicial procedures followed in my test cases remains consistent.

[48] Such issues have indeed been the subject of litigation; see respectively *Fred Fisher, Inc. v. Dillingham* (298 F. 145 (S.D.N.Y. 1924)) and *Cooper v. James* (213 F. 871 (D.C. N.D. Ga., 1914)).

[49] Cronin, 189.

The featured musical works are mostly simplistic, melody-and-accompaniment songs written in regular four-bar phrases. Additionally, given that New York and then Los Angeles acted as the main entertainment law centers in the United States during the 20th century, most of the cases were filed in courts in these cities; as an indirect benefit, the variation of both the judges and Circuits of the United States Court of Appeal under scrutiny was minimized, increasing the probability of the application of a more consistent standard of musical infringement (at least theoretically; as has been discussed, in practice, this may or may not hold true). Finally, it should be noted that, collectively, these criteria somewhat reduced the proportion of dismissed cases within the pool of analyzed cases, compared to the original total pool of cases.[50] This problem is structural, as most cases that are heard are similar, if even fleetingly, on some level; after all, the motivation for a lawsuit needs to be spurred by *something*. Once a plaintiff clears the barrier of proving access to the work—the criterion that led to many cases being thrown out in court—one already has a much better chance of a finding of infringement. Consequently, the infringing/non-infringing split in the pool of eighteen cases is 12-6. While the quantification of a finding of non-infringement on the legal basis of insufficient similarity would be more reliable if more cases were available, the existing case law and refinement criteria preclude this possibility.

Based on the information supplied in each of the eighteen decisions, the sections of the works to be compared to one another were identified. Most of the time, this involved comparing the beginning of one song to the beginning of the other, but there were exceptions (for example, a main theme being compared to a chorus theme). As a baseline standard so as to preserve some notion of the wider musical context, only complete musical phrases were allowed

[50] A case where the defendant is found not to have infringed copyright (or, as per the circumstances of the case before the court, not have committed a crime, not found to be negligent, etc.) is, in legal terms, said to be dismissed. Because all cases studied here were filtered for decisions based on substantive (rather than procedural) grounds, a dismissal in this paper effectively stands in as a verdict of "not guilty of infringement" (as opposed to other ways in which a defendant could be found not guilty, such as insufficient evidence by the prosecution, etc.).

for comparison; one could not compare half a phrase or one eighth of a phrase. At least two phrases of each work were compared. Where prescribed by the court decision, or where one might plausibly argue that some similarity extends beyond two phrases, the comparison continued; where the works clearly diverged from one another's structures after two phrases, the end of the second phrase was deemed the endpoint of the analytical comparison.

The phrases were aligned vertically with one another and, if necessary, transposed into the same key and general register. The basic beat unit (BBU), the most common rhythmic value used in each work, was determined, and the number of BBUs in the excerpt for analysis counted.[51] The vertical alignment allowed for a mapping of the work for transforming the plaintiff's melody into the defendant's melody, as shown earlier by Typke *et al.*'s explanation of the PTD: all elements of the plaintiff's model were mapped to the most comparable corresponding feature in the defendant's melody.[52] Following this mapping, both the pitch penalty (measured in semitones) and the rhythmic penalty (measured as the difference in rhythmic alignment [in basic beat units] plus the difference in duration of the two notes [also in basic beat units]) were determined. The smallest "total penalty" (pitch penalty plus rhythmic penalty) mapping was always sought based on visual observations; where several possibilities appeared plausible, each was tried, and the smallest retained. An example based on Typke *et al.*'s earlier demonstration is provided in Figure 2.

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[51] The BBU is usually an eighth or a quarter note. For example, in Figure 1, the BBU of Stiévenart's *Variations* would be quarter notes. The BBU need not remain constant between the two works being compared, though; hence, *Les trois cousines'* BBU is an eighth note in the same figure above. In the final calculation, it is the *number* of BBUs that matters, not the rhythmic identity of those BBUs. Hence, in Figure 1, quarter notes in *Variations* are deemed equivalent to eighths in *Les trois cousines*, and the BBU value would be 16 in both cases.

[52] Note that, while the formulae were based on computerized algorithms, in the execution of the study, all mappings and calculations were done manually, given the limited computational resources available to the author.

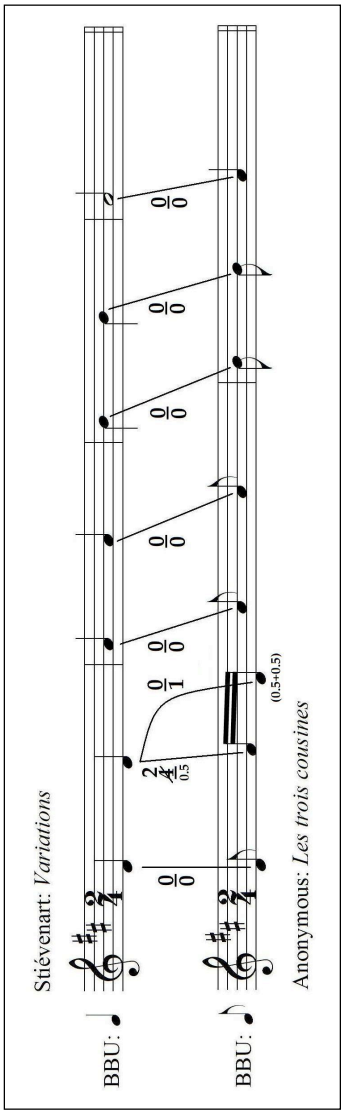

Figure 2. A demonstration of the selected methodology by the author, based upon an excerpt from the works used by Typke et al. at Figure 1. The top number beside a line represents the pitch penalty, and the bottom number represents the rhythmic penalty.

This basic system was subject to a few adjustments:

1. All pitch differences are subject to weighting corresponding to the rhythmic duration.[53] As such, if the rhythmic duration is one BBU, the pitch difference (counted in semitones) is multiplied by 1, and remains unchanged; where the rhythmic duration is 0.5 or 2 BBU, the pitch difference is multiplied by the respective amount. These adjustments are based on Ó Maidín's observation that "pairs of long notes contribute to the difference measure to a greater extent than pairs of short notes;" [54] as such, this renders any pitch difference proportional to the duration of the discrepancy. This is why the penalty of 4 in the above example at the F♯ in *Les trois cousines* has been crossed out and reduced to 2.
2. Under no circumstance will a penalty greater than 10 be attributed for either parameter of a single note, as not to unnecessarily skew the effect of one particularly large difference's influence over the final assessment. In practice, this limit applies only to the pitch dimension, since a situation where a rhythmic penalty of 10 would be allowable within the rules never occurred (the maximum encountered was five).
3. Perfect octave equivalences are assessed at a pitch distance of two points, as counting semitones disproportionately penalizes an otherwise highly consonant difference. The discrepancy is essentially equivalent to that of a whole tone. In all, the framework provides that occasional octave differences attract only a minor penalty, but consistent octave differences quickly accumulate an important penalty.
4. Rests at phrase endings or other "normal" breathing spots are ignored when assessing the difference in note durations; a note is deemed sustained until the next one sounds. Rests in one score that most directly correspond to pitched/rhythmic material in the other are particularly difficult to assess, because such comparisons involve

[53] This may appear to create a double penalty for rhythmic duration, but because the pitch and rhythmic differences are always considered separately in the analysis, this is not an issue.

[54] Ó Maidín, 68.

mapping some pitch or rhythm against the absence thereof. In all, a standard penalty of two points of distance for pitch and one point of distance for rhythm for each BBU of duration was established for this somewhat rare circumstance to account in some way for these differences.

5. When internal repetitions occur in one work but not the other, a flat penalty of two points per BBU is assessed for both pitch and rhythm for each full measure of repetition; hence, in a regular 4/4 measure where the BBU is quarter notes, the penalty is eight points. Once this penalty is assessed, the internal repetitions are ignored from all other calculations, and regular comparisons resume following that measure (if the repetition continues into further measures, penalties are levied until repetition ceases). Partial measures of overlap were assessed using the normal rules for comparison.
6. Where the time signatures of the two excerpts being compared conflict with one another (for example, one is in 4/4 and the other is in 3/4, yet an alignment of musical features measure-to-measure is still identifiable), a penalty of one distance point for both pitch and rhythm is assessed in each bar for each BBU of difference between the two time signatures. However, there is no additional offset penalty when moving a note from one work to a "neighboring" (+/- 1) beat in the other work.

Once all distance penalties have been calculated for a parameter, the total penalty is divided by the total number of BBUs in the portion of the work under consideration, as to normalize the penalties in relationship to the duration of the excerpts analyzed. If the two works under comparison are of a different length (due to a shorter excerpt, or because one work is written in 3/4 while the other is in 4/4), the lesser BBU count is used to determine the divisor; this serves to highlight the difference in length, as opposed to minimize it, by decreasing the value of the dissimilarity score.[55] Hence, in the above example, since there are 8 BBUs in both

[55] I will return to this point later in an example to explain its basis more fully. For now, simply note that as a dissimilarity score approaches zero, the similarity between the two melodies becomes greater.

excerpts, the pitch dissimilarity would be 2/8 = 0.250, and the rhythmic dissimilarity would be 1.5/8 = 0.19.[56] If, for some reason, the excerpts had been of unequal length and one excerpt had a BBU count of 12 instead of 8, the divisor would have remained 8, for the reasons described above.

While some of these additional rules were derived through various ad hoc judgments, all are motivated by considerations of how to maximize the mathematical impact of musically salient differences while reducing the significance of trite ones.

Applying the Methodology

Admittedly, the above considerations are numerous and somewhat complex. Thus, walking through a few examples from the retained body of case law ought allow the reader to fully understand how the methodology is applied. To this end, three analyses of varying complexity are presented and act as representative models for how the analysis was carried out on the other test cases. We begin with a fairly straightforward example, from the case *Italian Book Company v. Rossi* (1928).[57] The top staff is the plaintiff's music, and is alleged to have been copied by the defendant. The defendant's tune is notated on the lower staff. Note that, since the plaintiff's tune was originally in D major, it has been transposed for this analysis into the same key as the defendant's music, that is, F major.[58]

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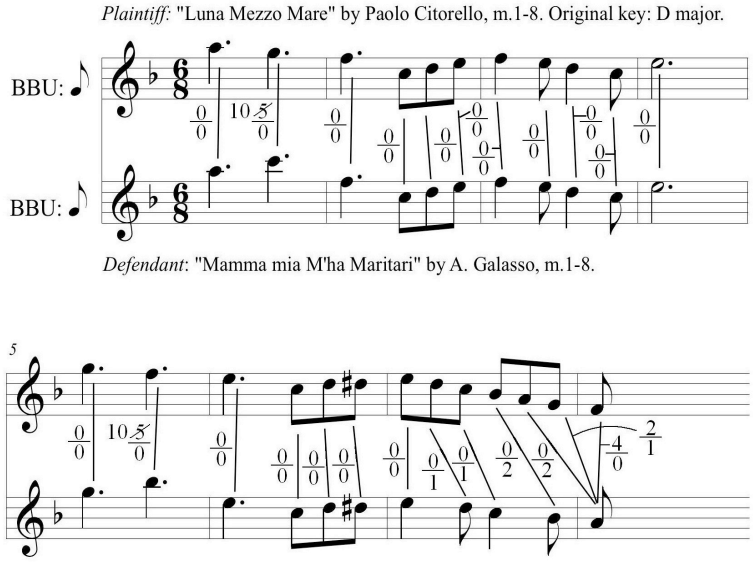
[56] Note that the short duration of the excerpt artificially inflates the similarity scores here; had the example continued on, the scores would undoubtedly have been much lower, owing to continued similarity between the works. Also, the results differ from Typke *et al.*'s in Figure 1 because the calculation considers a shorter portion of the excerpt, and does not blend the metrics into a single number.

[57] *Italian Book Company v. Rossi* (27 F. 2d 1014 (S.D.N.Y. 1928)).

[58] For all intents and purposes, if two works to be compared are in different keys, it is irrelevant whether it is the plaintiff's or defendant's work that is transposed into the key of the other piece. It simply matters that both excerpts are in the same key.

Figure 3. The analytical methodology applied to the excerpts considered in Italian Book Company v. Rossi (1928).



This is a fairly straightforward analysis. All 0/0 notations indicate an exact match of both pitch and rhythm between the two tunes. Some of the finer points may require an explanation. To begin, the second notation of measure 1, 10/0 with a crossed out 5, shows how pitches are weighted according to their durations, relative to the BBU. The crossed out 5 shows the intervallic difference of five semitones between the two pitches being compared before the durational weighting is applied. Since the BBU unit in this excerpt is an eighth note for both parts, and that the pitch being sustained is a dotted quarter note, this means that the duration of the pitch in BBU is three units. Thus, the intervallic difference, five, multiplied by the BBU value of the pitch, three, is fifteen; the analysis should thus attach fifteen pitch points to this difference. Yet, because there is a ten point maximum penalty for pitch on any one given note, this fifteen-point penalty is reduced to ten points. Hence, the crossed out 5 shows the starting point of the calculation, and the 10 its ending; the intermediary step of the

fifteen points is not shown. Second, the descending scale from measure 7 shows how rhythm points are applied. It essentially makes no difference in comparing rhythms whether there is greater or lesser rhythmic activity in the second excerpt; the mere fact that there is a transformation is what the methodology captures. Indeed, because there are less notes in the second tune, the greater number of notes from the top staff must be mapped onto some element somewhere, thus rhythmic penalty points are incurred in the process.

The analysis having been carried out, the dissimilarity calculations are straightforward. First, the total number of BBUs in the excerpt must be identified. In a 6/8 meter, where the BBU is the eighth note, there are thus six BBUs per full measure. There are seven full measures compared in the above example, plus one extra BBU from the downbeat of measure eight. Thus, there are a total of 43 BBUs (that is, [6x7]+1). To find the pitch dissimilarity score, the total number of pitch penalty points, 26, is divided by the number of BBUs—in this instance, 43. The result, 0.60, suggests that there is, on average, less than one semitone of difference between the two works at any given point. The same process is applied to the rhythm penalty points. A total of seven rhythmic penalty points were assessed in the analysis; this number is also divided by the 43 BBUs. The result is a dissimilarity score of 0.16, which indicates that the rhythm will differ by one unit approximately once for every six BBUs. On the whole, these numbers suggest a rather strong similarity between the two works. Of course, that much has been obvious to the reader from the moment the scores were presented; aside from changing the second pitch of the melody to another chord member and varying the scale-like descent at measure 7, the works are identical. Unsurprisingly, the court found for the plaintiff in this case.[59]

[59] That being said, after having read the case, considered the music and the identity of the parties (both composers were from Italian immigrant families), it seems reasonable to me that both tunes were likely derived from an Italian folk song. That two songs share familiarities because they are both derived from a common public domain (that is, not copyrighted) source ought normally constitute a full and sufficient defence to the charge of copyright infringement; at that point, only the plaintiff's original contributions (that is, those musical features not in the original folk song) should be considered by the court. The plaintiff

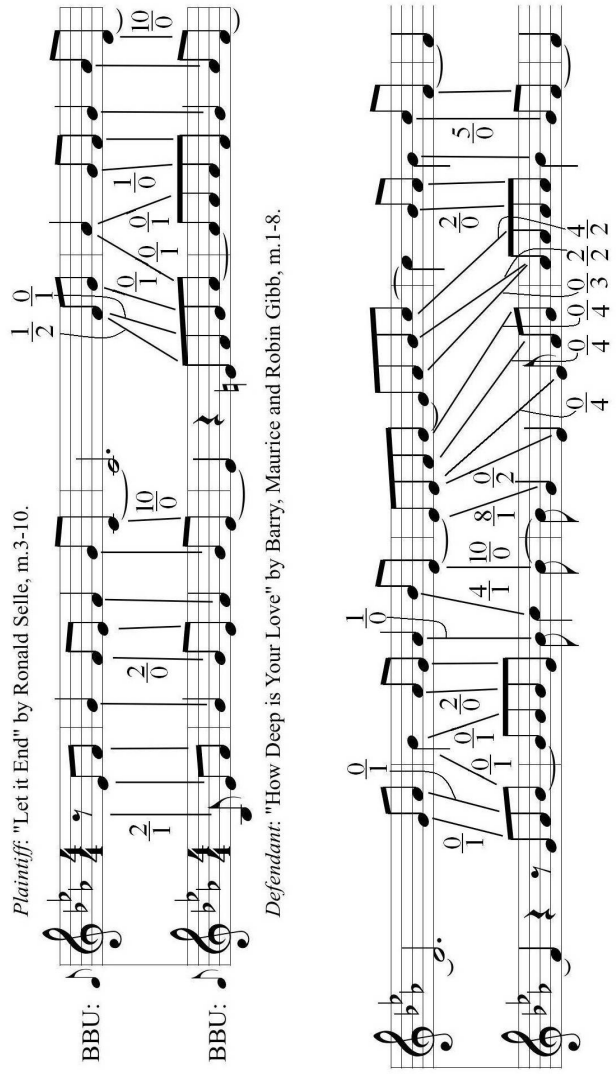


Figure 4. The analytical methodology applied to the excerpts in Selle v. Gibb (1984).

Plaintiff: "Let it End" by Ronald Selle, m.3-10.

Defendant: "How Deep is Your Love" by Barry, Maurice and Robin Gibb, m.1-8.

would then likely be left with little musical material from which to mount a case. Though the defense pleaded this argument, it seems that the judge was not moved by it, and proceeded to compare all of the musical features of the two pieces anyway. See *Italian Book Company v. Rossi.*

A somewhat more complex example is the music of *Selle v. Gibb* (1984), the analysis of which is shown in Figure 4.[60] In this analysis and the next, so as to not clutter the score, all 0/0 markings have been removed (that is, they are represented by a vertical matching line with no corresponding points assignment), and all manipulations of the basic pitch penalty scores show only the final penalty assigned; the basic penalty (the crossed out 5 in the previous example) is not shown. Several calculations should be explained here. The very first penalties assigned are derived from the rule that assigns two pitch points and one rhythmic point when a pitch in one score is mapped onto a rest in the other. The ten pitch points levied against the C/E discrepancy at the end of measure 1 represent the basic pitch penalty assigned to a minor third (three points), multiplied by BBU value of the shorter pitch, five (from the defendant's E natural; the rest is included in the calculation). The result is fifteen points, but is capped at ten points, just as was seen in the first example. The same analysis applies to the other 10/0 score at the end of the first line. The rest is fairly straightforward, excerpt for perhaps the offset rising scale seen in measure 6. While the plaintiff's melody rises sooner than the defendant's, the mapping of the pitches shows how the overall line is similar, simply offset by a few beats. Hence, no pitch penalty points accrue (a sign of similarity), while several rhythmic penalty points accrue to mark the importance of the offset.

The final dissimilarity scores are easily calculable. The number of BBUs in the excerpts is 61; there are eight for every full measure (and seven full measures), three in the anacrusis, and two on the final pitch. The pitch penalties total 64; hence 64 divided by 61 yields a score of 1.05. The rhythmic penalties total 34; divided by 61, the result is 0.56. The finding of no infringement was likely aided by the greater dissimilarity shown from measure 5 onward; as the analysis from the first line shows, the opening of the two tunes share significant similarities.[61] All in all, this excerpt represents a

[60] *Selle v. Gibb* (741 F.2d 896 (7th Cir. 1984)).

[61] Although, as a music theorist, I will be the first to acknowledge how trite these similarities are when considering some of the basic stylistic trends of this genre; it is for me entirely plausible that these two melodies could have been independently created despite their similarities.

good example of the 'average' degree of analytical complexity in this study. The most difficult part is not assigning points correctly, but rather finding the most efficient mapping of pitches onto one another. Though problematic in a few instances, testing out a few different possibilities and keeping only the most efficient pattern quickly solves this problem.

In contrast to the first two excerpts seen thus far, the final example to be discussed, *Arnstein v. Edward Marks Corp.* (1936),[62] is admittedly quite complex.

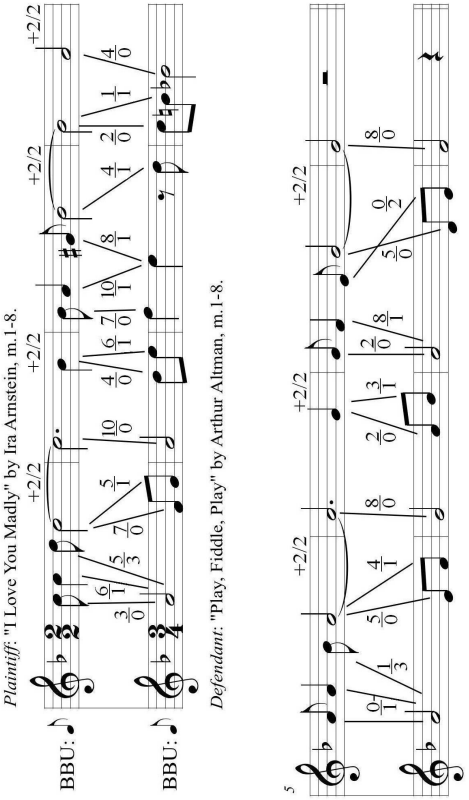


Figure 5. The analytical methodology applied to the excerpts considered in Arnstein v. Edward Marks Corp. (1936)

[62] *Arnstein v. Edward B. Marks Music Corp.* (82 F. 2d 275 (2d Cir. 1936)).

Given that the two melodies are not in the same meter and that they do not unfold in the same register for more than a few beats at a time, it is difficult to see how the plaintiff ever believed the defendant had copied from him.[63] Still, it is an important test case, to see just how the legal system reacts to pairs of melodies that strongly differ from one another. A comparison of the two tunes from the case is shown in Figure 5.

As the tunes have no readily apparent similarities, applying the analytical methodology is not necessarily obvious, nor are the many steps required to fine-tune its application self-evident. At the outset, because the meters of the melodies conflict with one another, a penalty of one distance point for both pitch and rhythm is assessed in each full bar for each BBU of difference between the time signatures. As noted earlier, though, there is no additional offset penalty when moving a note from one work to a "neighboring" (+/- 1) beat in the other work; this point will become very important shortly. Because the difference between a 2/2 meter and one in 3/4 is one quarter note, and that the BBU is fixed at an eighth note for this analysis, this means that a penalty of two points for both pitch and rhythm accrues for each full bar. This is notated in the above score as "+2/2" above each full measure.

Aligning pitches with one another for the purposes of the rhythmic penalty points according to the "neighboring" beats rule is undertaken on a measure-by-measure basis. Essentially, in any given measure, beat three of the defendant's work can be mapped onto either of the third or fourth quarter note of the plaintiff's tune without penalty (since a penalty has already been levied via the different time signatures formula); similarly, beat two of the defendant's work can be mapped onto beat three of the plaintiff's (or, theoretically, beat one, though there was no occurrence of this in the study), if so required. In measure 1 of the above analysis, beat three of the plaintiff's tune is aligned with beat three of the

[63] I invite all readers to consider the full scores of both works on the *Copyright Infringement Project* page for this case at <http://cip.law.ucla.edu/cases/1930-1939/Pages/arnsteinedwardbmarks.aspx> (accessed March 3, 2012), and to try to isolate how the main idea from "Play, Fiddle, Play" resembles any phrase from "I Love You Madly." It is a most curious task.

defendant's; but, in measure 2, it is more efficient to align the defendant's offbeat eighth notes with beat four of the plaintiff's song. Note that rhythmic activity that falls after that beat is still penalized, hence the one point rhythmic penalties levied on the last eighth note of both these measures; the same logic governs the penalty on the offbeat eighth note in measure 3 of the defendant's piece. With this system in place, the analysis becomes more responsive to the way the music progresses in both tunes.

The final item worth pointing out here is the "crossover" mapping of the E natural at measure 7. Following Typke *et al.*'s principles of efficient note mapping, it is sometimes more efficient to allow some events from the plaintiff's melody to occur in a different order when mapped onto the defendant's melody. Since an offbeat eighth note E natural occurs in both tunes, albeit one beat apart, it is more efficient to incur the rhythmic penalty of two points than it is to incur more severe pitch penalties by mapping that same E from the plaintiff's tune onto, say, the half note A on the downbeat of the defendant's tune. Such crossovers were not abnormal in the study as a whole, but this is the only example of the mapping technique in the three case studies being elaborated here, and so worth pointing out.

The last step is the calculation of the dissimilarity score. Here the methodology is faced with a new problem, due to the different meters of the two tunes: how many BBUs are in the excerpt for the purposes of the final calculation? There are 60 in the plaintiff's melody (seven full measures of 8 BBUs, plus four), but only 46 in the defendant's tune (seven full measures of 6 BBUs, plus four). The number to be used is 46. So as to further accentuate the difference between the pieces due to the shift in meter, the smaller number of BBUs prevails as the correct count. Mathematically speaking, in the set of positive integers, dividing any one number (say, 100) by any two smaller numbers (say, 10 and 20) will always yield a greater quotient when the smaller number is the divisor (that is, 100/20=5, and 100/10=10). Since, in this study, a greater numeric score represents greater dissimilarity between two melodies, using the smaller amount of BBUs as the divisor serves to further highlight the differences that the two conflicting meters create in the dissimilarity score, as opposed to diluting that difference. Hence, in this tune, the pitch dissimilarity score would

be calculated by dividing the total pitch penalty points levied (142) by the BBU of the defendant's melody (46), giving a score of 3.09. For rhythm, following the same principles, the total penalty (33) yields a score of 0.72. Both of these scores are very high, an indication that few similarities exist between the two works. Unsurprisingly, as mentioned, the judge found for the defendant, ruling that no copying had occurred.

Analytical Results

Having explained in detail how the methodology is applied to the music from copyright infringement actions, Figure 6 records the results of the analyses for all eighteen pairs of works in terms of dissimilarity. The table at Appendix 1 describes in detail the works and sections thereof compared to arrive at the results in Figure 6. Recall that, as dissimilarity approaches zero, the more the two works being compared in that lawsuit share similar pitch/rhythmic traits; conversely, the higher the dissimilarity, the more distinct the musical traits.[64] To get a sense of what Figure 6 communicates, recall that the dissimilarity index represents the average pitch deviation, measured in semitones, at any randomly selected BBU in the excerpt. Hence, a dissimilarity value of 2.00 shows that, on

[64] It is opportune here to comment on the terms used in the analysis. Where Typke *et al.* discuss the similarity of works in terms of the "distance" one work shows from another, this study prefers the more straightforward terms similarity and dissimilarity. The terms are differentiated primarily on the basis that Typke *et al.*'s distance is a measure that blends various metrics into one score; as noted above, this study will not blend pitch and rhythm into one score, but will rather examine them separately. Similarity and dissimilarity are understood as two ends of a spectrum describing degrees of difference in one parameter between two works; works are (usually) not similar or dissimilar in absolute terms, but rather in relative ones, with greater or lesser degrees of similarity according to the musical structures specific to every analysis. As explained in the previous section, these judgments are derived based on the quantity of penalty points a comparison between two works accumulates: the greater the amount, the more dissimilar works are (i.e., a score progressively greater than zero), and the smaller the amount, the less dissimilar works are (i.e., a score which approaches zero). The study often discusses this latter situation in vernacular terms, simply stating that the works under consideration demonstrate similarity.

average, the two excerpts differ by one whole tone (above or below) at every BBU value (they are quite different), whereas a dissimilarity value of 0.25 shows that, on average, the two excerpts differ by one semitone every four BBUs (they are quite similar).

Figure 6. Results of the quantification of dissimilarity for music from eighteen cases. Complete legal citations for all cases listed here are recorded in the References.

Case	Year	Pitch dissimilarity	Rhythmic dissimilarity
Haas v. Leo Feist	1916	2.23	0.06
Hein v. Harris	1923	1.42	0.75
Italian Book Company v. Rossi	1928	0.60	0.16
Arnstein v. Edward Marks Corp.	1936	3.09	0.72
Arnstein v. ASCAP	1939	0.70	0.73
Allen v. Disney	1941	1.68	0.65
Baron v. Leo Feist, Inc.	1948	0.45	0.56
Northern Music v. King Record Distr.	1952	1.47	0.19
Mills Music v. Cromwell Music	1954	0.00	0.00
Wihtol v. Wells	1956	0.00	0.02
Cholvin v. B & F Music Co.	1958	0.29	0.33
Dorchester Music v. National Broadc.	1959	1.25	0.40
Bright Tunes Music v. Harrisongs	1976	0.43	0.68
Herald Square Music v. Living Music	1978	0.52	0.55
Selle v. Gibb	1984	1.05	0.56
Benson v. Coca-Cola	1986	0.79	0.36
Baxter v. MCA	1987	2.81	0.94
Gaste v. Kaiserman	1988	0.51	0.70

Based on the analysis, a few observations should be noted. First, the relative scales of the pitch and rhythmic dissimilarity should not be interpreted as being equivalent to one another, as it is much more difficult to attain a high rhythmic score than a high pitch score; said otherwise, a pitch dissimilarity score of 0.25 shows much stronger similarity between the pitch contents of the two works compared to that which a rhythmic dissimilarity score of 0.25 shows between the rhythmic contents. This is mostly due to the fact that, in practice, it is much easier for a work to accumulate a high number of pitch penalties than it is for it to accumulate rhythmic offset and duration penalties; whereas offsetting one note by an eighth or transforming one quarter note into two eighths

carries only a rhythmic penalty of 1 (or even 0.5, depending on the BBU), moving a pitch up or down to the next degree of the tonal scale is worth an average of 1.7 pitch penalty points (one point if the next note is a semitone away, two if it is a whole tone away).[65] The smallest differences, then, are already disproportionately matched. At the other end of the scale, high point penalties for pitch differences are much easier to create than high rhythmic penalties. Simply writing one note a fifth above the "other" work in the equivalent location could result in 7 to 10 pitch difference points, [66] whereas attributing 10 rhythmic penalty points is incredibly rare, since in practice this would entail either an unmatched lengthy note mid-phrase (a truly uncommon event in popular songs), or a rhythmic offset of more than one entire measure (or some combination of both). In the study, it was rare to attribute a rhythmic penalty of more than 4 points to a single note, whereas this was a common penalty for pitches. Given these realities, for the two scales to be judged equivalent to one another, it is estimated that the rhythmic dissimilarity score would need to be multiplied by two to three. Given that an exact equivalency scale is by nature impossible to determine, the scores have been left as calculated.

This being said, it might be useful to identify the two extremes of the similarity spectra, as general points of reference for the reader. The 1954 case *Mills Music v. Cromwell Music* was as straightforward a case of copyright infringement as will ever be seen, as the works were exactly the same (after transposition). The most dissimilar works compared were undoubtedly those featured in *Arnstein v. Edward Marks Corp.* (1936, shown earlier as the third

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[65] A regular tonal scale unequally divides the twelve semitones of the octave amongst the seven different pitches that constitute it; therefore, the average distance from one tone to the next is 12÷7. Hence, moving from one scale tone to an adjacent tone involves an average move of ~1.7 semitones. Of course, there is never an actual instance of an adjacent scale degree being 1.7 semitones away; it is either one or two semitones away, and more frequently two.

[66] A penalty of seven points would normally arise from difference of a fifth, given the separation of seven semitones. More points could be assigned if a note is prolonged for more than one BBU (thus multiplying the penalty by the note's duration in BBUs), up to the single note cap of 10 points (see the rules above in the methodology).

sample calculation), which in the best of cases featured one or two identical notes at different points in the phrase, as well as very different rhythms and distinct time signatures.[67]

Figure 7 orders the results by pitch dissimilarity, and includes the court verdict from the case. The most pitch-similar cases/works are at the top of the table. Not surprisingly, blatantly plagiarized works top the list; a score of 0.00 indicates no differences whatsoever in the pitch content. The lower half of the list is more surprising.

Figure 7. Quantification of pitch dissimilarity for all cases, listed from strongest to weakest similarity. Cases where infringement was found have been highlighted.

	Case	Year	Pitch dissimilarity	Decision
1	*Mills Music v. Cromwell Music*	1954	0.00	Infringing
	Wihtol v. Wells	1956	0.00	Infringing
	Cholvin v. B & F Music Co.	1958	0.29	Infringing
	Bright Tunes Music v. Harrisongs	1976	0.43	Infringing
	Baron v. Leo Feist, Inc.	1948	0.45	Infringing
	Gaste v. Kaiserman	1988	0.51	Infringing
	Herald Square Music v. Living Music	1978	0.52	Infringing
	Italian Book Company v. Rossi	1928	0.60	Infringing
2	*Arnstein v. ASCAP*	1939	0.70	Dismissed
	Benson v. Coca-Cola	1986	0.79	Dismissed
	Selle v. Gibb	1984	1.05	Dismissed
	Dorchester Music v. National Broadc.	1959	1.25	Infringing
	Hein v. Harris	1923	1.42	Infringing
	Northern Music v. King Record Distr.	1952	1.47	Infringing
3	*Allen v. Disney*	1941	1.68	Dismissed
	Haas v. Leo Feist	1916	2.23	Infringing
	Baxter v. MCA	1987	2.81	Dismissed
	Arnstein v. Edward Marks Corp.	1936	3.09	Dismissed

[67] It is difficult to understand how Ira Arnstein ever truly believed that Arthur Altman had stolen his musical work. Mr. Arnstein, it should be noted, was a "regular" before the federal district court of the Southern District of New York, suing other musicians for musical infringement a spectacular five times during the 1930s and 1940s. He won none of his cases. After losing his first case (*v. Edward Marks Corp.,* 1936), it is suggested in later court decisions that Mr. Arnstein could no longer find counsel willing to represent him, and so represented himself at all subsequent court hearings, with predictable results.

At first sight, there is no particular pattern for predicting infringement on less than very strongly similar works. *Haas v. Leo Feist* in particular seems out of place, with an astonishingly high dissimilarity score of 2.23 accompanied by a finding of infringement; otherwise, scores of 1.68 or higher seem to positively lead to a dismissal. Excepting *Haas* (which we will revisit momentarily), one can divide the chart into three main groups, based on the generally observed probability of infringement relative to the dissimilarity score in any section of the chart. In Group 1, from 0.00 to ~0.60, such scores suggest strong similarity and that a finding of infringement is almost certain. In Group 2, from ~0.70 to ~1.50, findings of infringement are possible, but uncertain; the similarity is modest. In Group 3, for scores greater than ~1.50 (*Haas* excepted), findings of infringement appear highly unlikely, and similarity is judged to be weak.

Figure 8. Quantification of rhythmic dissimilarity for all cases, listed from strongest to weakest similarity. Cases where infringement was found have been highlighted.

	Case	Year	Rhythmic Dissimilarity	Decision
1	*Mills Music v. Cromwell Music*	1954	0.00	Infringing
	Wihtol v. Wells	1956	0.02	Infringing
	Haas v. Leo Feist	1916	0.06	Infringing
	Italian Book Company v. Rossi	1928	0.16	Infringing
	Northern Music v. King Record Distr.	1952	0.19	Infringing
2	*Cholvin v. B & F Music Co.*	1958	0.33	Infringing
	Benson v. Coca-Cola	1986	0.36	Dismissed
	Dorchester Music v. National Broadc.	1959	0.40	Infringing
	Herald Square Music v. Living Music	1978	0.55	Infringing
	Baron v. Leo Feist, Inc.	1948	0.56	Infringing
	Selle v. Gibb	1984	0.56	Dismissed
	Allen v. Disney	1941	0.65	Dismissed
	Bright Tunes Music v. Harrisongs	1976	0.68	Infringing
	Gaste v. Kaiserman	1988	0.70	Infringing
	Arnstein v. Edward Marks Corp.	1936	0.72	Dismissed
	Arnstein v. ASCAP	1939	0.73	Dismissed
	Hein v. Harris	1923	0.75	Infringing
3	*Baxter v. MCA*	1987	0.94	Dismissed

Figure 8 orders the results by rhythmic dissimilarity, and includes the court verdict from the case. The most rhythmically similar cases/works are at the top of the table. Again, there are no evident patterns here, but a division into three groups is possible: Group 1 from 0.00 to ~0.20; Group 2 features a very wide range, from ~0.30 to ~0.80; and Group 3 for values greater than ~0.90. The mystery posed by *Haas* in the previous table is solved here: the work was judged to be infringing likely because of its extremely strong rhythmic similarity (0.06). This result suggests that, contrary to some other scholarship in this area,[68] pitches are not the only relevant factor in a finding of infringement, as rhythm can apparently act as a determining factor.

While one cannot identify any consistent mathematical trend which definitively separates the infringing from the non-infringing, the results nonetheless lend themselves to the drawing of some hypotheses. The most arresting feature of the data emerges upon seeing which lawsuits fall into Group 1, the category reserved for similarities which strongly suggests finding of infringement in either pitch similarity, rhythmic similarity, or both. In Figure 9, infringing cases that belong to Group 1 in either of the two previous tables are highlighted. Here, one notes that ten out of twelve cases of infringement (or ~83%) display strong similarity for one of the two parameters considered in the study, and that none of the non-infringing cases display any strong similarity. Admittedly, because the lines between Group 1 and Groups 2 and 3 were somewhat arbitrarily drawn, it is difficult to discern if this measure is actually useful as a predictive mechanism in music infringement cases, or simply a handy manipulation of the data at hand. As a descriptive determinant for cases that have already been heard, it certainly appears that music plagiarism lawsuits are much more likely to succeed if the pitch and/or rhythmic similarities are particularly strong; the high pitch dissimilarity combined with the low rhythmic dissimilarity scores seen in both *Haas* and *Northern Music* lend credence to this theory. This finding is particularly

[68] Cronin, 188, claims that only pitches are actually considered in copyright infringement actions. Hofmann-Engl, 36, similarly claims that similarity is predominantly a pitch-based judgment, though he contextualizes this remark outside of copyright infringement.

significant due to the traditional nature of musical analysis in the courtroom, where the focus is almost entirely centered on pitch-based elements.[69] This claim contrasts the analytical outcomes of this study, which suggest that rhythmic similarity can play a role in moving a decision from non-infringing to infringing. This, in turn, suggests that rhythm may play a greater role than is currently understood in forming "intuitive" decisions about melodic similarity.

Figure 9. All cases studied listed in chronological order. Those cases where the music exemplifies strong similarity (Group 1) in either pitch or rhythmic similarity have been highlighted; those cases where infringement was found by the court are in bold.

Case	Year	Pitch dissimilarity	Rhythmic dissimilarity	Decision
Haas v. Leo Feist	**1916**	**2.23**	**0.06**	**Infringing**
Hein v. Harris	**1923**	**1.42**	**0.75**	**Infringing**
Italian Book Company v. Rossi	**1928**	**0.60**	**0.16**	**Infringing**
Arnstein v. Edward Marks Corp.	1936	3.09	0.72	Dismissed
Arnstein v. ASCAP	1939	0.70	0.73	Dismissed
Allen v. Disney	1941	1.68	0.65	Dismissed
Baron v. Leo Feist, Inc.	**1948**	**0.45**	**0.56**	**Infringing**
Northern Music v. King Record Distr.	**1952**	**1.47**	**0.19**	**Infringing**
Mills Music v. Cromwell Music	**1954**	**0.00**	**0.00**	**Infringing**
Wihtol v. Wells	**1956**	**0.00**	**0.02**	**Infringing**
Cholvin v. B & F Music Co.	**1958**	**0.29**	**0.33**	**Infringing**
Dorchester Music v. National Broadc	**1959**	**1.25**	**0.40**	**Infringing**
Bright Tunes Music v. Harrisongs	**1976**	**0.43**	**0.68**	**Infringing**
Herald Square Music v. Living Music	**1978**	**0.52**	**0.55**	**Infringing**
Selle v. Gibb	1984	1.05	0.56	Dismissed
Benson v. Coca-Cola	1986	0.79	0.36	Dismissed
Baxter v. MCA	1987	2.81	0.94	Dismissed
Gaste v. Kaiserman	**1988**	**0.51**	**0.70**	**Infringing**

But what of the remaining cases involving infringing works? As has been pointed out several times throughout this paper, the case law of musical plagiarism is rife with uncertainties. The results reaffirm this systematic uncertainty. For example, how is it that, in *Hein v. Harris*, infringement was found on scores equivalent to 1.42

[69] Cronin, 188.

and 0.75 for pitch and rhythmic dissimilarity, respectively, while non-infringement was found in *Arnstein v. ASCAP*, whose dissimilarity scores were 0.70 and 0.73, both of which are lower than the results of *Hein*?[70] The best explanation here is rooted in law, not music: given its system of lawyers, juries and judges, each with their own skills and biases, the legal system is structured in such a way that the outcomes of some ambiguous cases simply cannot be predicted; the court may find for either party. Cases with similarity scores like those of *Hein v. Harris* and *Arnstein v. ASCAP* are most susceptible to this ambiguity.

Reflections on the Methodology, Music and Copyright Infringement

Having completed the study, a reflection on the appropriateness of the methodology for measuring musical similarity and its potential role in music copyright infringement cases is pertinent. First, several small fallacies of the system have been hinted at previously. For instance, what kind of single note penalty cap is appropriate, such that one note not unduly influence the overall result? This remains unclear, though the ten points used in this study still intuitively seems like a reasonable standard. How should the fact that cadences generally feature similar musical structures affect the assessment of the similarities at cadential points? There is a reasonable case to be made that cadential similarity is indeed a very different phenomenon than general melodic similarity, yet this study makes no distinction between the two. Other problems remain thornier. Some concern musical judgments over which experts could reasonably disagree. For example, when discontinuing comparisons between phrases, how does one determine that the two compositions under consideration

[70] It is useful to remind readers that Ira Arnstein was representing himself against one of the richest and most powerful musical organizations of the day (see footnote 67). ASCAP almost certainly had access to the top infringement lawyers in New York for the trial while, according to the written decision, Mr. Arnstein was having difficulty grasping the basics of legal procedure. See *Arnstein v. ASCAP* (29 F. Supp. 388 (S.D.N.Y. 1939)).

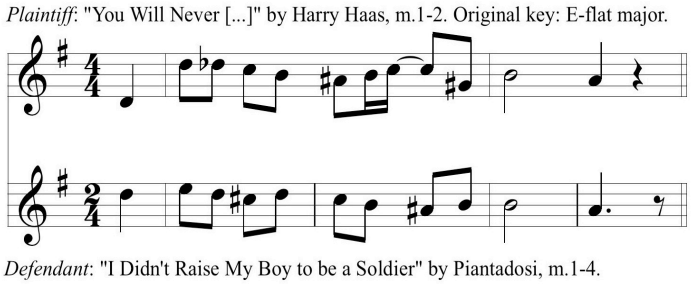
have clearly diverged from one another, or, when evaluating the function of rests, how does one decide which among them constitute breathing points and which do not? Other problems emerge from the need to assign appropriate penalties for musically common scenarios. How, for instance, should one penalize an octave difference between pitches? To frame the problem in another way, is there any real musical difference between two melodies, one which approaches the note do from the sol below it, the other from the sol above it? In terms of harmony and function, most music theorists would agree that there is no real difference. Yet, in terms of the contour of the melody, such a difference could indeed be quite significant. Within this context, arriving at some standard which could reasonably reflect the average person's mental balancing of the melodic contour against the harmonic function in deciding upon some measure of similarity appears quasi-impossible, and thus the formula used in this study is only a best approximation of reality.

There are other problems associated with the use of mathematical formulae in the evaluation of copyright infringement. In the aforementioned case of *Haas v. Leo Feist*,[71] the most efficient mapping (that is, the lowest pitch plus rhythmic penalty) does a poor job of capturing some of the essential similarities between the cases' two melodies, especially in the pitch dimension. As discussed, the rhythm is nearly identical; but this mapping comes at the cost of ordering pitches in a way that could greatly reduce the pitch dissimilarity score. Consider Figure 10, where the first phrases of the two works considered in that case are shown. The pitches are not wholly different from one another, certainly not as much as the eventual score of 2.23 suggests. The nature and approach to chromaticism in the middle of the phrase differ (causing many pitch penalties), but the overall idea is somewhat similar: a melody beginning on the dominant scale degree progresses downwards chromatically to a prolonged mediant tone, which then moves to the supertonic. But, under this study's definition of efficient mapping, the choice between capturing the

[71] *Haas v. Leo Feist* (234 F. 105 (S.D.N.Y. 1916)).

rhythmic similarity of the two pieces[72] and capturing pitch similarity[73] is removed, and rhythmic similarity "wins out." Thus, while it is accurate to say that the two pieces show strong rhythmic similarity, that statement comes at the expense of being able to suggest moderate similarity between the pieces' pitch contents.

Figure 10. The first phrase from the works considered in Haas v. Leo Feist (1916).



There are other scenarios in which the model could fail. Suppose a composer copied a melody, but replaced every harmonically functional melodic pitch with another pitch from the same chord. For instance, if an original melody elaborated upon the chord of C major (C-E-G) by alternating between the notes C and E, then this composer's adaptation of the melody would instead alternate between E and G. This type of copying, if exposed, should result in a finding of infringement.[74] Yet, given the formula developed in this study for assessing pitch similarity, it is doubtful that such an approach would register as displaying strong similarity. If every note in one melody is displaced by an interval of

[72] That is, by mapping every note to its neighbor directly above/below, reducing rhythmic penalties to near zero but increasing pitch penalties.

[73] That is, by mapping D to D, D♭ to C♯, A♯ to A♯, *etc.*, but incurring important rhythmic penalties in doing so.

[74] There are two principal reasons for this. First, though the melody differs, the harmony remains the same, and is not the result of independent creation (since it was copied); this is infringement. Second, the "new" melody is a direct result of the "composer" deceitfully copying the "old" melody; that one disguises the unauthorized appropriation of a melody in a musically "smart" way does not excuse the initial appropriating act.

a third in another, then by the standards of this study, each would accumulate three to four penalty points for the discrepancy.[75] With a pitch dissimilarity score averaging somewhere between 3.00 to 4.00 (or, even if there were enough moments of melodic alignment which would reduce this score by almost half to ~1.75) such dissimilarity would clearly place the work in Group 3, and thus suggest that the works are significantly dissimilar from one another. Consequently, a finding of infringement, as determined by this formula, would be highly unlikely. Yet, that conclusion would be wrong, both musically and hopefully in court as well. Admittedly, if a composer did exactly as described above, a full assessment of the works would likely register a strong rhythmic similarity, which might then lead to a finding of infringement. Still, the idea that there exist simple musical workarounds that can easily fool this system (and likely any other that could be developed) is important, and no clear solutions to this problem are available at this time.

Of course, all this is not to say that the methodology used in this study is inoperably flawed. On the contrary, the model shows itself rather adept at aligning its results with the cognitive decisions of judges and juries. The main point here is that, if mathematical methods of determining similarity between works are to have any place in the evaluation of copyright infringement in the way legal scholars like Yvette Liebsman would want them to,[76] the formula described in this paper could benefit from further refinement; in the meantime, an awareness of some of its shortcomings will need to act as a substitute for solutions to the problems demonstrated above. For now, the study suggests that, while there could be an important role for similarity metrics in the adjudication of music copyright infringement lawsuits, by no means should these processes entirely replace a circumspect examination of the plaintiff's and defendant's cases, a critical evaluation of the evidence, and expert testimony offered by qualified music scholars which is specific to the works under consideration. Similarity metrics, whatever form they take, should exist as tools to aid the court in its work, not as arbiters of infringement in and of themselves.

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[75] Three in the case of a minor third, four in the case of a major third.

[76] Liebsman, 353.

Conclusions

This study has endeavored to test a quantifiable measure of similarity for assessing melodic plagiarism that is sensitive to both legal and musical realities. In using a weighted model of similarity adapted from Typke *et al.*'s Proportional Transportation Distance, it is found that such models can act as modest predictors of music plagiarism lawsuit outcomes. The formula is at its best when used to situate two works' pitch and/or rhythmic similarity within a general category of similarity (strong, modest or weak, which have respectively been described as Groups 1, 2 and 3). In cases where either the rhythmic or pitch similarity is strong (Group 1 for either pitch or rhythm), these metrics were found to often result in a finding of infringement; where both metrics are weak (metrics in Group 3), a dismissal was certain. Given the model's potential fallibility in some musical circumstances, though, it should be used simply as a quantification of the degrees of similarity between two melodies, and not as an arbiter of music copyright infringement in and of itself.

Still, in contrast to other measures of similarity, perhaps the greatest strength of this model lies in the fact that it does not seek to reconcile various parameters into a single metric, but rather insists that the analyst consider its individual parameters on an "either/or" basis in relationship to the court's decision. The results of the study suggest that judges' (or jurors') intuitions might not amalgamate pitch and rhythmic elements into one judgment either, but might subconsciously be directed to identify similarity in one parameter as being equivalent to melodic or musical similarity in general; for the musical laymen that necessarily populate courtrooms, a clear separation of pitch and rhythm could be difficult to conceptualize. Obviously, further studies in cognitive psychology would be required to test such hypotheses. For now, based on the present data, these hypotheses at least seem plausible.

In the end, this study reaffirms that even though infringement and non-infringement exist as a dichotomy, such terms are stand-ins for a wide range of degrees of similarity and dissimilarity interacting in sometimes predictable, sometimes unpredictable ways. Some cases present works that clearly constitute infringement, and, in other cases, such claims border on the

ludicrous. Other lawsuits, such as that opposing Joe Satriani and Coldplay,[77] offer some latitude for reasonable debate on the merits of a charge of musical plagiarism, and invite an opportunity for reflection on the standard at which the law should draw the line between infringement and non-infringement. This study has begun tracing the lines between those charges that are unquestionably valid or invalid and those that may or may not have some reasonable standing, as they exist today. In a field where the top experts claim to have no way of predicting outcomes, certainly this represents a step in the right direction.

[77] Unfortunately for this study, the case was eventually settled out of court. See BBC News Online, "Coldplay Copyright Case 'Settled'" (London: BBC, September 16, 2009). Available online at: http://news.bbc.co.uk/2/hi/entertainment/8258217.stm, accessed March 3, 2012.

Appendix 1. Data for the entire study, including all cases, tunes and sections compared/analyzed.

Case	Year	Plaintiff's Work	Measures Analyzed	Defendant's Work	Measures Analyzed
Haas v. Leo Feist	1916	"You Will Never Know..."	1-8	"I Didn't Raise My Boy..."	1-16
Hein v. Harris	1923	"Marie Cahill's Arab Love..."	1-16	"I Think I Hear a..."	1-16
Italian Book Company v. Rossi	1928	"Luna Mezzo Mare"	1-8	"Mamma mia M'ha..."	1-8
Arnstein v. Edward Marks Corp.	1936	"I Love You Madly"	1-8	"Play, Fiddle, Play"	1-8
Arnstein v. ASCAP	1939	"Whisper to Me"	1-7	"My Wishing Song"	1-7
Allen v. Disney	1941	"Old Eli"	1-12	"Some Day My Prince..."	1-12
Baron v. Leo Feist, Inc.	1948	"L'Année Passée"	1-8	"Rhum and Coca-Cola"	3-10 (plus the anacrusis into 3)
Northern Music v. King Record Distr.	1952	"Tonight He Sailed Again"	1-8	"I Love You Yes I Do"	1-8
Mills Music v. Cromwell Music	1954	"Tzena"	5-11	"Tzena Tzena Tzena"	9-15
Wihtol v. Wells	1956	"My God and I"	1-8 (minus the anacrusis to 9)	"My God and I"	1-8
Cholvin v. B & F Music Co.	1958	"When the Sun Bids the..."	Chorus: 1-8	"While We Dream"	Chorus: 1-8
Dorchester Music v. National Broadc.	1959	"Rendezvous"	5-12	"I Dreamed"	5-12
Bright Tunes Music v. Harrisongs	1976	"He's so Fine"	4-13 (note repetition)	"My Sweet Lord"	8-15
Herald Square Music v. Living Music	1978	"Day by Day"	1-8	Theme of NBC's "This is Today"	1-8
Selle v. Gibb	1984	"Let it End"	3-10	"How Deep is Your Love"	1-8
Benson v. Coca-Cola	1986	"Don't Cha Know"	1-8	"I'd Like to Teach the World..."	1-8
Baxter v. MCA	1987	"Joy"	22-25	"Theme from *E.T.*"	5-8
Gaste v. Kaiserman	1988	"Pour toi"	1-7	"Feelings"	1-7

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