

# Historiography of the form of symbolic music through a computer-assisted analysis

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## ABSTRACT

This paper presents a selection of the analytical and music-historical results of the research project “Historiography of musical form through MIR”.<sup>1</sup> It discusses the modes of operation, strengths and shortcomings of the software ‘AnalyzeSrttPf’<sup>2</sup>, especially its suitability to contribute to closing a gap in the historiography of 18<sup>th</sup>-century music. The software identifies the small rounded two/three-part form (srttPf) in large corpora with symbolic music, the elements of which are short monophonic compositions (songs and dances). In doing this, AnalyzeSrttPf shall help to reconstruct firstly the occurrence of the srttPf in popular music published in London between 1650 and 1770, and secondly its relationship to popular Viennese classical music, a style that shows a similar preference for the srttPf.

## 1. INTRODUCTION: A MUSIC-HISTORICAL PROBLEM

Since the mid-19<sup>th</sup> century, the discourse on the ‘nature’ of the Viennese classical music has been shaped by the claim that the Viennese classical style is marked by a *Volkston* [folk tone].<sup>3</sup> The term ‘folk tone’ refers to the ‘spirit’, the collective identity of people as a value in itself and was therefore instrumentalized by nationalist and national socialist ideologists for their purposes. Closely connected with the promotion of the *Volkston* thesis is the discussion of a specific musical form: the small rounded two/three-part form (‘srttPf’ in the following) [3, p. 110ff] [4]. The srttPf can be found in the music of Viennese classical com-

posers such as Mozart’s “Komm lieber Mai” (1791) and Beethoven’s “Freude schöner Götterfunken” (1824). Because those pieces have become popular, they have falsely been considered ‘typical Austro-German’ folk music, together with children’s songs such as “Hänschen klein”, a song that was composed in the early 1780s or earlier<sup>4</sup> and also possesses the srttPf.



Figure 1: The scheme of an ‘ideal’ srttPf, visualized by means of colours and letter labels.

In those pieces, the srttPf is primarily constituted by the pieces’ melodies that consist of four sections (with a central caesura<sup>5</sup>) (Fig. 1). The second and fourth sections are authentic or varied repetitions (as a whole or in part) of the first section while the third section is different enough to constitute a contrast to these parts. Both main parts on the right and the left side of the central caesura can or should be repeated according to repeat signs and double bars. (The repeat signs and double bars serve as notational instructions for repetition. The repeat signs are obligatory; some types of them are precise. The double bars are optional and insufficiently determined.<sup>6</sup>) Because the srttPf, a four-part form in essence, – AA(‘) || BA(‘) – can be cognitively summarized into a two-part form

**P1** (= AA(‘)) || **P2** (= BA(‘)) with the rounding A(‘)

or a three-part form

**P1** (= AA(‘)) || **P2** (= B) **P3** (= A(‘)),

music theorists have coined this form ‘rounded binary’ [10] as well as ‘small ternary’ [11, pp. 13-15 and 70-86].

Throughout the 20<sup>th</sup>-century, musicologists intensely examined (and differentiated) the (alleged) relationship between the ‘folk tone’ and the Viennese classical style pointing out similarities between the music of Haydn and Mo-

<sup>1</sup> For the project website: <http://historiography-of-musical-form-through-mir.sbg.ac.at>

<sup>2</sup> Source code and instructions for installation and application: <http://historiography-of-musical-form-through-mir.sbg.ac.at/instructions-for-the-installation-of-analysesrttPf/>.

<sup>3</sup> The cultural historian and sociologist Wilhelm Heinrich Riehl stated, in 1849, with nationalist impetus that “Mozart’s opera is based on the - folk song” while “Hasse’s opera is based on the artificial, scholarly system of Italian arias” [1, p. 667]. Guido Adler claimed in 1929 that “the art [of Viennese classical music] [...] is based on folk music”, but did not give any arguments or evidence for his assertion [2, p. 783]. Walter Wiora noted in 1957 that the Viennese classics created “in the folk tone”; this constituted an “essential aspect of the concept of Viennese classicism” [3, pp. 110 and 132].

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<sup>4</sup> The earliest manuscript of “Hänschen klein” we know today is from 1784. The earliest print was released in 1807 [5, p. 11, set to the lyrics “Fahret hin”].

<sup>5</sup> The central caesura of the srttPf is to be distinguished from the medial caesura that separates the presentation of the first and second theme in sonata form from each other (on the medial caesura [6, p. 55]).

<sup>6</sup> Double bars are undetermined as performance instructions. They can be interpreted as a prescription to repeat one part, both parts or no part at all. The instructions are likewise not obligatory in general, but are left to the subjective interpretation of the performers [7–9].

zart, on the one hand, and popular pieces of music that were claimed to have been performed in Central Europe, on the other. Since the latter were usually falsely classified as folk music, scholars considered their findings proofs of the Volkston thesis (on the fiction of the concept of ‘folk music’: [12], [13], [14]). Having demonstrated the similarity of themes by Mozart and themes in folk songs by means of synoptical tables, Walter Wiora, one of the most ardent advocates of the Volkston thesis, concluded in 1965: “For him [Mozart], as for the ‘Viennese classics’ in general, the folklorist elements [...] form [...] a basic feature of his oeuvre, his style, his character” [3, p. 67]. At the same time, however, the promoters of the Volkston thesis permanently failed to produce evidence for a causal relationship between Viennese classical music and folk music as Thomas Hochradner, for instance, pointed out: “Whether Mozart strove for this [folklorist] musical level or grasped it en passant remains open” [15, p. 863]. Other scholars such as Koraljka Kos and Rudolf Flotzinger aimed at a fundamental criticism of the Volkston thesis, but regularly concluded their studies not with its rejection but with a mild relativization. Kos stated that most suspected quotes of folk music were central European common knowledge and the effect of polygenesis [16, p. 228], i.e. could be considered as belonging to numerous genres of music including folk music and Viennese classical music (similarly [17]).

In this light, it is noticeable that, according to the findings of Beate Kutschke, an extensive repertory of popular music published in London in the first two thirds of the 18<sup>th</sup> century (1710-1770) – multi-volume song and dance collections and airs of ballad operas with numerous performances – show a similar preference for the srtpf and its intertwining with popularity and folklorist associations (note that the terms “popular”, “folkloristic” and “folk music” must not be intermingled. In this context, “popular music” is considered to be the only one of these three terms that is suitable to describe music that many people know (see also [12], [13], [14]).) The connection between popularity and srtpf are best visible in *The Beggar’s Opera*, which is the first ballad opera premiered in London of 1728. 31 % of its airs possess an srtpf [14, p. 228ff].<sup>7</sup> The similarity between the English popular music of the early 18<sup>th</sup> and the Viennese classical music of the late 18<sup>th</sup> century is remarkable because the latter does not seem to have ties with the former.

Against this background several music-historiographical questions arise: Is the preference for the srtpf in the context of popular music at two different times and in two different places, 1400 km apart, a mere coincidence; or did a causal relationship exist between the formal preferences articulating themselves in both music cultures? Did, in other words, the srtpf migrate from London to Vienna and, if so, which way did it take: via Amsterdam, Paris, Frankfurt, Prague and/or Munich? What were the vehicles of the journey: performed and/or heard music, scores, compositional practice or conscious concepts and unconscious sense of form? Did the srtpf migrate at all from

London to Vienna or did this form similarly strongly occur at numerous places in Europe at the same time, i.e. was it wide-spread, when *The Beggar’s Opera* was premiered in London of 1728?

To answer these questions, a complex, multi-step music-historical study is necessary that investigates diverse musical repertories on the British islands and in central Europe throughout the 18<sup>th</sup> century. This paper focuses on a subproject of the study: the in-depth investigation of the repertory of popular music (more than 12,800 pieces of which 1159 pieces were transcribed) published in London between 1650 and 1770, which includes the above-mentioned pieces and genres – mostly monophonic, short songs, dances, and airs from ballad operas.

In order to determine in which segments of the repertoire of 18<sup>th</sup>-century popular music in London the srtpf appeared to a higher or lower proportion, a large corpus of pieces must be analyzed with respect to the pieces’ form. Carrying out the analyses manually, i.e. by means of the music-analytical techniques that have been established in musicology and music theory appears to be methodologically difficult in more than one respect. The analysis of numerous pieces – big data instead of case studies – is not only time-consuming and tedious, but above all inaccurate.

Human beings tend to make arbitrary decisions, especially in borderline cases, for example, when they have to determine whether two rather vaguely similar melodies are to be classified as still ‘similar’ or already ‘different’ – a decision that is crucial for whether a series of notes is still a variant of a preceding series of notes or operates more as a contrasting passage in the formal structure.

This arbitrariness in judgement and decision-making regularly leads to unreliable, incomparable data. Only computers consistently apply the same set of (subjectively determined) criteria to a given set of data regardless of the size of the data set. Computer-assisted analysis of the musical form (of symbolic music) is therefore desirable.

## 2. TECHNICAL CHALLENGES

### 2.1 Solving the technical problem – research survey and approach

Numerous research projects in the digital field have explored ways of recognising compositional aspects that function as constituents of musical forms in major-minor tonal music (1600 to 1910). Those aspects are, first, boundaries (defined by *clausulae* and cadences as well as closure cues), and, second, repetitions.<sup>8</sup> However, computer scien-

<sup>8</sup> Regarding the use of the technical terms ‘cadence’ and ‘clausula’ for two different types of “Endigungsformel” (in the terminology of Heinrich Christoph Koch, 1787) and the distinction between the two, we follow the practice of German music theorists. According to them, ‘cadence’ refers to an ‘ending formula’ which consists of the interplay of several voices (e.g. full and half cadence); ‘clausula’ refers to an ‘ending formula’, which consists of only one voice (e.g. tenor and soprano close) [18]. Arnold Schönberg highlighted that “smaller notes” are symptoms of a terminating section [19, p. 29]. According to Marcelo Enrique Rodríguez-López, closure cues are a “[l]ong note or rest; pitch jumps; [a] [c]hange in dynamics, timbre, register, rhythm, motive, contour, meter, key, or tempo; [or the opposite:] [c]onsistency in dynamics, timbre, register, rhythm, motive, contour, meter, key, or tempo; [e]xact or inexact repetitions; [c]omplete tonal motion; cadence preparation and completion; implicit harmonic progression; [m]etrical accent: beat, bar, hypermetric; [t]emplate form structure, recognition of stylistic motive or

<sup>7</sup> Popular dance and song collections were published from 1651 (Playford’s *Dancing Master*) onwards, but an increasing preference for the srtpf does not become visible before the 1710s [14, p. 223ff].

tists have rarely interpreted their findings in terms of musical forms as defined by musicologists and music-theorists.

Furthermore, the use of digital means to determine the boundaries in music in analogy to punctuation in verbal language has so far proved to be little successful.<sup>9</sup> This is so because the criteria that define boundaries, including cadences and *clausulae*, are difficult to describe even though for human listeners the identification of boundaries seems to be a simple task.

In contrast the second constituent of form, repeated series of notes, is more promising for the research objective of this study.<sup>10</sup> The occurrence of a note string such as e' e' f' g' more than one time

e' e' f' g' ... || e' e' f' g' ...

defines the first occurrence and its repetitions not only as two sections (such as AA(')). Contrasting sections (B) such as d' d' e' c' are likewise recognizable against the background of the repetitions.<sup>11</sup> In computer science, the investigation of repetitions in music has been carried out under the headings “melodic self-similarity” [22, p. 2], “musical parallelism” [26] or “pattern recognition” [27].

Both constituents of form – cadences and *clausulae*, on the one hand, and repetitions, on the other – do not only concern different aspects of the music, but also occur in different places of a musical piece. While boundaries, caesuras and closure cues stimulate the investigation of the beginning and ends of a section detected by perception, repetitions draw the researchers' attention to the music's shape in the middle of a section.

Note that both groups of constituents of musical caesuras – cadences, *clausulae*, and other closure cues; repetitions – cannot be found in all musical styles and genres alike because they were developed and occur to varying degrees in different music-historical periods. The cadences and *clausulae* can be traced back as constituents of form to the 15<sup>th</sup> century – musical phrases were considered equivalents to verbal language – and were complemented by repetitions in the later 18<sup>th</sup> century [28].

As can be seen from sample analyses which we manually produced at the beginning of the project, the constituents of form of the pieces in the London corpus – short, monophonic songs and dances – are primarily those of the second group, i.e. repeated series of notes. The form of many pieces is formed from literal or almost literal repetitions. If

varied repetitions, such as sequences, occur in these short pieces, they form a contrasting section (B), not a repeated one (despite the similarity of the melodic contours between the initial and sequenced notes), just like completely different series of notes.

In contrast, the identification of boundaries (between the authentic and/or variedly repeated or contrasting note strings) by means of cadences and *clausulae* turns out to be more or less irrelevant for the pieces of the London corpus, because of two reasons: first, knowledge about the exact point of the phrase ending is not indispensable to determine the series of formal sections and parts. What counts is the melody's shape in the middle of the sections and parts, and their relationship to each other (as authentic or varied repetition or contrast such as A, A' and B). Second, the determination of phrase endings (boundaries) on the basis of the harmonic progression (cadences and *clausulae*) requires polyphonic, multi-part music whose combinations of sounds constitute chords and cadential chord progression. The phrase endings of monophonic music such as that one in the London corpus allow to identify *clausulae*, but not chords and especially cadences. Note sequences that look like *clausulae*, however, do not have to function like them, i.e. mark a boundary, for the listeners and performers of the piece.<sup>12</sup> Consequently, the software AnalyzeSrtptf we developed<sup>13</sup> analyzes the pieces of the corpus mainly on the basis of repetitions, yet takes into account boundaries into the analysis, that repeat signs and double bars unequivocally indicate.<sup>14</sup>

To identify literally and varied repeated series of notes, three algorithms are available that identify identical note strings and sequences, and the different degrees between them: the longest common substring algorithm, the longest common subsequence algorithm and edit distance.<sup>15</sup> In music informatics, researchers have used these algorithms thus far for analytical objectives, which differ significantly from those of this study. In keeping with the original purpose of the algorithms, namely to determine the degree of similarity between two strings and/or sequences of characters, in the context of music, the algorithms serve to determine the similarity between two different compositions. For this project, in contrast, we had to develop an algorithm that identifies the repeated note strings as constituents of the srtptf *within* a piece, not between two different pieces.

## 2.2 Solution to the technical problem: reshaping the longest common substring algorithm into the all common substring algorithm (ACS)

The longest common substring algorithm (LCS) serves as starting point for the development of our digital tool. To recapitulate briefly the basic principle of the LCS algorithm: the LCS algorithm finds, within two given strings (A of

quotation” [20]. The Local Boundary Detection Model (LBDM) in the version by Emiliós Cambouropoulos is based on the Gestalt principles of change and proximity [21, p. 1 (our page count)]. Rodríguez-López and Anja Volk, however, point out that, according to their findings, change, i.e. “local discontinuities” are not universal, genre-independent closure cues [22, p. 7].

<sup>9</sup> The algorithm developed by Mathieu Giraud, Richard Groult, Emmanuel Leguy, and Florence Levé identifies about 82 % of the PACs (perfect authentic cadences) which are indicated in the ground truth data (fugues with annotated cadences) [23, p. 88]. The software that Jesse Rodin and Craig Stuart Sapp developed in the context of the Josquin Research Project reliably identifies the interval steps that constitute *clausulae*, but cannot distinguish between these *clausulae* that effect boundaries, and others that do not interrupt the continuity [24].

<sup>10</sup> “Repetition”, “coming back to what has already been there, in all its forms – as simple repetition or dislocation or imitation and the like – does indeed provide the main lever of musical form formation.” [25].

<sup>11</sup> Seen in this way, in epistemological-cognitive respect, the srtptf is the most basic and, at the same time, efficient form. Contrast requires repetition without which the contrast cannot be recognized as such.

<sup>12</sup> See footnote 9.

<sup>13</sup> Tobias Bachmann designed the architecture and executed the coding; Beate Kutschke defined the objectives and functions of the tool and ensured usability for non-computer scientists.

<sup>14</sup> For more details: see subsequent section.

<sup>15</sup> The first two algorithms detect substrings and subsequences shared between two note strings; the latter quantifies the degree of the similarity between two strings.

length  $a$  and  $B$  of length  $b$ ), the longest substring and returns the position of the substring's elements. It does so by comparing the elements of two strings  $A$  and  $B$ , which are each characterized by a value representing a letter of the alphabet and a position within the string, with respect to their value, and notes the results –  $LCS(i-1)(j-1)+1$  for identity; 0 for difference – in a two-dimensional matrix. This matrix is then searched for the cell  $LCS(i)(j)$  with the highest value, indicating the end of the longest common substring with ends at  $A(i)$  resp.  $B(j)$  and the length  $LCS(i)(j)$ . (Diagonal strings of non 0 indicate substrings that are identical between the original strings  $A$  and  $B$ .)

For AnalyzeSrttpe, we have reshaped the LCS algorithm into the all common substring algorithm (ACS). The ACS algorithm is distinguished by the LSC algorithm in three respects.

1. The elements of the investigated strings are the values not of letters, but of music21 note objects which, in the context of this project, are characterized by the parameters 'duration', 'pitch' and 'position within string'.<sup>16</sup>
2. While the LCS algorithm enters the values of the letters of two different strings ( $A$  and  $B$ ), the ACS variant enters, in the first row and column of the matrix, the values of the same string and, thus, compares the piece with itself.
3. Instead of the longest common substring, the variant returns all common substrings of at least the minimal length  $m$  that appear more than once (exclusively, meaning another appearance of the same substring must not be a part of another appearance) in the given string ( $A$  of length  $a$ ). It does so by searching the matrix for  $ACS(i)(j) \neq 0$  and  $ACS(i+1)(j+1) = 0$ , indicating the end of a pair of identical substrings of length  $acs(i)(j)$  and ends  $A[i]$  resp.  $A[j]$ . In the final step, the algorithm consolidates the found pairs in order to link all pairs describing the same substrings.

ACS algorithm: string  $a$ , string  $b$

$$acs_{a,b}(i, j) = \begin{cases} acs_{a,b}(i-1, j-1) + 1 & \text{if } a(i) = b(j) \\ 0 & \text{else} \end{cases} \quad (1)$$

Using the ACS as only algorithm to identify the constituents of the srttpe has two shortcomings that, however, are not relevant for successfully pursuing the defined objective of identifying pieces with srttpe (in contrast to pieces with other forms or the lack of a recognizable form). The first weakness is that because the ACS algorithm finds only identical note strings, a flaw or variant in the repetition of a note string makes AnalyzeSrttpe identify two

repeated note strings instead of one. Second, the ACS algorithm can determine the contrasting section  $B$  only *ex negativo*, i.e. by not finding the same note string(s) in sections  $B$  and  $A(')$ .

### 2.3 Criteria for the four sectors: the method of operation of the criteria script (CrS)

The ACS algorithm, however, is only one of two main components of AnalyzeSrttpe. The other main component is the criteria script (CrS in the following). Using the all ACS algorithm in order to display all common substrings inside of the analyzed melody, the CrS determines the occurrence (or lack of occurrence) of common substrings within different sections of the analyzed piece. Since the srttpe is essentially a four-section form whose sections can be combined into two or three parts (see 1), the CrS identifies the occurrence or lack of occurrence of common substrings in each of the four different sections (sectors 1 to 4) that jointly constitute the form. Because many, but not all scores in the London corpus have a clear marking of the central caesura – a repeat sign or a double bar –, the CrS firstly determines the central caesura (see yellow stripe in Fig. 2). For those pieces that do not have a repeat sign or double bar in their middle, we have defined an artificial, speculative boundary after 50 % of the total length of the analyzed pieces (that, however, can be changed by the user if needed). Placing the artificial boundary in the middle of the piece is reasonable because, according to our 'manual' control, at least half of the pieces without explicit central caesura in the investigated corpus can be divided into two parts of the same or almost the same length.<sup>17</sup>

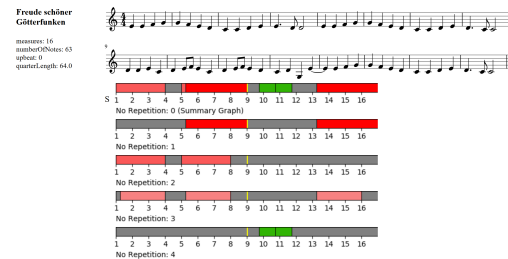


Figure 2: Analytical results of the software 'AnalyzeSrttpe'. The second, third and fourth of the four graphs (from above) show three different pairs or triplets of identical note strings, which partially overlap. The first graph (from the top, labeled "S") shows the summary of the individual graphs below.

Based on the determination of the central caesura, the CrS identifies the following four criteria:

Criterion 1 defines the occurrence of two identical note strings – the original and the repetition – of a minimum lengths of 12 % each within each half of part 1 (sector 1 and 2).<sup>18</sup> The CrS allows a tolerance of the position

<sup>16</sup> AnalyzeSrttpe deletes information about the note's articulation and ornamentation which, in music21, are parameters of the note object [29]. However, our software considers grace notes (because they are relevant for the determination of repeated note sequences and, thus, musical form). It does so by analyzing two versions of a piece: first, without and, then, with grace notes.

<sup>17</sup> A slight difference between the notated and the artificially defined central boundary does usually not affect the analytical results. See 3.1.

<sup>18</sup> These and the following percentages were determined by the authors by trial and error. AnalyzeSrttpe is designed in such a way that the thresholds can be changed if other percentages seem more appropriate to AnalyzeSrttpe users.

of the identical note strings by 10 % on each side of the string (its beginning and end) because the exact place of the boundary between sector 1 and 2 (as between sector 3 and 4) is unknown (cf. 2.1); identified note strings that meet the defined criteria for part 1 are marked by red color (here: graphs no. 3 and 4). They shape the first two sections AA or AA'.

Criterion 2 is an excluding criterion. It identifies two identical note strings in the center of part 1 (positionBegin=25, positionPivot=50, positionEnd=75 of part 1; positionTolerance=20) because identical note strings in this position in part 1 usually do not define the sections AA('), but are a symptom of the fact that part 1 has no internal division (as a condition for AA(')); the two short repetitions in the middle of part 1 are more patterns than thematical material (Fig. 3).

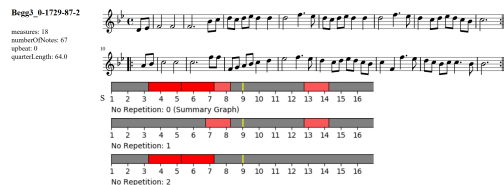


Figure 3: George Frideric Handel, “March in Rinaldo”, in J. Gay and C. Pepusch, *The beggar’s opera* (1728), London, 1729, p. 20.

Criterion 3 defines the contrasting section B in sector 3. In order to constitute the srtpf, sector 3 must possess a note string that does not occur in any of the other three sectors. This unique note string has the minimum length of 14 % of the total length of part 2 with a tolerance regarding the string’s position of 10 %. In the paradigmatic example (“Freude schöner Götterfunken”, Fig. 2), the contrasting section is not only marked by a note string that does not occur in the remaining sectors (presented in grey color), but are additionally repeated within sector 3. The repetition of note strings is a compositional strategy particularly suited to mark the contrasting section as individual section (on the epistemological-cognitive relationship between repetition and the definition of a section: see 2.1) Unlike the preceding criteria, the unique note string should be located not only on one of the individual graphs (here: graph 5), but also on the summary graph (graph 1 marked with an S (for ‘summary’)) on the left side of the graph). The location of criterion 3 on the summary graph is to ensure that the CrS does not consider the criterion fulfilled even if red sections (A(')) on other graphs determine the understanding of the melody in this sector as repetitive rather than contrasting.

Criterion 4 (4a, 4b and 4c): To determine the rounding in sector 4 (A(')), we have defined three variants of the same criterion. They determine roundings of three different lengths: 5, 7 and 9 % of the total length of a piece (with a position tolerance of 10 % regarding the boundary to sector 3). In Fig. 2 the rounding is located on graphs 2 and 4.

## 2.4 Exclusion criteria/counter-indications

The following musical characteristics, if possessed by a piece, can lead to inaccurate analytical results from AnalyzeSrtpf:

- no explicit, notated boundary (repeat sign or double bar); the absence of an explicit boundary, however, does not necessarily mean that the piece does not consist of phrases whose endings effectuate implicit boundaries,
- more than one boundary in the middle of the piece; AnalyzeSrtpf neglects repeat signs at the very end or in the last measures of the piece because they do not alter the form, yet, in its current release, the digital tool cannot deal reasonably with more than one central boundary,
- pattern-like repeats (‘accompaniment figures’) in the middle of part 1 that the CrS of AnalyzeSrtpf misinterprets as AA' (= part 1) even if part 1 consists only of A (see. Fig. 3 and description of criterion 2 in preceding section).

AnalyzeSrtpf notes the weak points of the analysis in the report that the digital tool automatically returns after each analytical run.

## 2.5 Visualization

AnalyzeSrtpf differs from other software that analyzes symbolic music in that it not only returns values, i.e. statistically evaluable results, but also piece-individual visualizations of its analytical findings. The visualization has been inspired by the DB-position indicator of trains and its method to use colors that refer to types of coaches (Fig. 4). Just as the latter displays the position of all trains and their coaches next to the platform in relation to each other, AnalyzeSrtpf displays the location of repeated and contrasting note strings of all analyzed pieces in relation to each other on an infinite canvas.

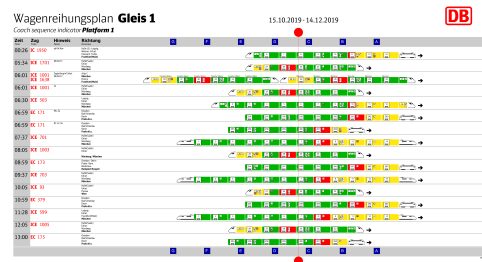


Figure 4: Position display of trains on platform as used by Deutsche Bahn (© By courtesy of Deutsche Bahn)

The visualization, like the return of the abstract values, takes into account that a significant amount of pieces in the London corpus possesses repeat signs (obligatory repeat signs such as :||: and optional ones such as ||<sup>19</sup>) and

<sup>19</sup> Double bars suggest optional repetitions of only the left, only the right or of both sides of the piece.



grace notes. Both – repeat signs and grace notes – ask the performer(s) to add individual notes and entire sections of music that are only indirectly notated in the score.<sup>20</sup> Considering a composition with or without additional (grace) notes and (repeated) sections, significantly alters which passages the ACS algorithm identifies as repetitions and, thus, which form the CrS derives from the algorithm’s results. For example, a piece that has the form  $A :|| BA'$  in the notated version becomes an srttpf ( $AA || BA'$ ) when performed with the repetitions prescribed by the obligatory repetition mark, while double-sided repetition marks ( $:||:$ ) transform all pieces into pieces with the form  $AA || BB$ , regardless of which form is present in the notated version. Since it is not clear what significance a composer writing music attributes to the two versions of the piece – notated vs. performed version – AnalyzeSrttpf analyzes the pieces in both versions.

### 3. RESULTS

#### 3.1 Analytical Results

Although the CrS cannot accurately evaluate specific melodic configurations and, if they occur in pieces, returns ambiguous results (see 2.4), the overall results of AnalyzeSrttpf are sufficiently reliable, as a comparison between the results from the analysis of the London corpus (1159 pieces) produced by AnalyzeSrttpf and the results produced by manual annotation (groundtruth dataset) shows. 97 % of the pieces of the London corpus, do not meet the criteria of ambiguity and, thus, provide reliable results regarding the analytical objective ('srttpf' vs. 'no or other form').

Similarly positive are the results for pieces with more than one boundary (in the shape of a repeat sign or double bar) or without an explicit, i.e. notated boundary in the middle of the piece (see Table 1).<sup>21</sup>

Even though AnalyzeSrttpf is specialized in identifying the form of pieces with one central boundary, the fact that only 65.4 % of the pieces of the London corpus have exactly one central boundary does not significantly reduce the reliability of the results. This is so because of the following reasons. Regarding the pieces with more than one boundary (6.56 %), the method of AnalyzeSrttpf to ignore the second boundary proves to be inefficient: most classifications of the form of those pieces by AnalyzeSrttpf are false. It is therefore advisable to omit those pieces from investigations. In contrast, regarding the pieces without boundary (28.04 %), the comparison with a manual annotation shows that the method of having AnalyzeSrttpf add a hypothetical boundary in the middle, i.e. after 50 % of the piece (see 2.4), leads to satisfactory results. This is so even though, paradoxically enough, the place of the artificial boundary of almost half of the pieces without boundary (160 of 325 pieces; 49.23 %), has not been accurately located. Despite the incorrect placement of the hypothetical

boundary, which is thus unusable for the determination of the form, the results obtained by AnalyzeSrttpf are largely correct: only with regard to 4.38 % of the pieces with inaccurate, schematically-set artificial boundaries (or 2.15 % of the pieces without boundary or 0.65 % of the total),<sup>22</sup> the placed boundary distorts the analytical results.<sup>23</sup>

#### 3.2 Music-historical (preliminary) Results<sup>24</sup>

Using AnalyzeSrttpf, it is possible to reconstruct in detail the preferences of music editors and publishers of popular songs and dances regarding the srttpf in England of the 18<sup>th</sup> century. To give two examples: first, the number of pieces with srttpf published in London increases in comparison to pieces without form and pieces with other forms throughout the 18<sup>th</sup> century (Fig. 5).

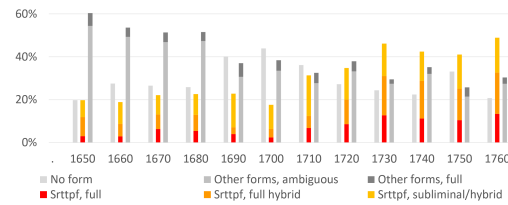


Figure 5: The form of pieces in popular tune collections published in London between 1651 and 1770; percentages of form types within a decade. (The diagram distinguishes between three groups of srttpf: 1. pieces with ‘srttpf full’ have all the properties that define an srttpf; 2. pieces with ‘srttpf hybrid’ have all the properties, but their graphs can also be interpreted as another form (often as  $PI-PI' / 2$ ,  $AA||A'A$  or  $AA' || BB'$ ) if other graphs are prioritized (perspective dependency); 3. pieces with ‘srttpf subliminal/hybrid’ have all properties only in the parameter ‘duration’, while in the parameter ‘pitch’ the rounding is missing – the form is existent only subliminally –; the group ‘srttpf subliminal/hybrid’ contains pieces which have either a clear srttpf subliminal or both an srttpf subliminal and at the same time other forms. The diagram also distinguishes between two groups of other forms (such as  $A||BB'$ ,  $AA||A'A$  and those mentioned above). In contrast to pieces with “other forms, full”, pieces with “other forms, ambiguous” can be interpreted as two or more other forms superimposing each other (perspective dependency). ‘No form’ means that the CrS cannot assign any of the forms it ‘knows’ to the piece.)

Second, the year 1719 marks an important turning point of the publishing history of popular pieces with srttpf. In this year, the actor-poet Thomas D’Urfey developed a remarkable publication activity. Of the total of 2154 popular songs and dances (first prints or uniques, and reprints) released by various publishers in 1719, D’Urfey alone published 1436 pieces, i.e. 67 %. He was able to accomplish

<sup>20</sup> Music has always two different modes of being (*Seinsformen*) manifesting themselves in the use of two different sign systems: the visual score and the performed, sounding music.

<sup>21</sup> Repeat signs at the end of a piece do not pose any difficulties for CrS to apply its criteria. In case of the presence of square brackets (for prima and seconda volta), AnalyzeSrttpf neglects the first bracket and therefore considers this passage as marked by only one boundary.

<sup>22</sup> 1083 pieces (1159 transcribed pieces in total minus 76 pieces with more than one boundary).

<sup>23</sup> Cf. statistics, unpublished, available with the principal author, beateruth.kutschke@sbg.ac.at.

<sup>24</sup> The complete results will be published in an extensive monograph forthcoming in the next two to three years.

Number of explicit boundaries in piece	0		1		More than 1		Total	
Number of pieces in corpus	Number	%	Number	%	Number	%	Number	%
	325	28.04	758	65.40	76	6.56	1159	100

Table 1: Number of boundaries in the pieces of the London corpus.

this through numerous reprints from earlier publications (Fig. 6).<sup>25</sup>

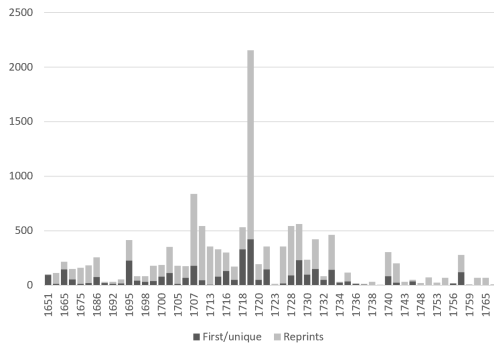


Figure 6: Absolute number of publications between 1651 and 1770.

Most importantly for this project, D’Urfe’s publishing activity also influenced the history of the ‘visibility’ of the srttpf. His publications almost doubled the number of pieces with srttpf in the investigated corpus (Fig. 7a).

However, D’Urfe did not achieve this by selecting pieces for reprints with srttpf, but by publishing new pieces, the origin of which is unclear. As the diagram shows, the pieces in D’Urfe’s volumes that had been made favorites by four or more (re-)prints in the past have an srttpf much less often than the pieces published in D’Urfe’s volumes that were comparatively new and therefore had been printed only three times or less in the past (Fig. 7b).

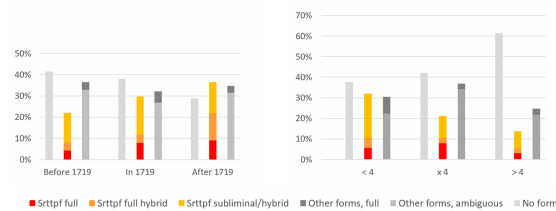


Figure 7: 7a) Number of the occurrence of srttpfs before, in and after 1719. 7b) Number of pieces with and without srttpf within each reprint group of D’Urfe’s publications in 1719 (less than 4 reprints, exactly 4 reprints, more than 4 reprints).

Third, Scottish tunes, which became popular in the second half of the 18<sup>th</sup> century and for which British publishers commissioned Central European composers such as Haydn and Beethoven to arrange, seem to have played a significant role in increasing the popularity of the srttpf not only in Britain, but also Central Europe (Fig. 8).

<sup>25</sup> As regards popular music, English publishing policy in the decades around 1700 was characterised by sophisticated reprinting strategies.

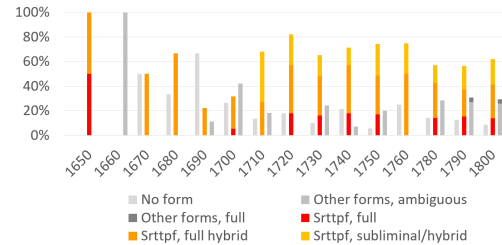


Figure 8: The form of Scottish tunes published in London between 1650 and 1800; percentages of form types within a decade

Fourth, the history of popular songs and dances in England draws attention to the fact that the similarity and apparent akinship of the Viennese classical style with the music of the folk is not a coincidence, but the effect of communication and exchange – not, however, between Viennese classical composers and minstrels in Austrian villages, but between Viennese classical composers and English music publishers keen to market – true or bogus – Scottish tunes.

#### 4. FUTURE DIRECTION/WORK; UNSOLVED PROBLEMS

##### 4.1 Regarding MIR

There is still no software that determines musical form as a result of repetition, variation and contrast. AnalyzeSrttpf provides a component for this purpose. The following extensions and additional components, most of which are already available but not yet connected to our tool, are desirable:

- an algorithm capable of analysing polyphonic music with respect to musical form
- the implementation of software that identifies cadences
- criteria scripts that reliably identify forms other than the srttpf
- a software architecture that autonomously derives these criteria through machine learning.

##### 4.2 Regarding music historiography (by means of MIR)

The research findings with respect to the London corpus demand to be complemented by the production and investigation of corpora with popular music – dances and songs – in France and German-speaking regions of the 18<sup>th</sup> century.

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