The melodic beat: exploring asymmetry in *polska* performance

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Some triple-beat forms in Scandinavian Folk Music are characterized by non-isochronous beat durations: asymmetric beats. Theorists of folk music have suggested that the variability of rhythmic figures and asymmetric metre are fundamental to these forms. The aim of this study is to obtain a deeper understanding of the relationship between melodic structure and asymmetric metre by analysing semi-automatically annotated performances. Our study considers archive and contemporary recordings of fiddlers' different versions of the same musical pieces: *polska* tunes in a local Swedish tradition. Results show that asymmetric beat patterns are consistent between performances and that they correspond with structural features of rhythmic figures, such as the note density within beats. The present study goes beyond previous work by exploring the use of a state-of-the-art automatic music notation tool in a corpus study of Swedish traditional music, and by employing statistical methods for a comparative analysis of performances across different players.

Keywords: Asymmetric metre; rhythm; Scandinavian folk dance; polska; corpus analysis; oral music theory

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1. Introduction

Triple-beat couple dances such as *polska*, *pols*, *springlek*, and *springar* hold a central position in Scandinavian Folk Music traditions. The tune types related to these dances – apart from the more recent *vals* and *mazurka* forms – can be traced back to the dance-music prevalent in central Europe from the sixteenth century on (Norlind 1911, Gustafsson 2016) and have developed into numerous local styles. Some of these styles are characterized by non-isochronous beats, in particular in parts of Norway, and central and western Sweden. These beats have been described as asymmetric (Blom 1981; Ahlбёck 1989) with either short-long-medium or long-medium-short beat duration patterns. Already in the late nineteenth century and early twentieth century, folk music collectors noted the asymmetrical beat pattern as significant for regional styles (Elling 1915; Ramsten 1982; Sandvik 1943; Andersson 1923). Style-specific labels, such as *polska with short first beat*, and other labels with metrical connotations, have become commonly used among folk music practitioners as descriptions of musical form (Ahlбёck 2003).

A fundamental distinction for this study is to separate between metre types with non-isochronous beat cycles regulated by isochronous sub-units (such as 2+2+3 patterns in, i.e., the
Greek Kalamatiano), and types with non-isochronous beat cycles not depending on isochronous, regulating subdivisions. Asymmetric polska belongs to the latter type; indeed, polska metres are often described as “oval shaped” (Ahlbäck 1989, 2003; Kvifte 1999, 2007; Johansson 2009). Equally important is that repeating non-isochronous beat cycles in polska cause periodic isochrony on higher metre levels (the measure and above). This isochrony can be understood as a function of this music’s role as a dance accompaniment: the movement cycles (step and turning patterns) in the related dances are typically aligned with this periodicity on measure level (Kvifte 2007; Blom 1981; Haugen 2015; Misgeld and Holzapfel 2018). Another fundamental distinction for our study is that of the temporal organization of music into rhythm – i.e. durational patterns perceived as gestures, motifs, figures, etc. – and metre – the periodic and regular beat structure (London 2001; Ahlbäck 2003). We will explore asymmetric metre and relate it to rhythms within polska tunes in a systematic analysis of automatically notated performances.

The subject of beat asymmetry has been a focus of much Scandinavian folk music research. Such research includes studies on music performance (Groven 1971; Bengtsson 1974; Ahlbäck 1989; Kvifte 1999; Johansson 2009), dance movements, (Blom 1981) and recent studies involving motion capture techniques (Märds 1999; Haugen 2015; Misgeld and Holzapfel 2018). Drawing on Norwegian springar, Kvifte (2007) introduces the term common slow pulse as the stable central time reference above the beat level and which often corresponds to the measure level in other mainstream notation systems. Furthermore, Kvifte (2007) and Blom (1981) point to the dance movements as the fundamental reference structure for the unequal beat lengths below this level. Based on recordings from the Swedish-Norwegian border area, Ahlbäck (2003), on the other hand, points to gestural rhythms indicative for asymmetric beat and, in general, that beat asymmetry is related to the number of notes within a beat. Johansson (2009) also points to the variability in beat duration being dependent on the melodic motives.

Moving below the beat level, polska rhythms include a variety of patterns that vary between styles (Ahlbäck 1995; Kvifte 1999; Bengtsson 1974; Johansson 2009) and that are subject to variation between performers. The combination of equal, long-short, and short-long sub-divisions of different integer ratios within the same tune is common (Kvifte 2007). While many studies treat non-isochronous patterns as deviations of duple and triple frameworks (London 2012), this interpretation has been challenged, for instance, in empirical studies on the non-isochronous metric subdivision in West African music (Polak 2020). The large number of studies on swung rhythms in jazz further illustrate the significance of rhythmic subdivision beyond isochronicity (Friberg and Sundström 2002).

Importantly, since this music is generally not performed from notation, the non-isochronous subdivisions and beat cycles of asymmetric polska styles should be primarily understood as a performance-based phenomenon. As a consequence, the current study will focus on examples of performances of particular Scandinavian polska/pols/springar forms. We choose particular examples that exemplify this tradition, and select tunes that are some of the most well documented in audio and visual recordings from the early twentieth century and onwards, featuring an uninterrupted chain of oral transmission up to the contemporary players.

This article will focus on a local tradition centred around the parish village of Orsa in Dalarna, Sweden. We study five specific polska tunes within this tradition that have been played by the famous fiddler Gössa Anders Andersson (1878–1963), the most influential local musician in

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1 Viennese waltz is another well-known example of a triple beat dance music form performed with short first and prolonged second beat, sometimes with similar proportions as in asymmetric polska. However, these forms have different relations to the main regulative metrical level (tactus): In Viennese Waltz, this level occurs at the first beat of the measure, forming an isochronous duple compound metre of 3+3 (Bengtsson and Gabrielsson 1980). In polska, however, the main regulative metrical level occurs at the level of three beats per measure, corresponding to the gravity points in body movements and weight on feet corresponding to walking. Furthermore, Viennese waltz traditionally includes large and expressive tempo changes, while the polska is typically performed at a steady pace, without rubato.
Orsa throughout the twentieth century. Documentations of the music of Gössa Anders and associated players of the region include notations, audio recordings, and filmed material, spanning the period from 1910 until 1961. One among these sources is an inventory of pieces including 108 polska notations, compiled by folk music collector and violinist Karl (Sporr 1963), who was supported by Gössa Anders himself in reviewing his notations. Although Gössa Anders also played with other fiddlers, the vast majority of notations and recordings are with solo fiddle. The metric structure is thus shaped through the articulated melodic line, with the accompaniment of foot-tapping, typically marking beats one and three. Although other collectors of the same time period experimented with notations in composite metres for asymmetric tunes, all notations of the polskas from Gössa Anders and related players in these historical collections are written in 3/4 time signature, implying isochrony on the beat level. However, the collectors and annotators of these tunes would often comment on the fascinating rhythms within this metric framework, for instance, as “outbreaks of powerful, heavy bow-strokes, emphasizing a certain section of a repeat as if wanting to push away the fencing of tempo, measure boundaries and rhythm.” Commentators report on how transcribers struggled with expressing such rhythmic features in notation, and relied heavily on syncopation, tuplets, temporary tempo markings such as rubato, accelerando, and ritardando, and stress and articulation markings (Andersson 1923).

This discrepancy between performance practice and transcribed notation raises questions related to oral music theory. Ahlbäck (1995) proposed a typology for Scandinavian dance tunes based on rhythmic and metric features of the tunes. Drawing on acoustical measurements of beat proportions in performances, Ahlbäck employs 2+4+3/16 as a metrical notation model for tunes with short-long-medium asymmetry, indicating the short first beat being roughly half the duration of the second beat. Importantly, Ahlbäck’s metric notation is not to be interpreted as a composite beat grouping of a common subdivision, such as 9/16, but rather as an indication of beat proportions accommodating for some variation by allowing metric groupings of 3+3+3 and 2+4+3, alternating between symmetric and asymmetric measures.

Studies on beat asymmetry in Scandinavian folk dance music have generally presented data from relatively isolated performances. For instance, there is a lack of studies including multiple performances of the same pieces. Additionally, little work has been done either with large datasets or with computational analysis within this topic. This lack may be a result of the difficulty to implement automatic note onset estimation on instruments with continuous note production – such as the violin – or the complexity of automatic beat estimation on music with varying beat lengths. The present study extends previous research by both comparing several performances by contemporary expert performers with historical performances, and by using computational tools to do so. In addition to the manual annotating of beats, we employ a state of the art automatic notation tool (Ahlbäck et al. 2020), which estimates onset times, note durations, and pitch values from a sound signal. This step towards automatic notation facilitates a larger-scale analysis of musical structures in music corpora as conducted in this article.

In sum, our goal in this study is to explore the duration and variation in non-isochronous rhythms in music in the polska style using automated and computational methods. Rosenberg (2019) illustrated that certain timing qualities remained stable over time in a number of folk singers’ interpretations of orally transmitted songs, indicating a kind of “singers imprint.” Our research adds to this exploration of transmission in oral music tradition by studying how consistent recordings of recent players are with historical players in an instrumental dance music tradition. Similar to Rosenberg (2009), we investigate timing features that can elude being expressed in categorical music notation.

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2 Einar Övergaard (1871–1936) and Catharinus Elling (1858–1942).

3 This quote by Andersson (1922), translated by the first author, refer to the player Bleckå Anders Olsson (1832–1922), who is said to have strongly influenced Gössa Anders’ playing.
The present study should be viewed as an example of music performance research employing scientific methods with the aim to explore performance features within a musical tradition that the researchers themselves take active part in. The main scope is to explore methods for analysing features in this subset of possible interpretations within a style, and not to test hypotheses that would require a larger dataset.

Within this context, statistical analysis is suitable for exploring the main research question of our study: How does beat asymmetry depend on (a) the tune, (b) the individual performer and, (c) the rhythmic patterns. Our results illustrate a strong correspondence between rhythmic figures and beat asymmetry in our material, and present how these asymmetric beat pattern can be modelled through variables defined by the rhythmic structure. Furthermore, our results illustrate musically relevant adaptations within consistent performances of the same pieces by different players.

In the next section we describe how these questions are approached by statistical analysis of data obtained by manual and automatic annotation. The outcome is presented in Section 3 and discussed with relation to previous research in Section 4.

2. Method

The aim of this article is to analyse the variability of beat proportions in a corpus of Swedish polska tune recordings. Our analysis explores how beat proportions correlate with the rhythmic profile of melodies, and what variations occur within performances and between players. To this end, we use the music recordings described in Section 2.1. The procedure of annotating these recordings, together with the production of staff notations, is described in Section 2.2. Section 2.3 describes the process of categorizing rhythmic figures to facilitate statistical analysis that aims to identify the relations between rhythm categories and beat asymmetry.

2.1. Material

The corpus for this study consists of 20 recordings of five polska tunes played by four different players. One of the players is the fiddler Gössa Anders Andersson (1878–1963), in recordings made by Sveriges Radio on 1 and 17 March 1949 and 6 June 1950, and re-issued by Caprice (Andersson et al. 1995) and Hurv (Andersson, Andersson, and Spelmanslag 1998). The other players are the fiddlers Ellika Frisell (born 1953), Sven Ahlbäck (born 1960) and Olof Misgeld (born 1973), who were recorded between 2018 and 2020. The tunes were selected as representative examples of the polska repertoire of Gössa Anders, and familiar to all three of these contemporary performers. The five polska tunes are listed in Table 1 along with additional information. Appendix 1 contains references to recordings and published historical notations of these pieces.
The typical polska tune consists of two (or sometimes more), most often repeated, main sections, which are traditionally referred to as repriser (repeats) or turer (turns). Performances usually include two or more repetitions (volta) of the tune, repeating all main sections in the same order. Some polska styles feature repeats of the concluding note of a section, which results in added measures to a main section, which we refer to as repeated endings. Figure 1 illustrates this structure for the first volta of one of our tunes.

2.2. Annotation

The procedure of annotating beats and producing staff notations from the recordings listed in Table 1 included manual beat annotation with the sound analysis software Sonic Visualizer (SV; Cannam et al. 2006), and automatic transcriptions in staff notation with the music notation software ScoreCloud (SC; Ahlbäck et al. 2020). As a result of this process, we obtain beat time annotations and SC staff notations for each recording, which facilitate associating beat and note duration in seconds to the transcriptions.

2.2.1. Manual beat annotation

For the manual beat annotation, the first author tapped beats on a keyboard while listening to each recording at normal speed, labelling the resulting annotations as time instants in a three-beat cycle. Next, these time instants were corrected while inspecting a spectrogram of the recording. Whenever the recorded players’ foot-tapping marking beats stood out as a transient in the spectrogram, the beat time instants were checked to be aligned to the onsets of these foot-taps; this was regularly the case on beat one and three. In the absence of foot-tapping, time instants were checked to be aligned with the note onsets marking the start of a beat. In a final step, the annotations were corrected by listening to the whole recordings with the inserted time instants sounding as clicks.

2.2.2. Music transcription

The notation software SC conducts automatic transcription based on machine-learning pitch detection (Thomé and Ahlbäck 2017) and a rule-based music structure model (Ahlbäck 2004). The SC music structure model is based on general cognitive principles, such as Gestalt laws,
and is not adapted to specific musical styles. It performs onset synchronization, voice analysis
identifying parallel voice streams, beat detection, and contextual tempo and metrical analysis,
relating to segmentation on different hierarchical levels based on melodic similarity and struc-
tural discontinuity. Furthermore, an analysis of ornaments as opposed to melodically structural
note events is performed. An analysis of general tonality is conducted that results in estimates for
mode, key, and pitch spelling. Hence, the procedure aims at producing automatic music notation
from a model based on cognitively informed music theory.

The obtained SC automatic notations of the performances in our study were manually
corrected by moving misplaced notes into the correct metrical position within the SC software interface. These corrections were informed by the manual beat annotations described
in Section 2.2.1. In the next step, we manually accounted for notes that SC’s pitch detection
failed to capture and, finally, removed notated ornaments. Onsets that were considered as
merely parts of trills or grace notes were thus removed from our further analysis. The moti-
vation for this final step was to allow comparisons of motives across versions without taking
into account performance-specific embellishments. Transcriptions of each tune are included in
Figures 1, 7, 8, A1, and A2.

2.2.3. Annotation analysis

For our further analysis, the auto-detected notes (Section 2.2.2) were aligned with the manu-
ally annotated beat times (Section 2.2.1). Although beat durations were also derived from the
auto-annotated note times in the corrected ScoreCloud notations, these sometimes failed when
metrically strong events were obscured by ornamentation or when beats did not coincide with a
note onset.

Using staff notation and metric annotations, each measure was annotated to show its metric and
formal position, showing beat position and the position within the main section and the volta.
The process uses the following four parameters:

1. Level 1: Beat $b$. Number from 1…3.
2. Level 2: Measure $m$. Number from 1…$N_m$, with $N_m$ being the number of measures in the
   related section of the tune.
3. Level 3: Section $s$. Letters in upper case for each section, with a superscript denoting the
   section repetition. $A^1$, $A^2$, $A^3$.
4. Level 4: Volta $v$. Number from 1…3 with $N_v$ being the order of repeating all sections of a
tune.

Each annotation takes the form of a tuple $(b, m, s, v)$. For instance, an annotation $(2, 4, A^2, 1)$
refers to the second beat in the fourth measure of the second A-section of a tune in its first
repetition, equal to beat 2 in measure 15 of Figure 1.

In order to facilitate measurements of beat asymmetry, the beat durations (BD) in seconds were
calculated for each such annotation instance. From the beat durations, beat proportions (BP) of
the local measure duration (MD) was calculated:

$$BP = BD / MD.$$  \hspace{1cm} (1)

The beat proportion hence represents the relative duration of a beat in relation to the measure. In
the remainder of the text, $BP_1$, $BP_2$, and $BP_3$ refer to the proportion of each beat in the three-beat
cycle.
2.3. Rhythm categorization

In order to systematically explore the previously observed effect of rhythm gestures on beat asymmetry in our material (Ahlbäck 1995, 2003; Johansson 2017b), we categorized rhythm figures occurring in the corpus as illustrated in Figure 2. The numeric labels follow the formulation $d_{1}^{n_{1}}d_{2}^{n_{2}}$ with $d_{n}$ being the number of notes of the $n$th beat, and $a_{n}$ being a binary operator such that 0 indicates equal durations and 1 indicates a long/short relationship between the sub-beat durations of the respective beat. The reasons for focusing on the first two beats and on long/short relationships will be discussed in Sections 3.1 and 3.2.

These categories distinguish between rhythms based on these two features: the number of notes within a beat, which we will refer to as note density, and whether or not sub-beat durations were equal. These categories were designed to exhaust all combinations of note density, and sub-beat symmetry or asymmetry that are present in our corpus. For further analysis, we added a coarser categorization that indicates whether the number of notes from beat 1 to 2 was increasing (I), decreasing (D), or stable (S). In addition to this categorization based on rhythms, we added structural labels for ending measures (E) and repeated ending measures (RE), as it is common among performers to refer to phrase endings as relatively more straight or symmetric, a distinction that was supported by our preliminary analyses. Figure 2 shows examples of this categorization and labelling taken from our transcriptions.

3. Results

In the following, we present the results of our analysis aimed at predicting beat asymmetry from rhythmic patterns in our corpus. Section 3.1 presents general properties of the corpus, such as form structure, tempo, and the distribution of beat proportions (BP) for tunes and players. In
Table 2. Tune structure of the five tunes in our study.

| TUNE        | Measure sum |
|-------------|-------------|
|             | Pellar      | Lorik       | JamtOlle   | Bleckå      | Storpolska  |
| No. of measures | 8 (+1)     | 10 (+1)     | 4          | 8 (+1)     | 4          |
|              | 8 (+1)     | 10 (+1)     | 4 (+1)     | 8 (+1)     | 4 (+1)     |
|              | 10 (+1)    | 6           | 8          | 8           | 8          |
|              | 10 (+1)    | B1          | B1         | B2          | C1          |
|              | 8 (+1)     | B2          | B2         | B2          | C2          |
|              | 40         | 34          | 25         | 34          | 30         |

Note: Numbers in parentheses indicate added measures with the repeated ending gestures.

Section 3.2, we investigate how the observed large variance in first beat proportion (BP1) is distributed between the categorized rhythm figures, again comparing between player and tunes. This variance in beat asymmetry with rhythm categories is in line with previous work, and in Section 3.3, we explore how underlying variables could explain this variance, using linear regression and analysis of variance (ANOVA).

3.1. General corpus properties

The inspection of the repeat structure annotation (see Section 2.2.3) indicates that all tunes have been performed in the same general form by all players. Table 2 displays the form of each tune. These forms were similar to the polska form described in Section 2.1, although the number of measures in each section differs significantly between the tunes. Moreover, all tunes include a repeated ending, exemplified by measure 11 in Figure 1, where the final note of the previous phrase is repeated for one measure. This appeared in all players’ renditions, but with some variation between the tunes. The fact that tunes were played in similar forms by all players allowed for detailed comparisons between the different performances.

The mean tempo and tempo variability were derived from the annotated measure durations and are listed in Table 3. The low standard deviations reflect that the tempo was generally stable; it can be noted that the recordings with Gössa Anders are characterized by higher performance tempos (133–143 BPM) than recordings with the contemporary players (114–131 BPM). These tempo differences between archive recordings and contemporary playing can be compared with the considerably slower polska tempi in some other contemporary performance contexts.

Figure 3(a,b) depicts the distribution of beat proportions (BP) for each player and each tune respectively. These histograms illustrate a generally larger variance in the first (BP1) and second (BP2) beat, while the third beat is more even. Notably, for one player (P1), the distribution of BP1 and BP2 shows two separated peaks indicating a rendering of two beat categories by this player. Across the tunes, the distribution of BP1 and BP2 differs. For example, the tune Pellar contains a larger share of smaller BP1 values than the tune Blecko. This style of polska does

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4 Form differences were limited to the precise placement of reduced endings, the amount of voltas in some performances (2 or 3), and one player’s repetitions of main section C in Storpolska.

5 As an example of a slower tempo, the linked video show Orsapolska performed for dancing at a tempo of approximately 103–105 BPM in a contemporary setting (https://youtu.be/959uDWH05nI). Few filmed recordings show Gössa Anders playing for dancing, however, in a silent film from 1947 the tempo seems considerably higher: approximately at 135–140 BPM; and in a (sounding) film from 1962, the tempo is around 130 BPM (Norman et al. 2000, https://youtu.be/7rEvLOOVVs). These higher tempi correspond with sound recordings and tempo indications in historical transcriptions with Gössa Anders. The authors have first-hand experiences of the conflicting tempo preferences between some of these music and dance contexts.
indeed traditionally feature variability between the first and second beats while using a more stable third beat, something described in previous research on this repertoire (see Section 1). To the extent that they host a representative proportion of the metric/beat variability within this corpus, we focus our analysis on the distribution of first beat proportions (BP1) in our corpus. Figure 4 plots BP1 over the main sections of the tunes to show distinct contours of beat asymmetry. These distinct contours suggest that the different renditions of the tunes by the different performers follow similar patterns of beat asymmetry. Apart from the asymmetries that characterize a particular tune, Figure 4 also indicates in what part of tunes the variation was larger. In the following sections, we further investigate how such temporal progression of asymmetry relates to the rhythmic characteristics in the melodies.

3.2. Beat length analysis

The results in Section 3.1 illustrated variability between the first and second beat, whereas the third beat remains more stable. We now explore the distribution of first beat proportions (BP1) within the rhythm categories described in Section 2.3. Figure 5(a) displays mean BP1 with confidence intervals for these categories, while Figure 5(b,c) displays the data divided by individual
performers and tunes. Category labels follow conventions to show categories of note density and sub-beat note durations across the first two beats; letters denote categories not considered in this analysis, with “E,” “RE,” and “DS” denoting endings, repeated endings, and decreasing/stable note densities, respectively.

Among these categories, rhythms labelled $1^02^0$ corresponded to the lowest mean BP1 ($M = .23$, SD$ = .026$). When comparing BP1 between the categorized rhythms, the plotted means in Figure 5(a) suggest a relation between the number of notes and a shorter first beat: rhythms where the first beat contains one note correspond to a smaller BP1 value (These rhythms are those with “1” as their first value: $1^02^0$, $1^04^0$, $1^02^1$). In addition, relatively smaller BP1 values appeared for some rhythms with an increasing note density from the first to the second beat ($2^04^0$, $3^04^0$). Interestingly, for some rhythms with the same number of notes in each beat, as for instance $2^02^0$ and $2^12^0$, the means differed depending on if they were categorized with equal ($M = .27$, SD$ = .044$) or unequal (long-short) ($M = .30$, SD$ = .032$) sub-beat note durations. This could be explained by the rhythms with equal notes being variations of the $1^02^0$ rhythm, whereas unequal sub-beat durations establish a more symmetric flow of beats with the long-short structure implying a triple-like subdivision of the beat, exemplified by the rhythm “k” in Figure 2.

Comparing rhythms between the players, the individual plots in Figure 5(b) reveal some interesting variations. For Player 1, the distinct peaks of beat proportions appearing in Figure 3(a) are reflected in the grouping of BP1 values for rhythm categories, while for other players the mean BP1 of these rhythm categories spread out more. In line with the common conception among performers, ending measures (E) show close to isochronous BP1 values. However, the repeated endings (RE) were shorter ($M = .28$, SD$ = .037$) than ending measures ($M = .33$, SD$ = .031$), for all players. These comparisons show that, albeit with some individual differences, the overall mean effects of the rhythm categories on the proportion of the first beat apply for all players.

Comparing between the tunes, Figure 5(c) illustrates that the amount of beat asymmetry illustrated in Figure 3(b) corresponds to the presence or absence of particular rhythms in the different melodies. For instance, the tune Blecko displays only one of the rhythm categories corresponding to a larger beat asymmetry, while Pellar contains several of these rhythms. These findings taken together suggest that a large part of the beat proportion variation in this material is inherent to the observed connection between asymmetric metre and the structuring of rhythm figures expressed in the melody. In the next section, we present the results of variables that were measured across all performances, in order to further explore these dependencies between the different tunes.

### Modelling first beat proportions

Our analysis in this section explores to what extent underpinning parameters of the rhythm categories predict the asymmetric beat variance related to rhythm figures. These parameters include three sets of variables: (1) the note density of each of the first two beats (NDB1 and NDB2); (2) the difference between sub-beat note durations on each beat (also with one variable for each beat,
SB1 and SB2, parameterized as either equal or unequal); and (3) the change in note density from beat 1 to 2 (NDC, parameterized as either increasing, decreasing, or stable). In order to include variance related to tempo or rubato, we introduced one variable (T) for the mean tempo of each performance (BPM values in Table 3), and one (Tdev) for each measure’s deviation in percent to the mean tempo of that performance. To see how these variables interact with the rhythmic profiles present in these tunes, Table 4 shows the correlations between all of these variables and the beat proportions (BP1, BP2, BP3).

Using linear regression in our analysis requires that we assess the inter-dependencies between our predicting variables. To start with, the beat proportions are by definition interdependent, with the strong correlation between BP1 and BP2 having motivated the focus on beat one in our analysis. Secondly, the variables NDB1 and NDB2 both highly correlate with both BP1 and BP2. This seems to suggest dependency, as a result of the number of notes being divided between the first and second beat depending on the interrelated beat proportions. However, the

Figure 5. Mean first beat proportions (BP1) for each rhythmic category with 95% confidence bars. Solid horizontal lines represent the proportion of an isochronous beat, and dashed lines denote the mean BP1 of that sample selection. (a) Mean overall performers and tunes, (b) individual performers, and (c) individual tunes.
an interaction between NDC and tunes (and decreasing between the increasing category (change of note density in beats one and two (NDC) as co-variate within a repeated measurements ANOVA. We found an effect on BP1 by the us of both models. Table 5 shows the outcome of these two separate linear regressions. With the NDB1 and NDB2 models, BP1 increases by 1.7 for each rising number of notes in the first beat and decreases by 1.1 for each rising number of notes in the second beat. For both NDB1 and NDB2, the number of notes ranges from 1 to 4 creating a maximum effect size multiplied by 3, i.e. −5.1 for NDB1 and 3.3 for NDB2. In comparison, with NDC as the predicting variable, BP1 decreases by 3 for each step. The maximum effect of the two steps in the NDC categories, from decreasing, via stable to increasing, amounts to 6. This equals 72% of the mean duration of a 16th note in $\frac{3}{4}$ notation. Comparing the mean BP1 of the three NDC categories, the larger difference appears between the increasing category ($M = .26, SD = 0.040$), and the stable ($M = .31, SD = .040$) and decreasing ($M = .32, SD = .036$) categories. This suggests that an increasing number of notes between beat one and two predict a larger part of the change in beat asymmetry within this variable. When comparing the two regression models, we find that the effect sizes interpreted from b-coefficients are not far apart. However, the NDC model appears parsimonious, accommodating a larger part of the variance (in terms of $R^2$ values) within just one single variable. Furthermore, the results of both models illustrate that the effects of tempo and tempo deviation are of a small magnitude compared to the rhythm parameters.

Unlike the rhythm categories, the NDC predictor appears in all performances, which allowed us to compare mean BP1 for each level of NDC with tunes as between-subjects factor and players as co-variate within a repeated measurements ANOVA. We found an effect on BP1 by the change of note density in beats one and two (NDC) ($F(2, 28) = 16.79, p < .000$). There was also an interaction between NDC and tunes ($F(8, 28) = 2.67, p = .026$). Comparing the means

Weak correlation between NDB1 and NDB2 indicates that the variables are in effect independent, which can be explained by the different rhythms including various combinations of short and long notes within each beat. Variables defined by sub-beat duration proportion (SB1, SB2) by definition only apply when beats contain more than one note, and in our material, this parameter is only applied at the level of two notes per beat. Thus, SB1 and SB2 cannot be regarded as independent from any of the note density variables, although Figure 5(a) shows examples of rhythm categories with different means for equal and unequal SB. Finally, the variable NDC is defined by, and thus dependent on, the combination of note density in beat one and two (NDB1 and NDB2), which is reflected in the high correlations between these two types of parameter. The variables for tempo and tempo deviation were expected to be independent to all other variables.

Table 4. Spearman’s correlation coefficients between beat proportions, tempo variables, and the variables underpinning the rhythm categorizations.

| Variable | BP1  | BP2  | BP3  | NDB1 | NDB2 | SB1  | SB2  | NDC  | T    | Tdev |
|----------|------|------|------|------|------|------|------|------|------|------|
| BP1      | −.882** | −.320** | .446** | −.411** | .250** | −.116** | −.574** | −.176** | .273** |
| BP2      | −.134** | −.429** | .409** | −.254** | .161** | .543** | .208** | −.260** |
| BP3      | −.320** | −.134** | −.078** | .049 | −.034 | −.088** | .116** | −.029 | −.058* |
| NDB1     | .446** | −.429** | −.078** | −.138** | .164** | −.152** | −.677** | −.101** | −.039 |
| NDB2     | −.411** | .409** | .049 | −.138** | .106** | .165** | .717** | −.016 | −.314** |
| SB1      | .250** | −.254** | −.034 | .164** | .106** | .195** | −.041 | −.090** | .058* |
| SB2      | −.116** | .161** | −.088** | −.152** | .165** | .195** | .178** | .030 | .027 |
| NDC      | −.574** | .543** | .116** | −.677** | .717** | −.041 | .178** | .088** | −.171** |
| T        | −.176* | .208** | −.029 | −.101** | −.016 | −.090** | .030 | .088** | −.005 |
| Tdev     | .273** | −.260** | −.058* | −.039 | −.314** | .058* | .027 | −.171** | .005 |

*N = 1409

| Correlation is significant at the 0.05 level (2-tailed). |
| Correlation is significant at the 0.01 level (2-tailed). |

$^{*}$ Correlation is significant at the 0.05 level (2-tailed).

$^{**}$ Correlation is significant at the 0.01 level (2-tailed).
between tunes reveals that with increasing levels, BP1 remains much shorter than with stable or decreasing levels, but this difference varies between tunes, as illustrated in Figure 6. No co-variance with player was found ($F(2, 28) = 0.06, p = .94$).

Summarizing the results of exploring rhythm patterns and first beat proportions, Figure 6 depicts mean BP1 for all parameters we have included in our analysis: rhythm categories, note density, and note density change per tune. This figure provides, first, an overview of the distribution of beat proportions in our corpus and, second, aims to facilitate a comparison between the asymmetry related to the explored three parameters. A complete reference to the distribution and mean BP1-values of all these parameter variables across tunes is supplied in Appendix 3. For all these variables, the observed difference in first beat proportions constitutes a third of an isochronous beat. However, as a general parameter for characterizing rhythm patterns, the change in note density between beats one and two (NDC) appears as the single predictor that can accommodate a large part of the variance.

4. Discussion

This study analysed beat asymmetry in a corpus of polska performances in a local Swedish style. This exploration has been facilitated by a novel combination of manual beat annotation and automatic staff notation and has explored predicting the variance in beat proportion from rhythmic features of the tunes by means of regression analysis and a repeated measurements ANOVA.

Our study compared rhythm categories characterized by variables for note density (ND), note density change (NDC) and sub-beat note durations (SB). In line with previous observations (Ahlbäck 2003), our results have confirmed that the amount of beat asymmetry corresponds with the type of rhythm figures found in the tunes and that asymmetry to some degree corresponds with the number of notes in a melody. The present study goes beyond these findings by showing that a considerable amount of the variance in beat asymmetry can be predicted by one single variable – the compared note density (NDC) of the first and second beat, a variable that shows whether the note density between these two beats increases, decreases, or remains stable.

Table 5. Linear models of predictors of the proportion of beat 1 (BP1).

|            | B     | SE B  | Beta  | p     | $R^2$ Change |
|------------|-------|-------|-------|-------|--------------|
| (a) NDB1 and NDB2 predicting BP1 |       |       |       |       |              |
| Constant   | 0.212 | (0.155, 0.270) | 0.029 | 0.000 |              |
| NDB1       | 0.017 | (0.015, 0.020) | 0.001 | 0.364 | 0.000        |
| NDB2       | −0.011| (−0.013, −0.009) | 0.001 | −0.266 | 0.000        |
| T          | −0.001| (−0.001, −0.001) | 0.000 | −0.168 | 0.000        |
| Tdev       | 0.002 | (0.002, 0.002) | 0.000 | 0.199  | 0.000        |
| $R^2 = .34$, ($p < .001$) |       |       |       |       |              |
| (b) NDC predicting BP1 |       |       |       |       |              |
| Constant   | 0.290 | (0.237, 0.342) | 0.027 | 0.000 |              |
| NDC        | −0.030| (−0.032, −0.028) | 0.001 | −0.520 | 0.000        |
| T          | −0.001| (−0.001, −0.001) | 0.000 | −0.155 | 0.000        |
| Tdev       | 0.002 | (0.001, 0.002) | 0.000 | 0.186  | 0.000        |
| $R^2 = .37$, ($p < .001$) |       |       |       |       |              |

Notes: Model (a) with note density (NDB1 and NDB2), Tempo (T), and tempo deviation (Tdev), and (b) with compared note density (NDC), Tempo (T), and tempo deviation (Tdev) as predictors. 95% bias corrected and accelerated confidence intervals reported in parentheses. Confidence intervals and standard errors based on 1000 bootstrap samples. In both tables, the full models are described by $B$, SE B, Beta, and p, while $R^2$ change reflects the increase in proportion of variance predicted for each introduced parameter.
Figure 6. First beat proportion with 95% confidence intervals with three parameters: rhythm category, note density and note density change. The triple quaver at the selected proportion ($0.22 < x < 0.33$) of the measure duration illustrates that this equals an isochronous beat divided by three.

However, the NDC variable displayed in Figure 6 does not capture all the variation. For instance, *Blecko* and *Storpolska* have rhythm categories with a very short first beat. Thus, it appears that all performances include expressive variations with an asymmetric beat, and not all variations can be predicted by note density parameters.

Beat asymmetry patterns are relatively consistent between repeated sections and across versions of the different performers, a relationship shown by the annotated repeated structure illustrated in Figure 4. This extends the description by Johansson (2017b) of replicated beat duration patterns in one single polska performance to a group of individuals performing five
tunes. Notably, these performers included contemporary players and a historical player, with the former all being influenced by the latter. The historical player can therefore be considered as a common source of influence for the other players. Some differences were revealed between players’ performances by comparing the general distribution of beat lengths, and the grouping of first beat asymmetry by rhythm category. In particular, for Player 1 a clearer distinction appeared between short and isochronous first beats than for the other players.

The relation between melodic rhythm and asymmetric metre is be exemplified by two contrasting tunes in our material: *Pellar* and *Blecko*. In order to illustrate some of the performer-related variance, we show both tunes in versions by two players in Figures 7 and 8. Figure 7 shows notations of *Pellar* in versions by Gössa and Player 1 – with the plotted first beat proportions including section repetitions. Figure 8 does the same for the tune *Blecko*.

Figure 7 illustrates that the first section in the tune *Pellar* begins with two measures (A1 and A2) with rhythms corresponding with short first beat asymmetry: a single note in the first beat (low ND) and an increasing number of notes from beat one and two (NDC). These measures are followed by measures (A3 and A4) with a stable (2:2) and then a decreasing (4:2) NDC. This pattern is repeated for measures A5 to A8. For player 1, the BP1 curve follows the expected outcome of these predictive variables in this section, while for Gössa this tendency is less pronounced.

The tune *Blecko* (Figure 8) generally has less asymmetric measures than *Pellar*. This is in accordance with most rhythms in this tune showing higher first beat ND and decreasing or stable NDC. Comparing more detailed variations reveals more of these correspondences between BP1
and rhythm variables: in Blecko, measure A5, different first beat ND corresponds with different BP1. In Pellar, measures B4 and B8 for Player 1 reveal a similar correspondence between BP1 and first beat sub-beat durations (SB).

Contrasting examples also exist: in Pellar, measure B2, the rhythm does not fit the expected outcome of the underpinning variables. It has a large ND in beat one and a decreasing NDC yet it retains the short first beat asymmetry of the previous measure. One explanation is that the same level of asymmetry might be kept for several measures, regardless of the rhythm of the melody, by some law of similarity or reflecting some sort of higher segment hierarchy for beat asymmetry. However, this does not hold for other tunes, such as Lorik, where the asymmetry in the first section is fluctuating for each measure (see Figure 4). Alternatively, we can assume that the rhythmic figure in Pellar:B2 is a variant of the previous measure’s rhythm, with the single note of the first beat being subdivided into three fast notes. This assumption suggests that we can draw conclusions for interpreting rhythmic figures based on the metric asymmetry, as a reversed model of our exploration.

In line with previous observations (Ahlbäck 2003; Johansson 2017a; Kvifte 1999), we can argue that the temporal succession of asymmetric beats should be considered an intrinsic component of the melodic shape of these tunes. Expressing precise beat asymmetry in staff notation is a challenge, in particular when the proportion of beats, as well as the subdivision of notes within beats, does not appear to be regulated by consistent sub-pulse units – what Kvifte (2007) refers
to as the absence of a common fast pulse. Our results are in line with Kvifte’s observations; however, where Kvifte relates the timing of asymmetric beats to the regularity of dance movements, our study demonstrates how beat asymmetry corresponds with variability in rhythm figures. (Of course, these interpretations are not mutually exclusive!)

In our view, this correspondence supports the use of compound metres, such as 2+4+3/16. Although it does not reflect all variations within beat proportions, it facilitates notating rhythms more precisely within alternative metric groupings of 2+4+3 and 3+3+3, which can point towards the relation between rhythm figures and beat asymmetry in this type of music. The kind of representations exemplified by Figures 4, 7, and 8 have potential for complementing such notations by providing a more detailed level of asymmetric beat adaptations.

5. Conclusions

The precise and delicate articulation of rhythmic gesture and metrical flow is central to many oral music traditions; our findings illustrate such expressive variation in a local Swedish folk music style. The study has explored the relation between rhythmic patterns and asymmetric beat in polska, finding significant correlations between rhythmic structures and variations in beat proportions. These results are valuable for further explorations of these performance practices in various contexts, i.e. in connection with dancing (Misgeld and Holzapfel 2018) and playing for dancing (Misgeld, Holzapfel, and Ahlbäck 2019), or with the typical practice of improvised second parts accompaniment.

Our study focused on five pieces played by four musicians in an oral tradition. These performances represent snapshots of the performance practice of these players which may have differed depending for instance on whether players were playing for dancing. Whether the spotted differences in the precise rendering of beat lengths between the individual performers relate to personal conceptualization of performance strategies, or if they are shaped by certain pedagogical or artistic contexts, remains an open question beyond the scope of this article. Further studies could benefit from including more qualitative data on players’ views on performance strategies. However, exploring the effects of these rhythmic parameters on beat asymmetry invites further comparisons with related polska styles. To this end, the establishment of a methodology with the help of automatic notation can facilitate extended explorations into related performance corpora.

The present study carries the limitation that we focused our analysis on the first beat of each measure. Relevant factors relating to alternative metrical cycles may have been overlooked. For instance, we have not explored the possible regulation of the temporal succession of beat proportions by some segmentation above measure-level. Also, as we based our study on duration data, we ignored any possible relations between metric structure and note articulations – such as bowing patterns (Kvífte 1987; Blom 2006) and dynamic envelope articulation (Ahlbäck 2003). The development of automatic notation accounting for these factors would allow for interesting future explorations within the methodological scope of the present study.

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Appendices

Appendix 1. Recordings and historic notations

Recordings by Gössa Anders Andersson with corresponding notations in *Svenska Låtar Dalarna* (SvL Dal; Andersson 1922).

- **Polska after Pellar Anna**, also known as **Polska efter Bränd Jon** (1846–1918), (SvL Dal, no 101). Recorded in Orsa, 17th March 1949, by Mats Arnberg, Swedish Radio.
- **Polska after Lorns Ander Ersson** (1846–?), (SvL Dal, no 133). Recorded in Stockholm, 6th June 1950, by Mats Arnberg, Swedish Radio.
- **Polska after Jämt Olof Ersson** (1872–1938), (SvL Dal, no 125). Recorded in Orsa, 1st March 1959, by Mats Arnberg, Swedish Radio.
- **Polska after Blecko Anders Andersson** (1831–1922). Recorded in Orsa, 1st March 1959, by Mats Arnberg, Swedish Radio.
- **Storpolskan after Blecko Anders Andersson**, (SvL Dal, no 132). Recorded in Orsa, 17th March 1949, by Mats Arnberg, Swedish Radio.

Recordings with Sven Ahlbäck, Eliika Frisell and Olof Misgeld were made in Stockholm, February 2018 (*Pellar and Lorik*), and January 2020 (*JamtOlle, Blecko, and Storpolska*) by the authors.
Appendix 2. Additional transcriptions

Figure A1. *Polska efter JämtOlle*, first volta, played by Gössa Anders Andersson, transcription by the first author.
Appendix 3. Mean BPI and distribution of predictors

Figure A2. *Storpolskan efter Bleckå*, first volta, played by Gössa Anders Andersson, transcription by the first author.
Distribution of mean BP1 with rhythm predictors across tunes.

| Rhythm Category | Pellar | Lorik | Jamb/Olle | Blecko | Storpska | All tunes |
|-----------------|--------|--------|-----------|--------|----------|-----------|
|                 | Mean  | Mean  | Mean      | Mean   | Mean     | Mean      |
|                 | Confidence Interval | Lower (5%) | Upper (95%) | Lower (5%) | Upper (95%) | Lower (5%) | Upper (95%) | Lower (5%) | Upper (95%) | Lower (5%) | Upper (95%) | Lower (5%) | Upper (95%) | Lower (5%) | Upper (95%) |
| 1/8th           | 0.23   | 0.22  | 0.24      | 0.22   | 0.24     | 0.22      |
|                 | 0.24   | 0.23  | 0.25      | 0.26   | 0.24     | 0.27      |
|                 | 0.23   | 0.22  | 0.23      | 0.25   | 0.26     | 0.25      |
|                 | 0      | 0     | 0.29      | 0.27   | 0.31     | 0.29      |
|                 | 0.30   | 0.28  | 0.31      | 0.30   | 0.29     | 0.31      |
|                 | 0.31   | 0.30  | 0.33      | 0.29   | 0.31     | 0.31      |
|                 | 0.24   | 0.23  | 0.26      | 0.29   | 0.28     | 0.30      |
|                 | 0.31   | 0.30  | 0.32      | 0.25   | 0.31     | 0.32      |
|                 | 0.29   | 0.29  | 0.30      | 0.30   | 0.31     | 0.31      |
|                 | 0.27   | 0.25  | 0.28      | 0.29   | 0.30     | 0.30      |
|                 | 0.31   | 0.30  | 0.32      | 0.32   | 0.32     | 0.32      |
|                 | 0.24   | 0.24  | 0.25      | 0.27   | 0.26     | 0.25      |
|                 | 0.28   | 0.27  | 0.30      | 0.31   | 0.31     | 0.33      |
|                 | 0.30   | 0.29  | 0.31      | 0.31   | 0.31     | 0.32      |
|                 | 0.32   | 0.31  | 0.33      | 0.32   | 0.32     | 0.33      |
|                 | 0.33   | 0.32  | 0.33      | 0.33   | 0.33     | 0.33      |
|                 | 0.35   | 0.35  | 0.36      | 0.36   | 0.36     | 0.36      |
|                 | 0.36   | 0.36  | 0.36      | 0.37   | 0.37     | 0.37      |
|                 | 0.37   | 0.37  | 0.37      | 0.38   | 0.38     | 0.38      |

Figure A3. Table of mean BP1 for all tunes and variables.