Chapter 1

Books

1.1 Harmony - Piston

All of the following is summarised from chapter 12 “Harmonic Rhythm” in the book “Harmony” by Walter Piston [Pis78].

1.1.1 Root changes as harmonic rhythm

Piston defines harmonic rhythm as root changes (in roman numerals), thus implying an already existing analysis of the piece in the western tonal system. He therefore views harmonic rhythm as possibly, but not necessarily different from melodic rhythms (e.g. homophonic movement often leads to parallel harmonic and melodic rhythms).

1.1.2 Frequency of root change

One important aspect to him is the frequency of root change, e.g. very slow harmonic rhythm in an introductory section as opposed to restless fast changes, almost impossible to grasp for the listener. “Comparable to static harmony is the effect of a [...] pedal [...]. [It] tends to overpower the sense of harmonic progression.” (p.196)

1.1.3 Strength of harmonic progressions

Depending on the harmonies involved (among other things), a harmonic progression can be more or less “strong”, i.e. compelling. This implies a hierarchy withing harmonic rhythm, i.e. leaving out certain chord changes should have a higher perceptual impact than other progressions.

1.1.4 Dynamic indications

Dynamic indications can show a composer's specific idea, especially where they do not conincide with the interpreter's intuition.

1.1.5 Nonharmonic chords

Piston further suggests the existence of nonharmonic chords (just as there are nonharmonic notes), such that even though a root change can be observed, the chords need not necessarily be processed as entire harmonic entities by the listener. This mainly happens in fast passenges and is facilitated by the chords not being in root position, thus omitting the bass note and hindering easy recognition of the chord.

1.2 Harmonic Rhythm - Swain

All of the following is summarised from the first part (chapters 2-7) in the book "Harmonic Rhythm - Analysis and Interpretation" by Joseph Swain [Swa02].

Swain claims that his work is solely an extension of Piston's basic idea of assigning harmonic rhythm due to root changes with contextdependent elements (speed of the piece and harmonic progression, inversion, dynamic indications by the composer). He proposes a hierarchical system of multiple levels of harmonic rhythm.

1.2.1 Texture of the rhythm

His first level of analysis is the texture of a piece. However, since it is not very relevant perceptually (and is only the addition of all rhythmical events of a piece, thus giving the division into as many time spans as possible), I mostly disregard it in this thesis which aims to give a perceptually meaningful harmonic rhythm.

1.2.2 Phenomenal harmonic rhythm

The next level is called "phenomenal harmonic rhythm". It denotes all time points at which the chord changes in any way. This includes new harmonies as well as inversions of chords. However, he defines a texture phenomenal harmonic rhythm vs a contrapuntal phenomenal harmonic rhythm. The latter ignores very fast arpeggios and the like where the notes do not appear as single events, but instead only serve as necessary parts of the harmony invoked (example Chopin op. 25 no. 1). To cite Swain: "This is contrapuntal phenomenal harmonic rhythm: the changes in harmonic phenomena caused by moving voices." According to Swain, phenomenal harmonic rhythm serves two purposes: A comparison with the texture can already produce insight into the emotional valence of a passage (example Vivaldi Winter 1st movement: moderately fast texture, very slow harmonic rhythm, creating a tension from this contrast). Secondly, when dealing with non-tonal music (be it non-Western, modal or posttonal), this is the only level where chords are not assigned a value or ordered in some kind of hierarchy, thus allowing for a neutral juxtaposition.

1.2.3 Bass pitch harmonic rhythm

The next higher level (sometimes coinciding with contrapuntal phenomenal harmonic rhythm) depends on the movement of the bass voice (notably not necessarily the lowest voice in the score). This can also lead to a higher bass rhythm than the root rhythm, when the bass leaps an octave. It may also be slower than the root rhythm, since the same note may be used consecutively in different functions (though this raises the question of microtonal differences in non-equal temperaments). Bass pitches were ignored in the given analyses that I used, therefore, I will not lay any more focus onto it than this.

1.2.4 Root/Quality harmonic rhythm

With this level of harmonic rhythm analysis, Swain returns to Piston's original idea of harmonic rhythm being mainly defined by chord changes. However, he adapts the system in two important ways: First of all, he does not use a Roman numeral analysis as the basis of his rhythm analysis, but instead uses the absolute chord symbols (e.g. D instead of I, A instead of V etc.). He wants to extract the information more precisely by doing so (Functional harmonic rhythm will appear lateron). Also, it allows for ambiguity on the root level, while on the functional level, one will have to decide for one of multiple possible analyses. The second, probably more remarkable change in comparison to Piston's approach is to use hierarchical levels of root harmonic rhythm: On the lowest level, all chord changes are taken into consideration, while on higher levels, contrapuntal coincidences that can be subsumed into a longer lasting primary triad are omitted.[1] This type of analysis obviously

[1]This idea of hierarchical harmonic analysis seems strongly influenced by Schenker, whose ideas also build the foundation of the work of Prof. Martin Rohrmeier, TU Dresden.

requires fine judgement of a variety of factors, because there are decisions to be made about the number of levels needed and also the exact shape each of this levels is supposed to take. Swain formulates a number of rules to achieve a meaningful analysis at this level that I will not present in further detail here, but may be of interest to the more musicologically inclined reader.

1.2.5 Density of harmonic rhythm

On another (though not necessarily more complex) level, Swain considers the chords' density and thus, the strength of the harmonic progresison. The density of a progression is defined by the number of voices that change their sounding note into one that is part of the new harmony. While a singular density may not be of high perceptual importance, a passage with high density values will tend to appear more powerful than one with very low density changes, even if they may be of the same dynamic force. Again, Swain goes into more detail of the interpretational possibilities and challenges (such as two voices leading into the same note or even the question how to define a voice e.g. in a piano score), that I will not cover here.

1.2.6 Rhythm of harmonic functions

The last level of analysis is that of harmonic functions. While the original idea of Piston used them, the root level probably describes his intentions better. As does Piston, Swain allows for embedding of short phrases that are not long or significant enough to be called an entire modulation. Swain however only uses three symbols (I, IV and V for tonic, subdominant and dominant) since these three basic functions should suffice in his opinion. Thus, he has to use embedding more often than Piston.

1.2.7 Thoughts and Remarks

While almost all of the levels mentioned above seem perceptually important, it is impossible to model them all within the span of this thesis and I will have to focus on one level. It seems intuitive to choose an intermediate level for this purpose so the analysis does not lose itself in too much detail or stays at an overly broad level. This excludes texture and phenomenal harmonic rhythm (at least the textural kind). Density seems to lack semantic meaning, but may be an interesting addition to check for a transition's importance. This leaves bass, root and functional harmonic rhythm: Functional rhythm might, just as density, be interesting to check in terms of a transition's importance (e.g. V to I in a cadence seems very salient), but is a concept that is very hard to define precisely, especially since I worked with already existing analyses of the corpus that worked with root chords. The bass is certainly interesting, but seems mostly subsumed under root changes. Finally, within the root rhythm category, we have different hierarchical levels at our disposal. Again, I worked with given analyses, so I did not have much of a choice, but most of the time, the analyses seemed to interpret the pieces on a somewhat intermediate level, which appears desirable from a complexity standpoint.

1.3 Computational Music Analysis - Meredith

[Mer16] In the second chapter of this book edited by David Meredith, Emilios Cambouropoulos goes into detail on the GCT (General Chord Type) representation of chords that is being used in the CHAMELEON harmoniser as well.

1.4 Music and Probability - Temperley

[Tem07] In his book "Music and Probability", Temperley puts forth his earlier formulated idea of *communicative pressure* [Tem04], and uses different examples to show his idea: since music has the goal of communicating between composer/interpreter and listener, a common ground of this communication, some kind of ruleset, needs to be set so that the listener has any chance to understand the composer's intentions. This includes style-specific amounts of syncopation and rubato to be used. Temperley notes that styles with high syncopation tend to be very strict in the tempo used and vice versa. This supports the idea that concurring factors of complexity in music may be negatively correlated. Thus, it seems reasonable to assume that this might also apply to melodic rhythm and harmonic rhythm in terms of speed (since processing speed of the brain is limited) and complexity.

Chapter 2

Articles

2.1 Harmonic Rhythm in Beethoven's symphonies - LaRue

[LR01] In his article in the "Journal of Musicology", LaRue describes in length his interpretation as to why Beethoven's symphonies seem to be widely accepted as masterpieces of orchestral music. I am not so much interested in that than more in the way he defines and analyses harmonic rhythm. His article was published a year before Swain's book on the topic appeared, so his work seems to be based more on Piston's notion of harmonic rhythm. This means that LaRue is only interested in root changes, drawing from an analysis of functions denoted as Roman numerals. Other dimensions are mentioned, but do not find higher interest. He recognizes the problem of ambiguity, but himself does not offer a solution.

2.2 DeepBach - Hadjeres and Pachet

[HP16] Very notable is a paper yet unpublished in journals, though already available online. The DeepBach project by Sony France is an attempt at using Artificial Neural Networks (ANNs) for automatic feature extraction and consecutively using the newly learned stylistic information for generation of new harmonisations in the same style. As hinted by the title, the subject of analysis were pieces by Johann Sebastian Bach, more precisely chorales. The entire chorale corpus was used to gain as much information as possible. To assess the quality of the reharmonised chorale melodies, two tests were performed. 1600 subjects (among them 400 music students or professional musicians) were asked which of two versions of the same melody fragment they liked best. DeepBach outperformed other Machine Learning algorithms here. In a second test, roughly 1300 subjects were given the binary choice of “Bach” or “Computer” upon hearing an extract. Again, DeepBach outperformed other tools and even managed to fool roughly 50% of all listeners. This shows the feasibility of ANNs in music generation, but also demonstrates the problem that no theoretical understanding of the underlying structure is necessary and thus not generated. Therefore, the analysis of substructures - such as the harmonic rhythm - remains a fruitful and meaningful task.

2.3 Melodic accent - Thomassen

[Tho82] In the admittedly a little dated paper “Melodic accent”, Joseph Thomassen conducted a series of experiments to find out how the melodic contour influences perceived accentuation. His results are only of interest to this thesis since he found that melodic contour is indeed one factor for which to account. Hence, it seemed like a reasonable to idea to check for a possible relationship between contour changes and harmonic events, providing one plausible candidate of a predictor for harmonic rhythm in the melody.

2.4 Rhythm pattern perception in music - Dawe

[Daw93] In his dissertation, Lloyd Dawe finds experimental support for notions that music theorists have supported over a long time (starting with Jean-Philippe Rameau). The most important aspects for this thesis are: Chord changes are the most significant aspect for rhythm perception among harmonic rhythm, perceptual rhythm of chords and temporal accents. Also, they seem to be interpreted as indicators for meter, hinting at a strong prevalence of the first beat of a measure for a chord change. Additionally, this makes the hypothesis very plausible that harmonic rhythm tends to be rather regular.

2.5 Autocorrelation in meter induction - Toiviainen, Eerola

[TE06] This study is only partially relevant to my thesis: Under the assumption that harmonic rhythm somewhat depends on the meter that seems reasonable following Dawe [Daw93], indicators for meter seem to be one possible candidate for being predictors for harmonic change as well.

2.6 Learning and blending harmonies in the context of a melodic harmonisastion assistant - Kaliakatsos-Papakostas, Makris, Zacharakis, Tsougras, Cambouropoulos

[KPMZ+16] This paper lies at the heart of this thesis. It provides an overview over the by now so-called *CHAMELEON* harmonising system that is capable of learning idiom-specific style information to then harmonise a given melody of the same or another style. The way it harmonises is by taking the user's input as to where it should put a harmony (e.g. on a cadence) and then applying the learned "rules" to this note and the preceding chords. Here is where this thesis comes into play: For non-experts, making "good" decisions on where to put harmonies might be hard, so giving the system the ability to analyse the melody in such a way as to find spots where to put harmonies seems like the logical next step.

2.7 Learning and Creating Novel Harmonies in Diverse Musical Idioms - Kaliakatsos-Papakostas, Makris, Tsougras, Cambouropoulos

[KPMTC16] More detail about the above.

2.8 Mathematical measures of syncopation - Gmez, Melvin, Rappaport, Toussaint

[GMR+05] From this proceedings report and the idea of "Communicative Pressure" (see e.g. chapter 10 of [Tem07] stems the thought that harmonic rhythm and melodic rhythm or rather their complexities and/or speeds may be negatively correlated, i.e. if the melodic rhythm is very complex, composers tend to keep the harmonic rhythm at a more basal level so as to not overload the listener with too much information. As it is very hard to properly define “complexity” of a melody, I instead used syncopation as an indicator of rhythmic complexity (see [FR07] for experimental evidence). To assess the speed of a melody, I simply summed up the number of onsets within a measure. This has the obvious shortcoming of treating a range of different rhythms and tempi as equivalent, but was the only feasible option and should suffice for my purpose. ***ADD EXAMPLES! (Mendelssohn Lied ohne Worte oder Hochzeitsmarsch Intro vs. vier Viertel (think of something)***

2.9 Perception and Production of Syncopated Rhythms - Fitch, Rosenfeld

[FR07] In their study, Fitch and Rosenfeld tested if there was to find a correlation between the degree of syncopation of a passage and the difficulty subjects would have with tapping a beat “against” the syncopated beat, tapping a syncopated passage to a computer generated beat and remembering it lateron. As expected, in all categories, the more syncopated a passage was, the harder it was to fulfill any of the given tasks. This provides evidence for syncopation being a factor in making a melody complex.

Bibliography

[Daw93] Lloyd A Dawe. *Rhythm pattern perception in music: the role of harmonic accents in perception of rhythmic structure.* PhD thesis, 1993.

[FR07] W Tecumseh Fitch and Andrew J Rosenfeld. Perception and production of syncopated rhythms. *Music Perception: An Interdisciplinary Journal*, 25(1):43–58, 2007.

[GMR+05] Francisco Gómez, Andrew Melvin, David Rappaport, Godfried T Toussaint, et al. Mathematical measures of syncopation. In *BRIDGES: Mathematical Connections in Art, Music and Science*, pages 73–84, 2005.

[HP16] Gaëtan Hadjeres and François Pachet. Deepbach: a steerable model for bach chorales generation. *arXiv preprint arXiv:1612.01010*, 2016.

[KPMTC16] Maximos Kaliakatsos-Papakostas, Dimos Makris, Costas Tsougras, and Emilios Cambouropoulos. Learning and creating novel harmonies in diverse musical idioms: an adaptive modular melodic harmonisation system. *J. Creative Music Syst*, 1(1), 2016.

[KPMZ+16] Maximos Kaliakatsos-Papakostas, Dimos Makris, Asterios Zacharakis, Costas Tsougras, and Emilios Cambouropoulos. Learning and blending harmonies in the context of a melodic harmonisation assistant. In *IFIP International Conference on Artificial Intelligence Applications and Innovations*, pages 520–527. Springer, 2016.

[LR01] Jan La Rue. Harmonic rhythm in the beethoven symphonies. *The Journal of Musicology*, 18(2):221–248, 2001.

[Mer16] David Meredith. *Computational music analysis*. Springer, 2016.

[Pis78] Walter Piston. *Harmony. (Revised and expanded by Mark De-Voto)*. 1978.

[Swa02] Joseph P Swain. *Harmonic rhythm: Analysis and interpretation*. Oxford University Press, 2002.

[TE06] Petri Toiviainen and Tuomas Eerola. Autocorrelation in meter induction: The role of accent structure a. *The Journal of the Acoustical Society of America*, 119(2):1164–1170, 2006.

[Tem04] David Temperley. Communicative pressure and the evolution of musical styles. *Music Perception: An Interdisciplinary Journal*, 21(3):313–337, 2004.

[Tem07] David Temperley. *Music and probability*. The MIT Press, 2007.

[Tho82] Joseph M Thomassen. Melodic accent: Experiments and a tentative model. *The Journal of the Acoustical Society of America*, 71(6):1596–1605, 1982.