Measuring Rhythm: A Context-Sensitive Approach

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Introduction

[1] In this article I present some considerations on the measuring of musical rhythm with earlier research on rhythm and timing in Scandinavian traditional fiddle music as a point of reference (Ahlbäck, 1995; Bengtsson. 1974; Blom, 1981, 1993; Johansson, 2010a, 2010b, 2015; Kvifte, 1999, 2004; Waadeland,2000). The styles of music in question are called *pols*, *springar* or *polska* and often share the feature of being rhythmically irregular with beats of different (asymmetrical triple meter with long-average-short or short-long-average beat cycles) and varying duration.[1] In addition, the fiddle (here also including the Norwegian Hardanger fiddle) produces sound images which are particularly challenging to account for in terms of rhythmic onsets or attack points. These features provide an interesting point of departure for discussing the merits of different approaches to measuring rhythm, here understood as the systematic determination of the duration

1. I encourage the reader to consult audio and video clips featuring pols/springar playing and dancing:
   Tele-springar (long-average-short): https://www.youtube.com/watch?v=BWXg8G98guI
   Valdres-springar (short-long-average): https://www.youtube.com/watch?v=4rEQ3-Fv5eU
   Finnskogs-pols (long-average-short): https://www.youtube.com/watch?v=ol8BeSaCUv4
   Jössehärads-polska (short-long-average): https://www.youtube.com/watch?v=OaKA7VsMAOE

of rhythmic units (measures, beats and individual notes/tones/sounds). Such determination equals the identification of attacks/onsets and the subsequent measurement of inter-onset intervals (IOIs) (Danielson, 2010). It is important to note that IOIs represent but one out of several aspects, or outputs, of timing behavior (see below), which implies that possibilities for generalization should be defined accordingly.

[2] The outline of the article is as follows: Following this introduction, which provides some methodological considerations and broader framing of the subject matter, I discuss how a relevant degree of measurement precision is dependent on a range of contextual factors. I then proceed to present a series of concrete examples of analytical procedures and considerations. Of particular significance in this context is how idiomatic features of style and instrument inform and constrain the determination of rhythmic onsets. Further considerations include the relationship between physical onsets and experienced rhythmic onsets. Finally, I discuss the need for comprehensive contextualization of measurement data, arguing for the necessity of having a thorough knowledge of the musical style in question, including its particular regime of knowledge and modes of learning and interaction. This pertains to the perceptual and conceptual coding of rhythmic information and, in turn, to the qualitative implications of analytical results. More precisely, whether and how measured durational values bear upon the experience and meaning of rhythmic qualities and relationships is shown to be dependent on a variety of perceptual and attentional factors. At the same time, I argue that timing data, when consistently retrieved, may serve as a baseline for the further analysis and assessment of rhythmic behavior, which in turn emerges as a multidimensional phenomenon.

[3] Initially, I want to call attention to the fact that much of the work conducted within this area is made possible by technological developments throughout recent history. The most important step has perhaps been the possibility to record and repeatedly play back performances. With a recorded version at hand, rhythmic features of a particular performance can be studied in detail with a number of different methods and approaches. Moreover, given the possibility of speed reduction, which has been around at least since the disc phonographs of the early 20th century, it is in principle possible to perform analyses of very high resolution. Recently, software

features like visualization (waveforms, spectrograms etc.), sound processing, zooming and easy editing (cutting and pasting etc.) have eased the manual investigation of micro-rhythmic events and increased precision and resolution even further. In addition, much analytical work on musical rhythm and timing has been conducted by means of devices which facilitate the automatic detection of onsets. In particular, we need to consider the possibility of analogue registration of sound sequences facilitated by devices such as *the Seeger melograph* (see Moore, 1974). Further developments include modern digital software with so-called beat tracking features (see Goto, 2001). Finally, a range of methods involving some kind of translation between digital formats are facilitated by software capable of producing a loudness graph. For instance, as explained by Clayton et al. (2004), audio files can be re-sampled and loaded into an editor program where relevant events can be labeled. The reason I do not feel obliged to go any deeper into the subtleties of these approaches, or the continuously improved technological devices facilitating them, is that I do not find these details relevant in this particular context. As will be evident from the discussion of analytical procedures, although measurements are performed with the aid of sound editing software, the ears of the analyst are inevitable when it comes to deciding between several *possible* temporal positions of rhythmic events.

[4] The way in which analytical problems and challenges are identified, presented and dealt with here is thought to coincide to some degree with challenges facing musicians in certain practical musical situations. In short, I am attempting to have a "musical approach", or at least an approach which finds some equivalence in real musical interactions, in which performance decisions may parallel the processes of defining analytical units and choosing between possible interpretations of attack points. This is done by imagining myself in the position of a co-performer, thereby addressing ensemble-playing as a hypothetical interpretive framework. In addition, there is an introspective element to the analytical procedure in that I consult my own experiences of learning and performing the particular repertoire in question. I am not suggesting, however, that the process of analysis is equivalent to actually performing music. As mentioned initially, the output data represent information on inter-onset intervals (IOIs) only, and without

style-sensitive interpretations this information may tell us little or nothing about the constraints and potentials of this performance tradition. First of all, IOIs are certainly not the only important rhythmic information in a performance.[2] For instance, what happens in between onsets is particularly relevant in fiddle music, since the bow allows for a wide repertoire of expressive means in addition to the feature of changing direction. Furthermore, *how* the onset is articulated may be at least as important to our experience of rhythm and timing as exactly *where* it is considered to be located. Finally, and most importantly, the ever-present interaction of musical parameters (time, melody, timbre, intensity) and levels (local events – longer motifs and phrases) makes it highly doubtful to draw general conclusions concerning style, expressivity and temporality in musical performance on the basis of attack-point timing data alone. However, measurements may be understood as facilitating the identification of *patterns of possibilities* where different parameters are shown to interact, as much as statistical predictions concerning the behavior of individual parameters.

[5] In the analytical work referenced in the subsequent discussion I have mainly used standard sound-editing and processing software as working tools, some functions and features of which are particularly suited to the analysis of rhythmic onsets. The sound may be displayed as a waveform or a spectrogram, which in addition to a number of software features, makes the editing easy to handle. It is a straightforward operation to zoom in on a preferred resolution in the visual representation of the sound, and it is possible to filter and resample sounds, features which have proven valuable in certain situations.

2. This is convincingly argued by Waadeland (2000): "…a description of rhythmic performances which only takes the attack points and durations into account, is fundamentally based on information of *discrete points on a one-dimensional axis*. The very phenomenon under consideration – the rhythmic performance of music – is, however, created through an interaction between the musician and his instrument, expressed as *continuous* movements in time and space. The musical performance as such is thus basically a *continuous, multi-dimensional phenomenon*." (Waadeland, 2000: 115)

A musically and analytically relevant degree of measurement precision

[6] A question often actualized is whether the possibilities for scrutinizing musical sound using technology have any musical significance in terms of the level of detail facilitated. To begin with, an analytically relevant, or obtainable, degree of resolution and precision needs to be determined. Moreover, the significance of the position from which the succession of rhythmic events is experienced becomes evident. Ideally, there should be a correspondence between how rhythm is produced and experienced within a context of music-making (including normal, attentive listening) and how rhythm is measured within a context of scientific analysis. However, a sufficient degree of precision is difficult to determine, as it does not remain constant between different contexts and positions of observation. Moreover, as will be argued below, a reasonable degree of precision accounting for the relationship between noticeable (in the sense of identifiable) and musically significant differences cannot be generalized.

[7] First, there is the analyst position aided by different software facilities, where the time discrimination task may be, for instance, to identify whether a playback starting point is too early in relation to a perceived attack point in the sound.[3] A related analytical task would be to compare simultaneously occurring rhythmic sequences and thereby determine whether there are temporal discrepancies between the events unfolding. A normal music-making situation in which a related process of discrimination might be relevant is when two performers play a melody in unison. Here, the experience of a co-performer might be similar to the listener's in the experimental situation in terms of making comparative judgments on the basis of experienced synchrony/asynchrony. However, when it comes to the order of perceived onsets, cognitive constraints affect the conditions for such an operation, conditions within which musicians may take action to improve synchrony. Pöppel (1997) writes:

3. Cf. e.g. Kvifte's (1999) method of measurement.

> If the temporal order of two stimuli has to be indicated, independent of sensory modality, a threshold of 30 ms is observed. Data picked up within 30 ms are treated as co-temporal, that is, a relationship between separate stimuli with respect to the before-after dimension cannot be established (Pöppel 1997: 57).

[8] This does not mean that a 30 ms deviation between players is not perceived as asynchrony, but we cannot hear which one of the two attacks comes first. However, the limit at which we can no longer perceive any kind of distortion in the sound which might be caused by timing deviations, i.e. the limit between perfect synchrony and not completely perfect synchrony, is probably impossible to determine in acoustic musical performance. Furthermore, the 30 ms threshold does not mean that synchronization cannot be improved beyond this limit. Anticipatory action might play a significant role here, as it operates on a pattern recognition level rather than by comparing and adjusting attack points in real time.[4] Thus, analytical precision should not be decreased with reference to this generalized temporal order tolerance.

[9] Second, compared to the situations discussed above, perceiving the difference between two succeeding versions of a rhythmic pattern where one contains a small extension of a certain sound event (a more realistic listener position) is a completely different matter. Of particular interest is the finding that the possibility of detecting such timing discrepancies is highly dependent on the basic temporal organization of the sequences compared. In this connection, Clarke (1989) has presented an observation study in which the ability of listeners to detect small-scale timing changes in various kinds of musical sequences is investigated. The experiments were carried out by first presenting neutral melodies to the subjects (eight music students) and then altering them by introducing an additional lengthening of one of the tones. In the first experiment, metronomic melodies with a constant note duration of 400 ms were used as references, and subjects were told to indicate for each version presented whether the melody was metronomic or altered. The results show that the subjects were able to perceive as little as 20 ms lengthening in this context. The results of a slightly dif-

4. See Clayton et al. (2004: 40-41) who discuss this in relation to the concept of entrainment.

ferently designed experiment, however, did not demonstrate such a low tolerance for temporal deviations. Here, a rubato pattern was added to the neutral melodies "in order to make them sound more or less as they would if played by a pianist, whilst the altered sequences contained further timing changes in addition to the "timing curve of the neutral sequences" (Clarke 1989, 6). In this case, the amount of alteration needed to be 50 ms to approach the test values obtained with only a 20 ms alteration in the metronomic context. The observation that timing changes seem more difficult to pick up on in a rubato context is highly important for understanding the mechanisms by which temporal relationships in performed (i.e. non-metronomic) music are made sense of, and Clarke's own interpretation is worth quoting at length:

> This is probably the result of two factors: first, the intrinsic difficulty of picking up a small timing change in a sequence that is already temporally shaped by note-to-note durational variations of the same order of magnitude as the target changes; and second, the different quality of the neutral sequences in this experiment compared with the metronomic sequences of the first. Metronomic sequences have a perceptual quality (uninterrupted isochrony) that sets them apart from detectably altered sequences in something like a categorical fashion, whilst the neutral sequences in this second experiment are not distinguished from their altered counterparts in any similar categorical fashion (Clarke 1989: 7).

[10] Using metronomic melodies as references thus allows for a categorical determination of whether expressive timing is present or not, while the rubato melodies, already added expressive deviations, instead specify references for the identification of the degree of alteration. Given that the criterion that the rubato sequences should sound "more or less as they would if played by a pianist" is not precisely defined in terms of exact temporal values, these are completely different operations. The reason for this is that a variety of temporal patterns could meet such a "sounding natural" criterion, while this is not the case with the metronomic (artificial) versions.

There is, quite simply, no variety of different metronomic rhythms, although there is a tolerance in terms of the detectability of small deviations.

[11] Within the context of the asymmetrical styles of pols/springar playing, the categorical distinction between metronomic and non-metronomic rhythms seems experientially irrelevant, as performed rhythms generally deviate from metronomic regularity far more than the 20 ms limit for detectability (Johansson 2010a; Kvifte 1999).[5] At the same time, timing differences are important and presumably so is their detectability. However, temporal values might form patterns which are intuitively recognized as more or less correct or preferable when different versions are compared, while the manipulation range (tolerance) of single values cannot be exactly pinpointed. Moreover, one might not even be able to determine which one of several units has been shortened or lengthened, while still being able to detect important differences between the versions compared. This concerns the general fact that differences might be perceived as musically significant without the test subject (or anyone else) being able to determine exactly *what* the differences are. Clarke (1987) is aware of this problem in his discussion of categorical rhythm perception, where expressive information is defined as the durational information left over following categorization:

> It is perceived by listeners as qualitatively different from the temporal information that specifies rhythmic structure, and is easily confused with other parameters of expression, such as dynamic intensity. Similarly it is usually very hard for listeners to specify precisely *how* expressive timing has been used in a performance (whether particular durations have been lengthened or shortened) (Clarke 1987: 30–31).

[12] Moreover, the explicit or implicit assumption that listeners detect timing differences between alternative, slightly altered sequences by estimating the *duration* of individual events might be questionable. As Clarke (1989)

5. It should also be added that the metronomic/rubato distinction may have a completely different meaning within the context of pols/springar grooves than within a stylistic context in which rubato (in the sense of gradual tempo changes) forms a part of the musician's expressive repertoire (cf. the Classical/Romantic piano tradition). A pols/springar performance is, although certainly non-metronomic, characterized by a constant, danceable tempo.

writes in connection with the observation study previously referred to, a number of the subjects who were to determine a distinction between metronomic and non-metronomic melodies reported that the latter were identified as having a discontinuity in the temporal flow of the music:

> They were perceived, in other words, as being *qualitatively* distinct from the metronomic melodies and as being differentiated from them by the property of temporal flow. This suggests that while experimental materials and performance-data measurements may be expressed in terms of duration, it may be more perceptually realistic to think in terms of temporal flow or of rate detection (Clarke 1989: 8).

[13] To this methodological commentary I would like to add the empirical claim that evaluating temporal aspects of performed music is about getting a feeling of whether the music flows in the right way, rather than judging whether single note durations are too short or too long. Regarding the pols/springar style it should also be added that the references that might be used to evaluate temporal relationships seem to be very hard to define, as patterns of durations are constantly changing. This would seem to indicate that the reference in relation to which tone lengthening or shortening is perceived changes from one local melodic-rhythmic context to the next. Moreover, a lengthening of a particular tone in a motif might actually transform the very reference through which its durational quality is evaluated by affecting the contour of the rhythmic pattern as a whole. In such a case, tones other than the altered one might as well be perceived as too long or too short according to the new context established.

[14] In addition to the problems related to identifying temporal deviations associated with the continuously varying duration of events (tones, beats and measures), it should be noted that the acoustic reality of fiddle and Hardanger fiddle music is enormously complex compared to the "neutral" sounds with very short attack times used in controlled time discrimination experiments: the timbre of the sound produced changes continuously by the instrument resonating differently on every tone (finger); glissandos, grace notes and the legato vs. staccato variation in articulation make up a heterogeneous range of physical onsets with highly varying attack

times; the attack of the two tones in double stops are often asynchronous etc. Accordingly, determining the precise point in time when a rhythmic event "actually" starts is far from straightforward, even with the aid of sophisticated analytical tools (see the section on idiomatic features of style and instrument below).

[15] In sum, both these aspects of performance style (event duration diversity and onset ambiguity) would indicate a very high tolerance for detectable temporal variations between succeeding sequences. Thus, the results (20 ms tolerance) experimentally obtained under ideal circumstances (metronomic vs. non-metronomic simple melodies) cannot possibly be acquired within the context of the asymmetrical styles of pols/springar playing. This obviously calls into question the presentation of measured differences below the 20 ms limit. However, high measurement precision and resolution are not to be confused with the precision with which listeners and performers estimate and adjust the duration of individual events. On the other hand, very small temporal nuances are considered important to the quality of melodic-rhythmic flow, without necessarily being detectable as durational variations. Furthermore, as discussed above, perception precision may vary greatly according to rhythmic context, event density, onset quality etc. It is also believed that an improved skill and greater attentiveness among musicians, listeners and dancers may imply an increase in temporal resolution and precision, and that the limit for such an improvement cannot be determined according to some general principle.

[16] Related to this is also the issue of production precision vs. perception precision. That is, analytical precision should ideally not only account for a kind of imaginary listening position (the listener, dancer or coperformer), but also for the precision with which a skilled performer operates to produce and replicate rhythmic patterns. One aspect of this issue is that performance precision has been shown to vary according to factors such as melodic-rhythmic density ( vs.  etc.) and beat motif architecture ( vs.  etc.). This also appears to concern the relation between stable and flexible levels of rhythmic performance, in which the distinctive durational properties of different types of events (more stable or less stable) may not be detectable from the position of an observer, but may still be important for the performer's controlling of tempo and timing (Jo-

hansson 2010a). To explore these intriguing micro-rhythmic relationships, highly detailed measurements are required. All in all, this suggests that measurement precision needs to be greater than any experimentally determined or generalized perceptual precision. In other terms, precision needs to be as high as possible, given the limitations of the suggested manual approach.

Measuring rhythm – practical constraints and stylistic sensibility

[17] In the present context, measurements are thought to provide a set of manageable data in the form of durations of rhythmic units (beats and measures) that may merit further analysis and interpretation. This is achieved by means of a process of estimating and marking the points in the sound-graph where the unit concerned starts and ends. The estimation process is supported by both audible and visual clues, and often a distinct change in the shape of the amplitude graph guides the initial attempt to place the marker correctly (see fig. 1 below). However, distinct changes in amplitude may be absent and should in any case not be trusted to correspond to what will be interpreted as the start of the unit.[6] In other words, the measurements in principle need to be performed aurally.

Idiomatic features of style and instrument

[18] To perform the measurements I try to hear where the current unit seems to end and where the following seems to begin by moving the marker back and forth and starting the playback from different positions. Here, idiomatic features of the instruments and playing style often make it difficult to determine whether the start of a playback is too early, correct or too late. The relative distinctiveness of a physical onset is conditioned by factors such as rhythmic density, legato vs. staccato articulation, the type of

6. The fact that there is often no simple correspondence between experienced onset and visualized amplitude changes in fiddle-based pols/springar performances has also been observed by Kvifte (2004: 65).

onset/attack, bow pressure, single notes vs. double stops, instrument (fiddle vs. Hardanger fiddle), reverberation on the tone in question, echoing in the room where the recording was made, artificial reverb effects etc. These factors help blur the borders between adjacent rhythmic events and greatly affect the precision of measurements possible to obtain. To illustrate the relativeness of this problem, some concrete examples are discussed below. Note that the associated audio samples can be found by visiting the following link: https://youtu.be/RWvW5uNZnPo.

[19] The first example is a one-measure sequence from the *springar* tune *Slidringen* performed by Håkon Høgemo (2000) (Hardanger fiddle). In this case, the transition between beats stands out as distinct and unambiguous. Determining the start of the 2nd beat (B2) (the placement of the arrow) therefore is straightforward.

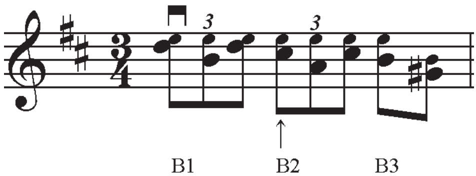


Figure 1. Slidringen*, 2nd beat onset. Audio sample 1a (see https://youtu.be/RWvW5uNZnPo).*

[20] A waveform graph of the area around the attack of B2 is displayed in fig. 2 below. The vertical, broken line in the middle shows the preferred location of the onset of B2, while the (white) selection displays the area within which alternative interpretations might be chosen. Here I have chosen a tolerance range of 40 ms (20 ms early or late respectively), which has been determined to be a realistic value considering the measuring procedure of moving the marker slightly back and forth. The sound examples associated with the graph feature three alternative placements and two listening perspectives. First, there is the "correct" location, played back from the start of B2 (1b). Second, the playback from B2 is started 20 ms earlier (1c). This alternative seems out of the question, as the attack is not anticipated in the way suggested here. Third, the playback from B2 is started 20 ms late (1d).

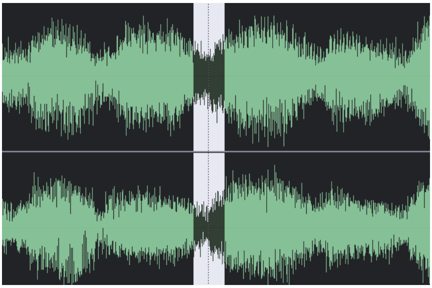


Figure 2. Slidringen*, 2nd beat onset (the vertical, broken line). Audio samples 1b–f.*

This alternative seems very difficult to evaluate, as it sounds almost identical to the preferred placement due to the "false" attack produced when starting a playback abruptly from a position immediately after a performed onset. Fourth, the playback is started from B1 (1st beat) and is stopped on the preferred location of B2 (1e). Fifth, the playback is again started from B1, but is stopped 20 ms later than the preferred point (1f), which leaves another impression compared to the situation in which the playback started where it now ends. Now the start of the following unit (B2) can be heard and the 20 ms late alternative can be dismissed. It should be added, though, that the "noise" heard right after the second beat attack cannot be interpreted correctly (i.e. as the actual start of B3) when isolated like this. Acoustic phenomena which do not coincide temporally with the position of the actual onset are often present, and the analytical method therefore presupposes both listening perspectives, i.e. *from* and *up to* the current onset position, as well as a recurrent "musical" control performed by playing back a longer sequence (the whole measure in this case).

[21] As an illustration of the relativeness of the problem of precision and resolution, and detectable vs. non-detectable measurement discrepancies, another example is introduced in fig. 3 below. This is a one-measure sequence from the *Røros-pols Finnleken i Brekken* played by Tron Steffen Westberg (fiddle).

[22] In contrast, this sequence demonstrates what might be called a reduced resolution in the transition between units, as judging what is too late or too early is far more difficult if we adhere to the 20 ms interval. In par-

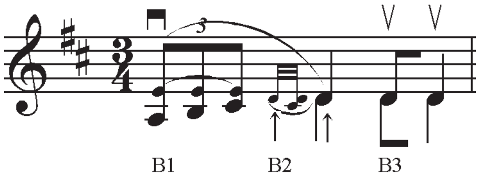


Figure 3. Finnleken i Brekken*, 2nd beat onset. Audio sample 2a.*

ticular, the legato articulation and the onset of the glissando-like grace note make it hard to tell exactly where the 2nd beat starts. The chosen placement is questionable, but the point here is to demonstrate only that the distinction between alternative placements within the 40 ms span is hardly detectable. The waveform display in fig. 4 of the area around the attack of B2 illustrates this in that there are no sharp peaks in the amplitude graph that correspond to the preferred location.

[23] In this case, it is very difficult to perceive a difference between the "correct" (2b) and 20 ms early (2c) start of B2. Even when this distance is doubled (40 ms early) (2d), the alternatives seem almost identical. The difference between the playback *ending* at the "correct" B2 location (2e) and the one ending 20 ms later (2f), however, is easily detectable, which again demonstrates the necessity of listening both *from* and *up to* the estimated starting point. Here it needs to be pointed out that the latter (20 ms late)

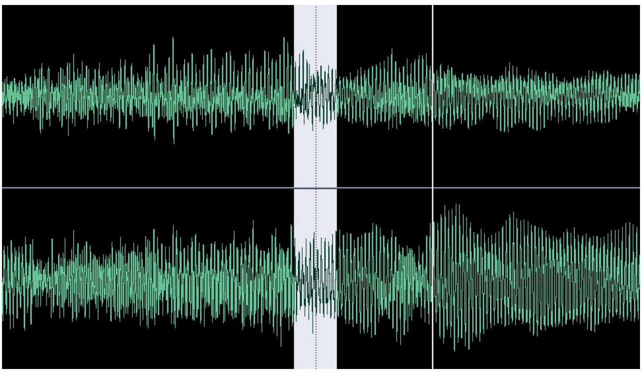
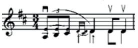


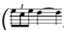
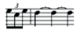
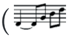
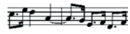
Figure 4. Finnleken i Brekken*, 2nd beat onset (the vertical, broken line). Audio samples 2b–h.*

alternative does not represent a feasible option in this melodic-rhythmic context, and there is more to this than the impression that the start of B2 is possible to hear. That is, in this example there is actually an alternative, which demonstrates another problem to be dealt with. First of all, the marker needs to be moved a lot further than 20 ms to represent this alternative start/ending point for B2. The choice, quite simply, is whether to interpret the two first short grace note onsets as belonging to B2 or B1, i.e. between the positions indicated by the left and right arrows in the notated representation ().[7] This entails the starting point for B2 having to be moved as much as 115 ms for a real alternative to become apparent (2g vs. 2h) (the white marker furthest right in the waveform display in fig. 4). In short, as long as one insists on choosing a position which is detectable by ear as being distinguished by the presence of an onset, there are no alternatives in between these rather distant points. However, these concerns are related to the measuring procedure and are not to be confused with the realities of experiencing rhythm in musical interaction. Accordingly, the smooth transition between rhythmic events and the sneaking onset which impairs the resolution in the borderland between B1 and B2 is to be regarded as a quality of its own rather than as a problem. In interpreting such ambiguities in relation to stylistic constraints and affordances, then, this "problem" concerns the relative quality and extension of *musical* onsets. When it comes to measurements, however, the examples reviewed above should demonstrate that the degree of resolution and precision possible to obtain will necessarily vary from case to case. In short, different forms and degrees of ambiguity in the borderland between units are and will remain an interpretive challenge, regardless of method. Thus, difficult cases in which the relationship between different kinds of anticipatory events, glissandos and potential starting points for rhythmic units are unclear, need to be given a musical reading which cannot be accounted for by a set of predefined criteria.

7. The issue of whether such grace notes belong to B1 or B2 cannot be solved by studying only their immediate context (the onset of B2) or the temporal and spectral values of the ornament. A musical interpretation is needed, which relies on a "normal" listening to the longer sequence (one or two measures) surrounding the current position.

The relationship between physical onset, measurements and experienced rhythm

[24] Except for the ambiguity discussed above in the area between rhythmic events, there are other factors that are problematic in connection with attempting to be consistent in the performance of analytical operations, and which therefore concern questions about validity and testability. The previous discussion might lead to the incorrect conclusion that it is the occasional lack of clear onsets, and nothing else, that makes this material challenging. This would be to ignore a more fundamental problem, namely the question of whether an onset (clear or not) really represents the start of the rhythmic unit as it is experienced by the musician, listener and/or dancer. Kvifte (2004) addresses this problem with reference to Bengtsson's (1973: 17) distinction between a tone as an acoustic phenomenon, as a notated one and as one experienced. He argues against some of the empirical rhythm research stemming from Charles Keil's (1987) concept of participatory discrepancies (PDs). Kvifte spots a fundamental problem in the lack of distinction between the physical and experienced beat. The fact that one cannot take for granted that these coincide is implicit in the subject as such, which seems to concern how one might measure and interpret the way played onsets deviate from beats.

> In fact, as attack points may be placed before or after the experienced beats , one has to find evidence of the timing of beat that is independent of the very attack points one wants to compare the beats to! (Kvifte 2004, 61).

[25] I will not enter into the deeper levels of this discussion, but only assert that there is not necessarily an intended correspondence between physical attack and experienced beat. The most obvious example is when the length of a tone extends over more than one beat, for instance when a long tone ends a strain or the whole performance (,  etc.). In these cases, the duration of the individual beats is impossible to measure as there are usually no perceivable contrasts in the sound representing the tied beats. It needs to be pointed out, however, that a tie in itself does not imply a lack of accentuation corresponding to a starting point of a second or third beat.

As already indicated, the transition between beats is by definition accentuated, as metrical accents can be seen as axiomatic, and not dependent on intensification in sound (Blom & Kvifte 1986; Cooper & Meyer 1960). Also, it varies greatly to what extent a dynamic intensification marks the transition from one unit to the next. Fiddlers might occasionally mark a structural division of a tone covering two beats by dramatically increasing the pressure of the bow, creating a clearly identifiable, although hardly measurable, division between the rhythmic units. This appears to be more common when beat motifs within a motif are tied together (,  etc.) compared to long tones occurring at the very end of main sections and/or strains, which may be performed and perceived as something nothing less than a single event, suggesting a completely coherent, undivided unit. It is hard to avoid questions of intentionality in connection with this issue, as judging relative accentuation relies on general sensations of weight and stress, rather than on measurements. The relationship between what is intended from the perspective of the performer and what is possible to detect by ear, however, seems rather irrelevant to discuss, as from both perspectives one might perfectly well experience an accentuation without really finding one in the sound.

[26] Moreover, even if there is a density of events which theoretically allows for a discrimination between beat onsets, melodic-rhythmic phrases may possess the qualities of complete, irreducible events while nevertheless extending over several formal rhythmic units (beats, or even measures). Fig. 5 below shows a one-measure ornamental phrase from a recording of the Tele-springar *Livius Smiths Minne* played by Bjarne Herrefoss (Hardanger fiddle), which clearly illustrates this phenomenon.[8] It should be noted that the actual distribution of temporal values is closely replicated in the notation.

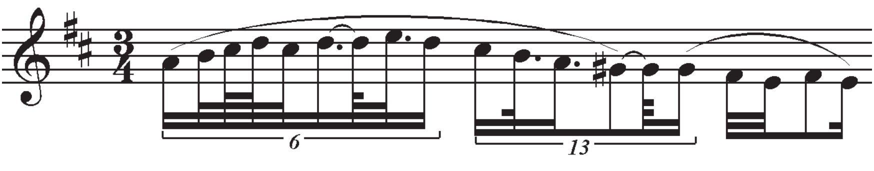


Figure 5. Ornamental phrase from Livius Smiths Minne. *Audio sample 3.*

[27] In this case, the beaming (i.e. beat division) is forced upon a pattern which resists this kind of segregation. In other words, the gesturally (referring to the bodily effort of the performer) and conceptually irreducible event is reified into a structure of sub-events (beats) which in turn are supposed to be subdivided. The example thus illustrates how measured units (measures, beats and subdivisions) may be more or less compatible or coincident with the way different portions of the melodic-rhythmic flow are discriminated between conceptually. Also, the relationship between measured patterns of onsets and rhythmic intentions is complicated by the notion that that certain fast ornamental movements are temporally locked by some mechanism of motor automatization that makes it impossible to intentionally control the durations of the individual components (Godøy 2011; Johansson 2015). Finally, an ambiguous physical representation of a beat onset may increase the tolerance range within which a beat is estimated to start. In other words, an experienced beat onset does not need to correspond to a specific point in time, even when there are such points to choose between (cf. figs. 3, 4, and 5). Instead, the onset may be perceived as having a certain extension (Danielsen 2010; Johansson 2010b). These observations and considerations clearly add complexity to the issue of assessing the musical significance of measured durational values.

[28] Yet another category of ”problematic” rhythmic behavior is early onsets, which means that the physical onset is located slightly before the point at which the performer would identify the beat to occur ( ,  etc.). This phenomenon seems to be an idiosyncrasy of individual style and here I shall primarily refer to experiences from playing with fiddlers who insist that certain tones (generally the first tone of a strain) should be started before an agreed beat position. In such cases, there is perfect agreement that our synchronized onset (the bow attack) does not represent the experienced beat. However, even if this deviation from a mutually agreed reference point is intended and controlled, rather than being due to the poor timing of an inexperienced fiddler, it cannot be measured, and we have still not achieved what Kvifte calls “evidence of the timing of beat that is independent of the very attack points one wants to compare the beats to” (Kvifte 2004, 61). But what we do have is the possibility to identify these exceptions thanks to a thorough knowledge of the style, fiddler and melodic-rhythmic context in

question. This, of course, is far from being an exact science and relies greatly on interpretations being stylistically valid.

Concluding remarks

[29] The above suggested approach is consistent with the aim of examining the temporal organization of *melodic rhythm* from the perspective of rhythm *production*. Melodic rhythm, then, is defined as the pattern of physical onsets as it is interpreted according to the considerations discussed in this article. As already indicated, the condition is not that there is an exact or intended correspondence between the measured onset and a musical onset (meaning the "point" in time that corresponds to the rhythmic experience of a performer, dancer or listener), even though this could be the case. Accordingly, instead of aiding predictions concerning the precise nature of synchronization (between co-performers or between dancer and musician), timing data may be used to negotiate the multitude of interpretive possibilities afforded by the musical material in question. Moreover, investigating how the melodic rhythm actually is performed allows for some generalizations to be formulated, which may assist the prediction of how temporal values are distributed without constantly including the very complex issue of experienced rhythm and intentionality. This being said, the relationship between measured and experienced rhythm should be seen as intrinsic to any discussion of measurement procedure and the analytical treatment of timing data. This argument could usefully be expanded to include the need for proper contextualization of measurement data. On this note, I argue for the necessity of having a thorough knowledge of the musical style in question, including its particular regime of knowledge and modes of learning and interaction (e.g. music/dance). This pertains to how sounds (in this case rhythmic information) are coded. For instance, in the context of the pols/springar styles, durational fluctuations are not heard as variations in tempo (faster and slower) but as variations in rhythmic articulation (shorter and longer). Similarly, there is a significant overlap or convergence between timing and accentuation (Clarke 1987) in the sense that measured variations in timing may be experienced in terms of accentual

(weight distribution) rather than temporal qualities (Johansson 2015). These are important contextual features to consider when engaging in analytical work.

[30] From the above follows that the status of measurement data is tentative in several respects: 1) The location of rhythmic onsets is not necessarily detectable by means of observable audible and visual clues. 2) The extension or *duration* of rhythmic onsets is variable and ambiguous by being affected by a variety of acoustic (timbral and architectural sound characteristics) and perceptual factors. Moreover, the durational qualities in question are experiential rather than measurable. 3) The inter-onset area (whether it represents one or several metric units) often contains important rhythmic information which is difficult to account for in terms of duration. 4) Duration and accentuation are converging features, which makes the former indefinite in terms of the relationship between quantitative and qualitative properties. 5) There are several contextual factors that influence the experiential attributes (i.e. musical significance) of temporal properties. These include the local melodic-rhythmic contexts within which measured events occur, as well as the more general expectational framework for rhythmic performance.

[31] Despite these reservations, I argue that measurement data in the form of tone-, beat- and measure durations may function as an etic baseline (Pike 1967) for the further analysis and assessment of rhythmic behavior. According to this approach, there should be no direct inference from observation (etic level: absolute durational properties) to interpretation (emic level: rhythmic intention and experience). For instance, it cannot be directly inferred from the observation of a long note whether it is experienced (or performed) as a long note or why it is long (e.g. that the performer would have intended to play a long note). The latter, interpretive, assessment requires a consideration of a range of factors (see above), which in turn work interactively and dynamically. It should also be noted that the suggested approach implies that it is imperative that measurements are performed consistently. In other words, when encountering difficult passages (e.g. the ambiguous onsets discussed above), the same decision of placement needs to be made in all comparable occurrences. Clearly, such a decision involves interpretation rather than mere observation. Yet, a consistent

measurement procedure allows for a certain degree of comparability given that all rhythmic events are relationally defined. As a final point, then, I suggest that the procedures and challenges of measuring rhythm should be a continuous subject of experimentation and academic discussion. I would also encourage further attention to features of rhythm and rhythmic performance that traditionally have not received much scholarly attention. Notably, these include the rhythmic properties of onsets (considered as events with duration and dynamic development) and inter-onset ranges (considered as somehow subdivided events); more precisely the possibilities to detect and represent such properties in a comprehensive way.

References

Ahlbäck, Sven. 1995. «Karaktäristiska Egenskaper för Låttyper i Svensk Folkmusiktradition: Ett Försök till Beskrivning.» *Kungliga Musikhögskolan*. Stockholm: KMH.

Bengtsson, Ingmar. 1973. *Musikvetenskap. En Översikt*. Stockholm: Scandinavian University Books.

Bengtsson, Ingmar. 1974. «On Notation of Time, Signature and Rhythm in Swedish Polskas.» *Studia Instrumentorum Musicae Popularis* III: 22–31.

Blom, Jan-Petter. 1981. «The Dancing Fiddle.» In *Slåttar for the Harding Fiddle. Norwegian Folk Music*, vol. 7, ed. Jan-Petter Blom, Sven Nyhus and Reidar Sevåg, 305–312. Oslo: Universitetsforlaget.

Blom, Jan-Petter. 1993. «Rytme og Frasering – Forholdet til Dansen.» In *Fanitullen: Innføring i Norsk og Samisk Folkemusikk*, ed. Bjørn Aksdal and Sven Nyhus, 161–184. Oslo: Universitetsforlaget.

Blom, Jan-Petter, and Tellef Kvifte. 1986. «On the Problem of Inferential Ambivalence in Musical Meter.» In *Ethnomusicology* 30, no. 3: 491–517.

Clarke, Eric F. 1987. «Categorical Rhythm Perception: An Ecological Perspective.» In *Action and Perception in Rhythm and Music*, ed. Alf Gabrielsson, 19–33. Stockholm: Royal Swedish Academy of Music.

Clarke, Eric F. 1989. «The Perception of Expressive Timing in Music.» *Psychological Research* 51, no. 1: 2–9.

Clayton, Martin, Rebecca Sager, and Udo Will. 2004. «In Time with the Music: The Concept of Entrainment and its Significance for Ethnomusicology.» *ESEM CounterPoint* 1: 1–81.

Cooper, Grosvenor W., and Leonard B. Meyer. 1960. *The Rhythmic Structure of Music*. Chicago: University of Chicago Press.

Danielsen, Anne, ed. 2010. *Musical Rhythm in the Age of Digital Reproduction*. Farnham, Surrey, UK: Ashgate.

Danielsen, Anne. 2010. «Here, There and Everywhere: Three Accounts of Pulse in D'Angelo's 'Left and Right.'» In *Musical Rhythm in the Age of Digital Reproduction*, ed. Anne Danielsen. Farnham, Surrey, UK: Ashgate.

Godøy, Rolf Inge. 2011. «Coarticulated Gestural-Sonorous Objects in Music.» In *New Perspectives on Music and Gesture*, ed. Anthony Gritten and Elaine King, 67–82. Aldershot: Ashgate.

Goto, Masataka. 2001. «An Audio-based Real-time Beat Tracking System for Music With or Without Drum-sounds.» *Journal of New Music Research* 30, no. 2: 159–171.

Johansson, Mats. 2010a. *Rhythm into Style: Studying Asymmetrical Grooves in Norwegian Folk Music*. PhD thesis. Oslo: University of Oslo.

———. 2010b. «The Concept of Rhythmic Tolerance: Examining Flexible Grooves in Scandinavian Folk-fiddling.» In *Musical Rhythm in the Age of Digital Reproduction*, ed. Anne Danielsen. Farnham, Surrey, UK: Ashgate.

Johansson, Mats. 2015. «The Organization of Time in Non-isochronous Meters: The Case of the Scandinavian Springar Style(s).» In *Musical Metre in Comparative Perspective*, eds. Hans Neuhoff and Rainer Polak. Musicolonia Vol. 11. Cologne: Dohr Publishing. [forthcoming].

Keil, Charles. 1987. «Participatory Discrepancies and the Power of Music.» *Cultural Anthropology* 2: 275–283.

Kvifte, Tellef. 1999. «Fenomenet 'Asymmetrisk Takt' i Norsk og Svensk Folkemusikk.» *Studia Musicologica Norvegica* 25: 387–430.

Kvifte, Tellef. 2004. «Description of Grooves and Syntax/process Dialectics.» *Studia Musicologica Norvegica* 30: 54–77.

Moore, Michael. 1974. «The Seeger Melograph Model C.» *Selected Reports in Ethnomusicology* 2, no. 1: 3–11.

Pike, Kenneth L. 1967. *Language in Relation to a Unified Theory of the Structure of Human Behavior*. The Hague: Mouton.

Waadeland, Carl Haakon. 2000. *Rhythmic Movements and Movable Rhythms. Syntheses of Expressive Timing by means of Rhythmic Frequency Modulation*. PhD thesis. Trondheim: Norwegian University of Science and Technology.

Discography

Høgemo, Håkon 2000. *Solo*. NORCD.

Westberg, Tron Steffen 2002. *Bortover all vei*. 2L.