Alexander Morgan*[1]

*Université libre, Brussels, Belgium

[1]alexanderpmorgan@gmail.com

Humlib Dissonance Classifier: A New Tool for Renaissance Dissonance Classification

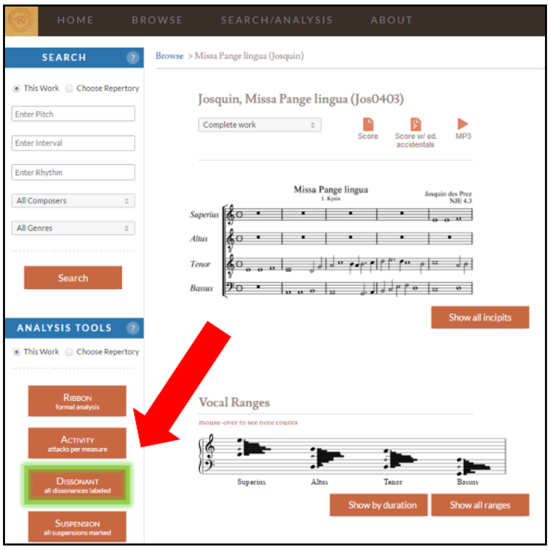
ABSTRACT

There is an acute need for a widely available open-source tool for automated classification of Renaissance dissonance types based on historically informed — i.e. intervallically based — analysis. This paper introduces the Humlib Dissonance Classifier, a new analysis tool for the Humdrum platform that satisfies this need and can be used entirely online. I begin by explaining what motivated the tool's development, where to find it, and what its score annotation looks like. The tool labels many different dissonance types, and all of these are listed along with their frequency in the repertoire of the Josquin Research Project Database. This provides both a sense of what the dissonance classifier can do, and an overview of dissonance treatment from early and mid-Renaissance compositions. The dissonance classifier is particularly thorough in its analysis of suspensions, including labeling agents and patients, alternative varieties of suspensions, and multiple types of dissonant suspension ornaments. I also provide a prose description of the program's analytical methodology, and offer suggestions for four primary ways this tool could be used in future research.

1. INTRODUCTION

Dissonance is a critical element of any musical idiom. In light of its near ubiquity in the repertoire, the abundance of dissonance types, and the number of research questions that can be addressed by its precise measurement, empirical quantification of dissonance treatment is a necessity for the field. This paper describes a new dissonance classification tool (hereafter the 'dissonance classifier') that is freely available online for scores in symbolic notation, and detects the wide variety dissonance types used by Franco-Flemish Renaissance composers.[1] This paper describes what the dissonance classifier is, how it works, and summarizes some of its primary research applications.

As part of my postdoctoral fellowship at the Université libre in Brussels, I developed the dissonance classifier with Craig Sapp of the Center for Computer Assisted Research in the Humanities at Stanford University. It is primarily intended for use on the Josquin Research Project's website (JRP, <http://josquin.stanford.edu/>, accessed 21/07/2023) and database of Renaissance scores. From the piece page of any work on the JRP database, one can click on the button on the left side of the screen marked 'DISSONANT: all dissonances labeled' (see Example 1) and the score with dissonance labels for each voice will open in a new tab. In-score labeling is the clearest way to visualize the dissonance analysis for any given piece, and it also allows other researchers to readily verify that they agree with the analysis. Example 2 shows a sample piece annotated by the dissonance classifier. Over forty different dissonance types are labeled by the classifier, and each one is explained with examples on the documentation page for the tool: <http://doc.verovio.humdrum.org/filter/dissonant/While > (accessed 21/07/2023), almost all of the dissonances in this particular piece are identifiable types, there is one in b. 19 that is unidentifiable, and is therefore given the 'Z' label.



Ex. 1. The JRP piece page for Josquin's *Missa Pange lingua* with an arrow pointing to the dissonance-classifier button.

The JRP database is the most well-known and respected source of Renaissance scores in symbolic notation from a variety of composers. For this reason, it is the ideal place to have access to the dissonance classifier. However, there is an even larger music analysis and notation initiative that dissonance classifier is more directly a part of. Craig Sapp's Verovio Humdrum Viewer (VHV), <http://verovio.humdrum.org/> (accessed 21/07/2023), is a general platform for viewing scores and their associated lyrics and/or analytical annotations quickly and easily online. It has a broader scope than that of the JRP, as it is also used by other projects such as the Tasso In Music Project, which can be found here: <http://www.tassomusic.org/about/> (accessed 21/07/2023). The VHV offers many analysis 'filters' of which the dissonance classifier is just one. The source of these analysis filters is Humlib — code available at: <https://github.com/craigsapp/humlib> (accessed 21/07/2023) — Craig Sapp's modernization and extension of the original Humdrum Toolkit. The scores are not stored, but generated on demand using Verovio,

[1] In its original presentation at the EuroMAC 2017 conference in Strasbourg, France, this paper introduced the dissonance classifier and went into depth about the distinction between what I call binary and ternary suspensions. For this printed version of the proceedings, I have opted to focus more fully on the dissonance classifier. The majority of the discussion of the ins and outs of binary and ternary suspensions is involved enough to require separate treatment in a future publication.

<http://www.verovio.org/index.xhtml> (accessed 21/07/2023), which is an online music-typesetting project led by Laurent Pugin of RISM. Verovio is designed to visualize scores in the MEI format, but Humlib analysis filters work on kern scores.

Ex. 2. Sample of dissonance classifier's analysis on Ockeghem's *Se vostre cuer*.

To ensure that these tools work together, Craig Sapp has developed (and continues to improve) automated conversions between the kern and MEI, and kern and music XML formats. This means that people interested in seeing what the dissonance classifier's annotations are for a score that they have, can simply drag and drop a kern, XML, or MEI score onto this blank analysis page: <http://verovio.humdrum.org/?k=ey&filter=dissonant> (accessed 21/07/2023).[2] This web of mutually beneficial and open-source music applications is an important boon to rapid and sustainable advances in music notation and analysis.

2. DISSONANCE CLASSIFICATION

2.1 Abundance of Dissonance Types

The dissonance classifier assigns forty-four different labels to dissonances, so one may wonder how I arrived at such a large number of types. There are two reasons for this. The first is that more labels allows us to distinguish between ascending and descending forms of dissonances, and between stepwise approaches and those by leap wherever pertinent. For example, an ascending passing tone is labelled with an uppercase 'P' and a descending passing tone with a lowercase 'p'. This granularity may be of importance for researchers and makes it easy to verify, for example, that ascending and descending passing tones happen in roughly equal proportion, whereas lower neighbors are over ten times more common than upper neighbors. Musicians may know this about Renaissance music intuitively, but this is precisely the sort of finding that automated analysis demonstrates most effectively, and most precisely. Table 1 shows a count of each of the dissonance types identified in the repertoire on the JRP database as of July 2017. In all, 1,100 pieces or movements were analyzed, of which two contained no dissonance whatsoever. The total number of dissonances classified is 158,445 — excluding the 'G' and 'g' labels which are agents and are generally not thought of as dissonant notes.

It may seem silly to include categories for dissonance types that rarely ever happen. To take an extreme case, in this query of 1,100 pieces, only two 'D' labels were assigned. Since each of the two dissonant notes of a double neighbor are labeled, this means that only one double-neighbor figure that starts with the upper neighbor was found in the entire corpus. It is shown in Example 3. This demonstrates that, defined in this way, double neighbors are not a significant feature of this repertoire. Since there is no harm in looking for practically non-existent dissonance types, the strategy employed was to always favor the inclusion of a greater number of well-defined categories. Working like this, even when a dissonance type is almost never found, we still learn something about the corpus.

Ex. 3. The only upper-lower double-neighbor figure in the corpus, from a loose Agnus Dei insecurely attributed to Josquin.

[2] There is no guarantee with conversions from MEI or XML file types, especially if there are any issues or abnormalities with their encoding.

2.2 Stylistic Exemplarity

The second reason that the dissonance classifier checks for so many different dissonance types is to accommodate analysis of the considerably more varied dissonance practice of late-15th and early-16th century composers. Since at least the time of Fux, Palestrina has largely been taken as the paragon of Renaissance syntax and style (most notably: Fux 1725; Jeppesen 1931; Taneiev 1909; and more recently Sigler and Wild 2015). While his works certainly merit the scholarly attention they have received, I find that they are not representative of most Renaissance compositions from before 1530, particularly with respect to dissonance treatment. Over the course of the 16th century, several dissonance types fell almost completely out of use. The 'resolution-against-patient' dissonance shown in Example 4 is a case in point. This is a viable dissonance type in thicker textures for late-15th century Franco-Flemish composers, but it is abandoned over the course of the first half of the 16th century (Arlettaz, 2000).

I find it peculiar that we would take one of the last composers of a stylistic period (Palestrina) as its quintessential exemplar. Nobody holds Mahler up as the primary reference for tonal music despite the lasting importance of his works. It makes more sense to base our analysis of critical elements of syntax, such as dissonance treatment, on works composed during the early and central years of a stylistic period.

Ex. 4. Resolution-against-patient type, labeled 'x', from Brunet's motet *Victime paschali laudes*.

Label	Dissonance Type	Count	Label	Dissonance Type	Count
P	Ascending Passing Tone	35,479	p	Descending Passing Tone	36,721
N	Upper Neighbor	871	n	Lower Neighbor	10315
D	Double Neighbor (Upper First)	2	d	Double Neighbor (Lower First)	12
E	Upper Echappée	919	e	Lower Echappée	3,198
J	Reverse Upper Echappée	59	j	Reverse Lower Echappée	632
C	Ascending Short-form Nota Cambiata	13	c	Descending Short-form Nota Cambiata	2,979
K	Ascending Long-form Nota Cambiata	214	k	Descending Long-form Nota Cambiata	3,359
I	Reverse Ascending Nota Cambiata	4	i	Reverse Descending Nota Cambiata	88
A	Ascending Anticipation	115	a	Descending Anticipation	3,034
S	Ternary Suspension Patient	1,215	s	Binary Suspension Patient	30,472
G	Ternary Suspension Agent	2,051	g	Binary Suspension Agent	47,999
F	Fake Suspension Leapt To	188	f	Fake Suspension Stepped To	996
M	Agentless Suspension Leapt To	18	m	Agentless Suspension Stepped To	172
x	Resolution Against Patient	74	o	Purely Ornamental Suspension	23
r	Repeat of Suspension Patient	8	h	Chanson Idiom	2,192
Q	Asc. Passing Dissonant Third Quarter	440	q	Desc. Passing Dissonant Third Quarter	13,607
B	Upper Neighbor Diss. Third Quarter	132	b	Lower Neighbor Diss. Third Quarter	626
T	Appoggiatura Approached From Above	50	t	Appoggiatura Approached From Below	58
V	Ascending Accented Passing Tone	1,023	v	Descending Accented Passing Tone	3,641
W	Accented Upper Neighbor	202	w	Accented Lower Neighbor	126
Y	Only Diss. Against Known Type, Asc.	586	y	Only Diss. Against Known Type, Desc.	1,034
Z	Unknown Type, 2nd or 7th	1,659	z	Unknown Type, 4th	1,326

Tab. 1. Dissonance types, their single-character labels, and the number of times they appear in the repertoire on the Josquin Research Project Database as of July 2017.

A composer's dissonance treatment is such a large part of what makes their idiom unique. It would be very worthwhile to examine the dissonance treatment of each composer individually, especially for specialists of a given composer. Ruth DeFord is doing precisely this with the works of Heinrich Isaac. Isaac is a particularly interesting choice because he is both a temporal and stylistic midpoint between the Franco-Flemish composers whose works I am focusing on here, and the better-known dissonance treatment of Palestrina.

If we consider all the known works from the Renaissance, those of the Franco-Flemish composers from around 1500 definitely stand out as the most complex in their use of dissonance. Furthermore, the dissonance types encountered in Franco-Flemish pieces represent nearly all of the dissonance types used by all Renaissance composers. Put another way, the dissonance types that Josquin's generation used constitute a superset of those that Palestrina's generation used, so concentrating on the dissonance treatment of the former means that we can also classify all the dissonances of the latter.

2.3 Detailed Suspension Analysis

In developing the dissonance classifier, I paid particularly close attention to suspensions because they are an integral part of the Renaissance cadence, and therefore are the most formally significant dissonance type. Due to this critical role that suspensions play in Renaissance syntax, they are quite common so it should come as no surprise that they are the locus of considerable variety. The dissonance classifier distinguishes between the patient (the suspended note) and the agent (the note that moves into the suspension), and also detects so-called 'fake' suspensions — with a sub-classification of those approached by step or by leap —, suspensions without an attacked agent (also broken down by melodic approach), purely ornamental suspensions, and several types of dissonant suspension ornaments. Crucially, the dissonance classifier distinguishes between binary and ternary suspensions (labeled 's' and 'S' respectively). When the rhythmically regularized first three phases of a suspension (the preparation, dissonance, and resolution) correspond to a unit of time that groups in threes in the metric organization of a piece, a suspension is ternary. Otherwise, it is binary. The binary type represents the majority of suspensions, as can be gathered from Table 1. Example 5 was chosen to provide an example of suspensions on the documentation page of the dissonance classifier because it contains both a binary suspension and a ternary suspension in close proximity. In order to automate detection of binary and ternary suspensions, I had to reassess my understanding of Renaissance suspensions entirely, which was primarily guided by Tinctoris's discussion of suspensions in the *Liber de arte contrapuncti* and Ruth DeFord's vital concept of contrapuntal rhythm (Tinctoris 1477 (Seay 1961, 113–126); DeFord 2015, 84; and Morgan 2017, chap. 4). This reassessment led me to the realization that Renaissance suspensions are fundamentally different from tonal suspensions because they are end-accented, whereas the latter are middle-accented — the dissonant portion of a tonal suspension is accented. The reasons for this, as well as a more involved discussion of binary and ternary suspensions, are beyond the scope of this paper and must be dealt with in depth on their own. For now, I will limit myself to the observation that devising automated ways of detecting dissonance types not only helps us locate and count them, but can also invite us to re-evaluate some musical events we think we know well.

3. ANALYTICAL METHODOLOGY

3.1 How the Program Works

How does the dissonance classifier actually work? The code is publicly available at <https://github.com/craigsapp/humlib/blob/master/src/tool-dissonant.cpp> (accessed 21/07/2023), but here I would like to give an overview of how the program works in prose. I strived to make the dissonance classifier execute historically informed analysis. I take this to be an analysis founded on an intervallic (as opposed to chordal) basis. In practice, this involves analyzing dissonance based on what Sigler and Wild have called the 'pairwise model' (Sigler and Wild 2015). This means that instead of deciding what chord is sounding, and then calling all notes outside of that chord dissonances, the pairwise model considers two voices at a time, and calls all seconds and sevenths dissonant. Fourths are also considered dissonant when the lowest sounding voice in the texture is the lower note of the interval. This is the only case where the dissonance classifier has to make a minor deviation from a purely pairwise model, because in order to know if a note is the lowest note in a texture, it must be compared to all of the other sounding notes. This tolerance is standard in pairwise dissonance classifiers, and appears to be an unavoidable necessity. Interval quality does not factor into the assessment of whether an interval is consonant or dissonant. This is particularly significant for perfect vs diminished fifths and octaves. The consonant status of these intervals depends on the application of *ficta*, and there is no prevailing systematic means of doing this. Also, in some harmonic scenarios, diminished fifths can be understood to function as intervals of intermediate consonant status. In practice, assuming that all fifths and octaves are consonant does not appear to result in any incorrect or missed dissonance labels. The dissonance classifier operates on the fundamental assumption that consonant intervals require no explanation, so they are not analyzed; however, we may still think of many of these notes as ornamental.

Ex. 5. Obrecht's motet *Mille quingentis* demonstrating binary and ternary suspensions in close proximity.

Ex. 6. An excerpt from Ockeghem's *Missa caput*, Kyrie, which contains both an ascending long-form nota cambiata labeled 'K', and a descending short-form nota cambiata labeled 'c'. Only the highest and lowest voices of the four-voice texture are shown.

The dissonance classifier passes over a piece once for each pair of voices.[3] Whenever it finds a dissonant interval, it checks to see if the contrapuntal context matches the profile of any of the known dissonance types. The contrapuntal context includes factors like the duration, beat strength, melodic approach to and exit from the dissonant interval, etc., in both of the voices. For most dissonant types, a single voice gets assigned a dissonant label, but for suspensions, both the patient and agent are labeled. If the contrapuntal profile of the dissonant interval does not match any of the predefined types, it is considered an unknown dissonance. Based on how an unknown dissonance is approached and left, one, or in some cases both of the voices involved may receive the unknown-dissonance label. If a note is assigned an unknown dissonance label with respect to one voice, that label can later be changed to a known label if the note is classifiable in another voice pair. However, once a known dissonance label is assigned to a note, it never gets relabeled as an unknown dissonance.

Rather than create a new dissonance classifier, Craig Sapp and I could have conceivably used a pre-existing one instead, as there were at least four well-known options (Antila, Morgan *et al.* 2016; Sigler 2015; Huron 1995; Tymoczko 2015).[4] We decided against this because we had six basic criteria that we wanted the tool to satisfy, and none of the other available tools met all these requirements. We wanted the tool to be:

1. Based on intervallic analysis;
2. Able to classify the large variety of dissonance types found in the works of Franco-Flemish Renaissance composers;
3. Compatible with the Humdrum format;
4. Open-source;
5. Reliable and fast;
6. Well-documented.

The dissonance classifier accomplishes all of these design goals so we are very pleased to share it with the greater music-research community.

4. APPLICATIONS

My hope is that the general availability of the dissonance classifier, the thorough documentation on the tool, and the user-friendly design of the VHV, will work together to make this a standard tool for Renaissance-music research. The dissonance classifier can help us better quantify, understand, and appreciate the wide variety of dissonance types that were in use at different times in the Renaissance. It will definitely facilitate future research in several avenues, and I will now describe the four ways it could be used that I find the most promising.

4.1 Style-Change Analysis

As dissonance treatment is an important element of any composer's language, research questions about style change are the most obvious application of this tool. For example, the dissonance classifier identifies two types of nota-cambiata figures. In the long-form nota cambiata — labeled 'K' or 'k' for ascending or descending varieties —, the voice that just had the dissonance moves by step in the opposite direction of the skip a third away from the dissonant note (see Example 6, m. 59). This can be understood as filling in the gap skipped over. In the short-form nota cambiata (labeled 'C' or 'c'), this stepwise turnaround after the skip does not happen. Instead, the most common continuation after the skip of a third is a step in the same direction (see Example 5, mm. 62–3). In addition to these figures generally becoming less common over the course of the Renaissance, I think we will find that the short-form gradually gives way to the long-form nota cambiata. With this tool in place, studies of this sort are now much more accessible to all researchers.

4.2 Compositional Process

The dissonance classifier could also shed light on the compositional process. If we analyze all of the pairs of voices in a three-part piece, we may notice that there are no unexplainable dissonances in a particular pair, and this could support a claim that the three-voice texture was formed by adding a new part to a pre-existing duo. Researchers can and already do take this into consideration for individual pieces. With automated analysis, however, we can easily search thousands of pieces in a database to identify the ones that could have been composed in this way.

4.3 The Consonant-Counterpoint Topic

In using the dissonance classifier on the repertoire in the JRP database, I was surprised to find that a couple of pieces had no dissonances at all. While this is exceptionally rare for an entire piece, once I was aware of this possibility I began to notice that many pieces include passages dozens of measures long that have no dissonances either, or at least considerably fewer than in the rest of the piece. I now think that fully consonant passages were a compositional topic available to Renaissance composers much like 'learned counterpoint' or the horn call were to classical composers. Following this line of thinking, a fruitful topic-theory research project would be to use the dissonance classifier to identify passages with little or no dissonance, and see if this compositional possibility should indeed be interpreted as the consonant-counterpoint topic.

4.4 Textural Analysis

Finally, the dissonance classifier could be used to explore the relationship between texture and dissonance-type usage.

---

[3] Pairwise analysis must be done for each voice pair, and the total number of pairs to be analyzed can be determined with the equation $n \times (n-1) / 2$, where n is the number of voices in the piece.

[4] The most advanced of these alternatives is Andie Sigler's program, but this was not a viable option because it is not open-source, and includes the 'match' and 'catch' dissonance categories which largely abandon the pairwise model.

This could be done by comparing the dissonance classifier results to those of the 'voicecount' Humdrum tool. This tool identifies how many voices are actually sounding at any given point in a piece: <http://extras.humdrum.org/man/voicecount/> (accessed 21/07/2023). In this way, we could see which types of dissonances are more or less common as the number of sounding voices increases. There are some dissonances, such as the resolution-against-patient type shown in Example 4, that cannot occur in fewer than three voices, because at a minimum one needs the patient and agent of the suspension, plus a third voice sounding this dissonance against the patient, so dissonance types are clearly influenced by contrapuntal texture. Vincent Arlettaz explores how the resolution-against-patient figure is usually found in thicker textures, and now we can return to this question and apply it to a greater number of pieces and dissonance types (Arlettaz 2015). This last potential research question demonstrates how useful it is to have an analysis tool in the Humdrum platform, because it allows us to benefit from the multitude of pre-existing Humdrum analysis tools, and combine them in new and interesting ways.

4. CONCLUSION

By being integrated into the Josquin Research Project website and the Verovio Humdrum Viewer, Craig Sapp and I have done all we can to ensure that the dissonance classifier is and will remain an accessible research tool. The openness and accessibility characteristic of Humdrum software are essential to its adoption as the gold standard in the field of empirical musicology, and are also fundamental to its steady improvement. As we use the dissonance classifier more extensively, it is likely that small mistakes in its analysis will become apparent. Please bring any such issues to my attention, and I will do my best to address them and continually improve on this tool.

KEYWORDS

Dissonance Classification, Renaissance, Franco-Flemish, Humdrum, Josquin Research Project.

REFERENCES

Antila, Christopher, Morgan, Alexander, *et al.*, 2016. *VIS Framework* (version 3.0.3, Python). Montreal (QC): McGill University.

Arlettaz, Vincent 2000. *Musica Ficta: une histoire des sensibles du XIII^{e} au XVI^{e} siècle*. Sprimont: Mardaga. (1st ed. 1998.)

Bent, Margaret, 1998. 'Grammar of Early Music: Preconditions for Analysis', in Cristle Collins Judd (ed.), *Tonal Structures in Early Music*. London: Garland Publishing, 15–59.

———, 2003. 'Ciconia, Prosdocimus, and the Workings of Musical Grammar as Exemplified in *O felix templum* and *O Padua*', in Philippe Vendrix (ed.), *Johannes Ciconia, musicien de la transition*. Turnhout: Brepols, 65–106.

DeFord, Ruth, 2015. Tactus *Mensuration, and Rhythm in Renaissance Music*. Cambridge: Cambridge University Press.

Fuller, Sarah, 1993. 'Tendencies and Resolutions: The Directed Progression in 'Ars Nova' Music', *Journal of Music Theory* 36/2: 229.

Fux, Johann Joseph, 1966. *Gradus ad Parnassum*. New York (NY): Broude. (1st ed. 1725.)

Huron, David, 1995. 'Humdrum Representation for Embellishment Tones, **embel', *The Humdrum Toolkit*, web site, <http://www.humdrum.org/rep/embel/?highlight=embel>, accessed 21/07/2023.

Jeppesen, Knud, 1939. *Counterpoint: The Polyphonic Vocal style of the Sixteenth Century*, trans. Glen Hayden. Englewood Cliffs (NJ): Prentice-Hall. (1st ed. 1931.)

Lowinsky, Edward, 1945. 'The Function of Conflicting Signatures in Early Polyphonic Music', *The Musical Quarterly* 31/2: 227–60.

Morgan, Alexander, 2017. *Renaissance Interval-Succession Theory: Treatises and Analysis*. PhD diss. Montreal (QC): McGill University.

Morris, Reginald Owen, 1922. *Contrapuntal Technique*. Oxford: Oxford University Press.

Pugin, Laurent, *et al.*, 2014–2018. *Verovio*, <https://www.verovio.org/>, 25/07/2023. (Music-notation software.)

Sailor, Malcolm and Sigler, Andie, 2017. 'Renaissance 'Dissonance Fingerprints': A Corpus Study of Dissonance Treatment from Dufay to Victoria', paper presented at the *Annual Meeting of the Society for Music Theory*. Arlington (VA).

Sapp, Craig, 2016–2018. *Verovio Humdrum Viewer*, <http://verovio.humdrum.org/>, 25/07/2023. (Online software.)

Schubert, Peter, 2008. *Modal Counterpoint, Renaissance Style*. Oxford/New York: Oxford University Press.

Sigler, Andie, and Wild, Jon, 2015. 'Schematizing the Treatment of Dissonance in 16th-century Counterpoint', in Meinard Müller and Frans Wiering (eds.), *Proceedings of the 16th International Society for Music Information Retrieval Conference – ISMIR 2015*. Canada: International Society for Music Information Retrieval, 645–50. (<https://archives.ismir.net/ismir2015/2015_ISMIR_Proceedings.pdf>, accessed 21/07/2023.)

Taneiev, Serge Ivanovitch, 1962. *Convertible Counterpoint in the Strict Style*, trans. G. Ackley Brower. Boston (MA): Bruce Humphries. (1st ed. 1909.)

Tinctoris, Johannes, 1961. *Liber de arte contrapuncti*, trans. Albert Seay. Rome: American Institute of Musicology. (1st ed. 1477.)

———, 1975. '*Liber de arte contrapuncti*', in *Johannes Tinctoris Opera Theoretica*, ed. Albert Seay. [Rome]: American Institute of Musicology. (1st ed. 1477.)

———, 2015. *Liber de arte contrapuncti*, trans Jeffrey Dean, <http://earlymusictheory.org/Tinctoris/texts/deartecontrapuncti/>, accessed 21/07/2023. (1st ed. 1477.)

Tymoczko, Dmitri, 2015. 'Harmonic Extroversion in the *Missa Papae Marcelli*', paper presented at the *Annual Meeting of the Society for Music Theory*. St. Louis (MO).