# 8 Tempo, meter, and form

An analysis of "Dansa" from Mali

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## 8.1 Introduction

This chapter aims to demonstrate the relevance of the analysis of tempo for the study of musical rhythm and meter. In particular, it argues for the relevance of the music-theoretical concept of tempo-metrical types (London 2012) and the relevance of empirically determined temporal thresholds or rate limits for such analyses (London 2002; Repp 2003; Polak 2017). As a demonstration, we present an analysis of "Dansa," a piece of West African dance/drumming. Dansa is characterized by a significant, large-scale accelerando that displays a specific shape, a shape that traces the formal structure of the piece. The first section of the chapter introduces the reader to the style and repertoire of drum ensemble music from Mali, as well as to the recordings and methods used in our study. We then detail the concept of metrical types and tempo-metrical types (London 2012), and present hypotheses about the metrical structure of Dansa. In the following section we give an analysis of the rhythms and timings of the most characteristic drumming patterns found in each section of Dansa as a test of those hypotheses. In our discussion, we show how the tempo-metrical types in Dansa are structurally related to each other and thus provide a framework for understanding both continuity and change over the course of the piece. We here expand on our earlier work on non-isochronous (asymmetric) meter (Polak 2010; Polak and London 2014), which showed how two levels of non-isochronous subdivisions can be hierarchically nested and used for metric transformation (i.e., addition or reduction of metric layers). We conclude with a consideration of Dansa in the broader context of a dance/musical performance.

#### 8.2 Materials and methods

Khasonka drumming is a style of music for dance from Mali, associated with the Khasonka people from the Khaso region in western Mali. The drumming mainly serves to animate local dance celebrations on occasions such as agrarian, religious, or life-cycle rituals (e.g., wedding celebrations), rather than being staged at concerts or recorded for mass-media distribution. It is performed by expert musicians, who in urban contexts often are professionals.

The core instrument in Khasonka drum ensembles is the *dundunba*, a large double-headed cylindrical drum with goatskin membranes, typically 30–35 cm in diameter and 60–70 cm in length. The player hits the drum with a curved wooden stick in his stronger hand, and at the same time hits a bell with a strong iron nut or ring slipped on his thumb; the bell is fixed to his weaker hand's index and middle fingers with a piece of string.<sup>1</sup> Typically, one *dundunba* plays the lead part, while a second one is responsible for providing a short and simple accompaniment with the bell and a catchy ostinato "hook" line, marking the typically four-beat metric cycle as well as the piece's identity, on the drum.

In rural Khaso the basic ensemble of two *dundunbas* is typically complemented by a large goblet-shaped drum (50–65 cm in diameter) called the *tantan*. The *tantan* is played by two or three musicians, one or two performing a very short and simple ostinato accompaniment with a pair of sticks, the other playing a slightly more complex and variative accompaniment pattern with his bare hands. In the present chapter, however, we study a local urban variety of the regional style of Khasonka drumming, one in which a *jembe* drum has been added to the Khasonka drum orchestra.

The fieldwork and recordings which form the empirical basis of our study took place in the third-largest town of the Khaso region, Mahina (~30,000 inhabitants), and its surroundings. In the present chapter, we focus on Dansa, a standard piece of Khasonka drumming that often serves as an emblematic signature piece when it comes to representing Khasonka musical and/or cultural identity.

Our corpus of seven Dansa performances was collected by author Rainer Polak in 2012, recorded in the context of fieldwork with two professional *dundunba* experts, Koly Sacko and his younger brother, Toutou Sacko. The Sacko brothers belong to a family of so-called griots, a hereditary socio-professional group specializing in performance arts and social mediation (Charry 2000, ch. 3). Based in Mahina, they also perform in small villages around their home region as well as in larger urban areas in Mali and neighboring Senegal.

The corpus comprises two sets of recordings, one made in a studio context without song, dance, or audience interaction (Recordings 1–4), the other at a public social celebration with song, audience interaction, and participatory dance performance (Recordings 5–7). The decision to include both studio and live performances in our corpus was based on earlier research, suggesting that while studio recordings are ecologically valid with respect to many aspects of rhythm and timing, live performances tend to be longer and faster than studio recordings (Polak 2010; 2017). To illustrate, see Videos 8.1 and 8.2: one studio and one live recording, both of the same piece, and each in its entirety (www.routledge. com/9780367470548).

In the studio recordings, a dedicated microphone was attached to each instrument (bell or drum) and the output recorded as a separate track on a multitrack audio recorder. Recordings 1 and 3 show the most basic setup capable of representing Khasonka drumming, which consists of two *dundunba*/bell players alone. Recordings 2 and 4 feature a typical urban setup, where the two *dundunba*/ bell players are assisted by a *jembe*. In the live celebration (Recordings 5–7), which took place in the village of Diallola, the two *dundunba* experts were joined by

Studio recordings	Playing time	Instruments	Drummers
Rec 1	6 min	Dundunba 1	Koly Sacko
		Dundunba 2	Toutou Sacko
Rec 2	9 min	Dundunba 1	Koly Sacko
		Dundunba 2	Toutou Sacko
		Jembe	Sambou Kante
Rec 3	5 min	Dundunba 1	Toutou Sacko
		Dundunba 2	Koly Sacko
Rec 4	10 min	Dundunba 1	Toutou Sacko
		Dundunba 2	Koly Sacko
		Jembe	Sambou Kante
Live recordings	Playing time	Instruments	Drummers
Rec 5	17 min	Dundunba 1	Koly Sacko
		Dundunba 2	Toutou Sacko
		Tantan	members of Diallola village community
Rec 6	13 min	Dundunba 1	Toutou Sacko
		Dundunba 2	Koly Sacko
		Tantan	members of Diallola village community
Rec 7	15 min	Dundunba 1	Toutou Sacko/Koly Sacko
		Dundunba 2	Koly Sacko/Toutou Sacko
		Tantan	members of Diallola village community

Table 8.1 Corpus of recordings of Dansa performances.

members of the village community playing the *tantan* (see Table 8.1). Separate microphones were dedicated to the two *dundunba* drums (though not to the corresponding bells), to the *tantan* (but not separating the two–three players of the instrument), and to the loudspeaker that was used to amplify the singers' voices.

Our methodological approach integrates both quantitative and qualitative methods. The quantitative analyses concern the tempo and timing of the rhythmic patterns as performed. We measured the tempo by manually marking the beginning and end of each metric cycle so as to determine duration and to calculate beats per minute (bpm) or events per second (Hz). Timing data were extracted by a hybrid, half-automated, half-manual procedure, which began with the application of onset detection tools, the outputs of which were then carefully checked and corrected on visual inspection of the drum strokes in the waveforms. The quantitative analyses of the timing data were complemented by standard methods of Africanist musicology: music transcription and analysis first, followed by ethnography. The latter included Rainer Polak's participant observation of performances and musicians' everyday life, interviews, and informal conversations.

#### 8.3 Tempo-based form

Performances of Dansa involve three discrete tempo "plateaus," along with the two brief interconnecting accelerando sections (see Figure 8.1). In our studio recordings (numbers 1–4, Figure 8.1 A), the tempo of the first section ranges between 65 and 70 bpm; the second section between 100 and 115 bpm; and the third and final section between 180 and 240 bpm. The accelerandos that bridge these sections typically last just a few metric cycles, on the order of 5–15 seconds. In the live recordings (numbers 5–7, Figure 8.1 B), the first section is roughly the same tempo as in the studio recordings (65–75 bpm), whereas the second and third sections are faster (130–150 bpm and 230–255 bpm, respectively). However, the tempo curves of both studio and live performances are of similar shape. The tempo within each plateau is quite stable, especially in the live recordings.



Figure 8.1 Tempo curves of seven performances of Dansa.

Curves were smoothed via a rolling average of ten successive metric cycles. Beats per minute are given on the y-axis; the number of metric cycles on the x-axis. Note that the absolute durations of A and B are not commensurate (Rec 1 = 219 cycles; Rec 2 = 314 cycles; Rec 3 = 137 cycles; Rec 4 = 319 cycles; Rec 5 = 631 cycles; Rec 6 = 513 cycles; Rec 7 = 496 cycles).

The differences between the tempo curves of the performances as visualized in Figure 8.1 are due to the number of metric cycles present (i.e., the absolute duration) in each section. The length of each section is flexible: in the studio setting it is contingent upon the drummers' sense of continuity and change in playing through the various rhythmic patterns and variations they have at their disposal; in the live setting the length of each section is fundamentally dependent on the number and actions of the dancers.

A tempo of about 65 bpm at the start of a Dansa performance is typically about as low as one finds in West African drumming for dance. Yet by the end of the performance, the tempo will have increased to between three and four times what it was at the beginning. This dramatic change represents one of the more extreme cases of how far tempo acceleration can go in human music performance in the course of a single piece.

This increase in tempo has implications for the metric structure of the piece, which we frame via London's (2012) concept of *tempo-metrical types*, which in turn is based upon more general temporal thresholds for rhythm perception and performance.

A *metrical type* is a fully specified metrical hierarchy, as opposed to the more generic time signatures used in Western music notation. Thus, a meter that is comprised of a cycle of four beats with a single layer of binary subdivision is a particular metrical type—regardless of how notated—and is distinct from a meter comprised of a cycle of four beats with a layer of binary subdivision and an additional layer of quaternary subdivision (e.g., a measure of 4/4 with constant eighth-notes versus a measure of 4/4 with constant sixteenth-notes).

A *tempo-metrical type* is a further specification of a given metrical type, one that takes note of the actual durations/timings of each metrical level. For example, the same metrical type at two substantively different tempos would manifest as two different tempo-metrical types. Much hinges here on what is meant by "substantively different tempos."

Based upon empirical studies of rhythm perception, production, and sensorimotor synchronization, tempo-metrical types are differentiated by various temporal thresholds for metric rhythm perception: (1) a limit in the range of 100 milliseconds (ms) (600 bpm/10 Hz) for the fastest/shortest elements in a metrical hierarchy (i.e., beat subdivisions); (2) a limit of around 250 ms (240 bpm/4 Hz) for the fastest possible beats; and (3) a limit of about 1.5 seconds (40 bpm/.67 Hz) for the slowest rate for undivided beats. Evidence for these limits comes from diverse domains of human behavior and is based upon a wide range of psychological and behavioral studies and methods (London 2002, 2012; Grahn 2009; McAuley 2010). As such, these limits do not involve hard, precisely specifiable thresholds, but rather ranges of durations within which perceptual constraints appear and show increasingly strong effects. These limits are contingent on individual musical skills, music-stylistic features, and music-cultural practices. For example, while London (2002, 2012) proposed 100 ms as a "rule of thumb" characterizing the lower limit for metrical subdivisions, Polak (2017) found that in percussion music from West Africa, subdivisions can be as short as 80–90 ms. The relevance of such thresholds thus does not lie in their precise location—that is, at which duration exactly they occur—but in their inescapable constraint of human rhythm perception and performance in systematic, comparable ways. While some styles of music may stay clear of the thresholds by dwelling in the safer tempo zones, this is not the only possible approach. Other styles may deliberately play with perceptual difficulties by approaching or transgressing some of these thresholds. For instance, Polak also found note durations of 50–80 ms, which are too short to be perceived as separate metric subdivisions, but longer than most ornamental double-strokes, which are often in the range of 30–50 ms. These "quasi-flams" or "near-unisons" (Benadon, 2017) are used for expressive purposes (Polak, 2010). In the following discussion and analyses, we present these limits/thresholds in terms of single values, which is done for the sake of simplicity. They should nevertheless be understood as rough proxies for ranges of durations.

Table 8.2 illustrates how these thresholds would map onto a meter with quaternary, ternary, and binary subdivisions occurring at the tempos as found in the different sections of Dansa. We note that the rates in Table 8.2 are based upon the live performances in our corpus, which are more ecologically valid than the studio recordings with respect to their use of tempo.

Given the generic temporal thresholds for meter and rhythm perception noted earlier, we put forth the following hypotheses regarding metrical structure in Dansa:

- 1. At the slowest tempo range (Section 1), binary, ternary, and quaternary subdivisions will all be safely above the 100-ms limit. In the context of Malian dance drumming, in which there is considerable emphasis on dense rhythmic surfaces, this suggests that quaternary subdivision will be used.
- 2. In the medium tempo range (Section 2), binary and ternary subdivision will again be above the 100-ms limit. At the slower end of the medium tempo range, a quaternary subdivision will approach that limit but nevertheless

	BPM	Beat duration	Beat subdivision duration					
			Binary	Ternary	Quaternary			
Section 1 (slow)	65	923	462	308	231			
	75	800	400	267	200			
Section 2 (medium)	130	462	231	154	116			
	150	400	200	133	100			
Section 3 (fast)	230	261	131	87	65			
	255	235	118	78	59			

Table 8.2 Approximate average durations of metric elements (beats and subdivisions) for the three different sections in the Dansa live recordings (Recordings 5–7).

The tier for each section (slow, medium, fast) shows two rows, the upper one giving the minimal and the lower one specifying the maximum tempo found in the respective section. Beat rates are given in bpm, beat and subdivision durations are given in milliseconds. Dark gray shading: too fast to be a useful unit of subdivision (<100 ms); mid-gray shading: suitable for subdivision, but too fast to serve as a beat (100–250 ms); light gray: suitable as a beat-level interval (>250 ms).

remain above it. For the faster tempos in the medium range, however, the quaternary subdivision will come close to the 100-ms limit. And while either ternary or quaternary subdivisions may be used as the fastest layer, another constraint comes into play. The generic limits/thresholds noted earlier were derived from studies of single-task behaviors (e.g., tapping along to a metro-nome). *Dundunba*/bell players, however, have a dual task, using one hand for the drum and the other for the bell. Therefore, in addition to perceptual constraints, sensorimotor thresholds also constrain the instrumentalists' production of rhythmic patterns. Thus, it appears more likely that in Dansa Section 2, they will confine themselves to the ternary subdivision.

- 3. In the fast tempo range of Section 3, both ternary and quaternary subdivisions would fall far below the 100-ms limit, predicting that only binary subdivision will be used.
- 4. In Section 3 the beat duration itself approaches the threshold of 250 ms. This suggests that the perceived main pulse may shift from the beat which comprises two fast pulses to a higher-level beat.

Common sense suggests that within the context of a stable metric hierarchy, tempo acceleration sooner or later will press the perceptual constraints on both beat and subdivision rates to their limits, where they become too fast/short to be perceived with fluency and ease. The tempo ranges illustrated in Table 8.2 and the hypotheses given in the previous list allow us to better understand the tempo-based form of Dansa, since they suggest that each of Dansa's three sections is comprised of a distinct tempo-metrical type.

# 8.4 Rhythm and timing

We now present an overview of some of the basic drumming patterns characteristic of each section of Dansa. This will allow us not only to test our hypotheses regarding the temporal constraints operating in each section, but also to understand how, exactly, the metric structures in Dansa permit the integration of binary, ternary, and quaternary subdivisions in a single coherent metrical hierarchy. Note that in the timing analyses in Tables 8.3–8.5 we aggregate data across performances insofar as we show *dundunba*/bell patterns (all recordings) in conjunction with both *jembe* (Recordings 1 and 3) and *tantan* accompaniment patterns (Recordings 5–7). We have prepared video demonstrations of the basic drumming patterns described; they can be accessed at www.routledge. com/9780367470548.

# 8.4.1 Section 1

The composite rhythm in Section 1 involves three concurrent layers of beat subdivision: binary, ternary, and quaternary. The binary subdivision of the beat can be heard in the second *dundunba*'s hook drum pattern and especially in the *tantan* accompaniment rhythm (see Video 8.3 and the upper rows of Table 8.3). The *tantan* accompaniment consists of a simple two-note ostinato which, borrowing from terminology for African-American music, one may describe as an "open shuffle" or "half-swung" rhythm. As can be seen in Table 8.3, in both the hook and *tantan* patterns the beat is asymmetrically divided into long and short elements, rather than a symmetrical/isochronous division. A ternary subdivision of the beat is explicitly present in the second *dundunba*'s accompanying bell pattern; it is also present in the accompaniment rhythm of the *jembe* (see Video 8.4 and the middle rows of Table 8.3). The ternary subdivision is non-isochronous in both instruments. Lastly, a quaternary level of subdivision is established by the first *dundunba*'s lead drum and bell parts. While some of the lead player's patterns roughly sustain the binary and/or ternary subdivisions as laid out in the other instruments, it also frequently introduces a fourth metric event per beat. A motive which features this quaternary subdivision in a prominent way occurs in the opening phrase of the first *dundunba* used in Recordings 1 and 2. This motive consists in simply playing out four strokes per beat in both the bell and the drum for about two or three metric cycles (see Video 8.5 and the bottom rows of Table 8.3).

Table 8.3 represents an aggregate display of the previously mentioned drumming patterns in a graphic raster notation, where columns represent metric bins (doubleline boxes represent beat bins, single-line boxes indicate subdivisions) and different column widths represent their relative durations. Table 8.3 also gives typical timings of these patterns, as extracted from the recordings in our corpus. Given Dansa's complex tempo structure, raw timing data are less useful for analysis of patterns of subdivision timing and structure. To show similarities and differences in timing across tempos, subdivision durations are given as proportions of their local beat

1				2				3				4			Beat cycle	
x		x		x		x		x		x		x	x			Tantan
58		41		59		42		59		41		59		42		Rec 5–7
0				0		0				0		0		0		Hook part
99				59		100				41		59		42		Rec 1–7
x	x	x		x	x	x		x	x	x		x	x	x		Acc bell
24	35	40		26	35	38		27	34	39		27	34	39		Rec 1-4
в		s		Т	Т	s		В		s		Т	Т	s		Jembe
59		40		31	29	42		58		41		30	30	41		Rec 2 and 4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Lead drum
28	31	18	23	29	29	18	24	29	29	19	23	28	29	19	23	Rec 1, 2
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Lead bell
28	30	19	23	29	29	19	23	29	29	19	24	29	28	19	24	Rec 1, 2

*Table 8.3* Survey of the basic drumming patterns and their mean timing ratios in Dansa Section 1.

Timing ratios in each part are expressed as percentages of a normalized beat; due to small timing variations some beats may manifest minimally more or less than 100%, but each row sums to 400%. x=stick strokes on the *tantan* or bell hits of the *dundun* player; O=open tones of the *dundun*; °=muted, thus softer, brighter/higher and shorter sounding *dundun* strokes. In the *jembe*, B=bass tone, S=slap, and T=open tone.



Figure 8.2 Tempo-metrical type 1 characterizing Dansa Section 1 at a range of tempos from 65–75 bpm.

duration. This also allows for convenient comparison and analysis of sections of Dansa within and across performances whose absolute tempos may differ slightly.

The underlying binary division of the beat is clear in all parts, exhibiting a 60:40 ratio on average. The bells play cardinal roles in marking the asymmetrical divisions at the ternary and quaternary levels. The accompaniment bell creates the ternary figure by asymmetrically dividing the binary long into a nested short-long pair. Similarly, the lead bell creates the quaternary figure by dividing both the binary long and short elements into nested short-long pairs. Figure 8.2 schematically displays the hierarchic structure of the tempo-metrical type in the first section of Dansa. The nested subdivisions of the metric hierarchy are achieved by dividing the longest subdivision element in each layer by one additional sub-division element in the next layer. It is this metrical framework that allows Malian musicians and listeners to integrate binary with ternary and ternary with quaternary levels of subdivision—a phenomenon which is conventionally assumed to be impossible in music theory (see, for instance, Hook 2011).

Given the bpm rates for the beat ranges in the live performances (Recordings 5–7) noted earlier, as well as the timing proportions observed in the non-isochronous subdivisions, in Section 1 the shortest elements of subdivision in the lead drum or lead bell would be between 152 and 175 ms, still comfortably above the 100-ms limit.

#### 8.4.2 Section 2

In Section 2, a non-isochronous, long-short binary subdivision is consistently present in the ostinato hook drum and bell accompaniment patterns of the second

A metric cycle of four beats shows three layers of nested subdivisions, where the first layer is bifurcated by subdividing its longer element, and the second layer again is further bifurcated by again subdividing its longest element.

1			2			3			4			Beat cycle
0		0			0			0	0			Hook part
57		100			100			43	101			Rec 1–4
x		x	x		x	x		x	x		x	Acc. bell
56		40	60		40	59		43	56		46	Rec 1-4
s			Т		Т	s						Jembe
99			58		41	201						Rec 2 and 4
x	x	x	x	x	x	x	x	x	x	x	x	Tantan
27	31	41	28	31	41	28	31	40	28	31	43	Rec 5–7
0	0	0	0	0	0	0	0	0	0	0	0	Lead drum
22	37	42	21	38	41	21	38	41	21	38	41	Rec 1 & 2
x	x	x	x	x	x	x	x	x	x	x	x	Lead bell
26	35	40	26	35	39	26	34	39	26	34	41	Rec 1 & 2

Table 8.4Survey of some basic drumming patterns and their mean timing ratios in Section2, the middle and medium fast (130–150 bpm) section of Dansa.

*dundunba*, reinforced by the *jembe* accompaniment (see Video 8.6 and the upper rows of Table 8.4). A ternary subdivision of the beat is present in the basic *tantan* accompaniment, as well as in the first *dundunba*'s lead drum and bell patterns (see Videos 8.7 and 8.8, and the lower rows of Table 8.4). Table 8.4 again represents the first *dundunba* and lead bell by a maximally saturated motive, articulating all three metric elements per beat.

The same type of hierarchical nesting between binary and ternary levels found in Section 1 is also present here; the quaternary level, however, is absent. Similarly, the timing ratios of the binary and the ternary subdivisions are much the same as in Section 1. Thus, the tempo-metrical type of Section 2 can be described as a transformation or, more precisely, a reduction of the tempo-metrical type of Section 1. As also can be seen in Table 8.4, the non-isochronous division of the binary long element in the lead drum is more pronounced than in the lead bell (note the differences of the within beat timing ratios). This could be due to the physical constraints of one person playing both instruments. However, timing patterns elsewhere turn out to be slightly sharpened in the lead drum compared to the lead bell. Thus, this could also be a musically intentional, expressive relationship between slightly divergent timing patterns in the different hands of the lead *dundunba*/bell player.

# 8.4.3 Section 3

In the final, fastest section of Dansa, nothing but binary subdivision remains after the accelerando of Section 2, as is evident in Table 8.5. The *jembe* still maintains the binary long-short ratio of about 60:40, even though the tempo is much faster than in Sections 1 and 2 (see Video 8.9 and the uppermost rows

1		2		3		4		Beat cycle
		S	S	Т	Т	S S		Jembe
		66	40	59	40	62 133		Rec 2 and 4
x	x	x	x	x	X	x	x	Tantan
38	46	63	52	42	43	62	54	Rec 5–7
0			0		0	0		Hook drum
149			97		47	107		Rec 1-4
x		x	x	x	x	x		Acc. bell
92		58	48	52	49	101		Rec 1-4
				0	0	0	0	Lead drum
				48	53	50	56	Rec 1,2 &4
				x	x	x x		Lead bell
				50	49	51 51		Rec 1, 2 &4

*Table 8.5* Survey of some basic drumming patterns and their mean timing ratios in Section 3, the final fastest section of Dansa (230–255 bpm).

Due to the lack of any consistent subdivision timing patterns across all parts, column widths do not indicate metric timings.

of Table 8.5). The *tantan* plays an asymmetric four-stroke pattern that repeats every two beats (see Video 8.10 and the second tier from top in Table 8.5). In the accompanying *dundunba*/bell part, the hook pattern is reduced to four strokes over the course of the measure (see Video 8.11 and the middle rows of Table 8.5).

The *jembe, tantan*, and hook drum parts are ostinatos, while the other parts are more variative. The accompaniment bell plays figures of five or six notes whose metrical positions and timings are variable; a typical pattern is given in Table 8.5. Similarly, the lead *dundunba*/bell part is highly variable in both note density and rhythmic pattern. Table 8.5 shows a four-note figure in both lead instruments in the second half of the measure; its timing is nearly isochronous.

Thus, in Section 3 there is a greater diversity of timing patterns than in Sections 1 and 2. Both the accompaniment bell and the lead drum and bell show a degree of timing variation, and no pattern consistently supports either the *jembe*'s two-stroke or the *tantan*'s four-stroke timing patterns.

# 8.5 Conclusion

In this study, we have integrated the analysis of rhythm and meter with the analysis of tempo, taking into account the temporal thresholds that constrain the perception of rhythm. The analyses of tempo and timing found in Dansa are what psychological studies of rhythm perception and performance would lead us to expect. The sequence of tempo-metrical types in Dansa turns out to be consistent with the hypotheses given on pp. 148–149. Specifically:

- 1. At the slowest tempo range (Section 1), binary, ternary, and quaternary subdivisions were all present.
- 2. In the medium tempo range of Section 2, binary and ternary subdivisions were used, but quaternary was not. While still above the 100-ms limit, the difficulty of playing the *dundunba*/bell parts at tempos near this threshold may have been the reason quaternary subdivision was avoided.
- 3. In the fast tempo range of Section 3, only binary subdivision was used, as both ternary and quaternary levels were well below the 100-ms threshold.
- 4. There was some evidence that the main pulse shifted to a higher-level beat (see the following discussion).

Thus, the relationship between tempo/beat rate and the absolute limits of metric density (i.e., fastest/shortest notes possible) is a significant constraint on the tempometrical types characteristic of each section of Dansa: binary-ternary-quaternary subdivision in Section 1, binary-ternary in Section 2, and solely binary in Section 3.

Rhythms in the Malian drum music repertoire often feature non-isochronous beat subdivisions that are highly stable across a wide range of rhythmic patterns, tempos, and instruments (Polak 2010; Polak and London 2014; Polak et al. 2016; Polak et al. 2018). As noted earlier, Dansa's metrical hierarchy involves three layers of non-isochronous subdivision (see Figure 8.2). The asymmetrical/nonisochronous timing pattern of these subdivisions is what allows for the structural nesting of binary, ternary, and quaternary levels in a single, coherent metrical hierarchy. This nesting does not produce polymetric patterns of three against two or four against three, but rather patterns of three-within-two and four-withinthree-within-two. In Dansa this is clearly audible, with each layer articulated by a distinctive drum timbre and rhythmic pattern. Likewise, these are not "crossrhythms" within a "metric matrix" (Locke 1982, 2011) as they do not occur on the same metric level. Rather, these nested binary, ternary, and guaternary layers exemplify the concept of "inter-rhythm" coined by Nzewi (1997), which he developed to avoid connotations of perceptual ambiguity and polymeter that "cross-rhythm" implies (see also Agawu 2003).

In the Malian drum repertoire surveyed in Polak and London (2014), which focused on the pieces "Ngòn Fariman" and "Bire," we posited a rule-of-thumb for differentiating long versus short subdivisions: long elements could be subdivided while short elements could not. Dansa, however, shows that this is not a general rule, for given its slow initial tempo, the short elements in the opening section can also be divided; this subdivision of both the short and long binary subdivision elements creates the quaternary layer. Thus, the general principle (in Sections 1 and 2, but not Section 3) is that asymmetrical subdivision may occur recursively in any metrical element, so long as the shortest "short" remains long enough to be perceived as a metrical element rather than an ornament, such as a drum roll or flam. This perceptual constraint has been estimated to occur not at a precisely specifiable "hard" threshold, but in a range of durations from 120 ms down to 80 ms, with increasing effect at the lower end (London 2002; Repp 2003; Polak 2017).

As noted earlier, the subdivision in the final, fastest section of Dansa is realized differently by the different ensemble parts: While the *jembe* keeps the original binary long-short subdivision, the *dundunba* and bells approximate isochrony, and the *tantan* realizes a different pattern entirely. That is, the subdivision timings in Section 3 do not consistently characterize a single metric type. There are several potential explanations for this seeming lack of rhythmic coherence, and they are not mutually exclusive.

First, the differences in timing reported in Table 8.5 are expressed in terms of timing ratios relative to the duration of the "local beat." While this allows for ready comparison of non-isochronous timings across the different sections of Dansa, it obscures the absolute values of the durations involved. At the rapid tempos found in the third section, the differences between the timing patterns of different parts of the ensemble, while considerable in terms of ratio, are small in terms of absolute duration—most are less than 20 ms. Many of these will therefore fall below a "just noticeable difference" (JND) threshold of detectability, and hence will not be perceptually salient. We also note a shift in the standard deviation within each part ranges from 1 to 2% of the beat duration; in Section 2, from 1.5 to 3%; and in Section 3, from 2.5 to 5%. Thus, some of the differences in timing documented in Table 8.5 may be an artifact of the increased variability in rhythmic performance which occurs with each tempo increase.

A second explanation is related to biomechanical and perceptual constraints on rhythmic production/performance. The *jembe*'s bimanual performance allows it to maintain the basic long-short pattern at the fastest tempos used in Dansa. By contrast, the *dundunba*/bell players have the dual task of playing separate instruments with each hand while maintaining their coordination; this was already noted as a factor in the shift from quaternary to ternary subdivision in Section 2. The flattening out of the long-short rhythm found in the *dundunba*/bell parts in Dansa is akin to softenings of the swing ratio in jazz performance at rapid tempos (Friberg and Sundström 2002; Dittmar et al. 2015).

Yet this does not explain the different timing pattern found in the *tantan*. The *tantan* gives evidence of a third explanation, that is, that different players within the ensemble are using different pulse levels as their primary frame of reference. While the *jembe*'s long-short pattern is clearly related to the rapid pulse that results from the accelerando of Section 2, the *tantan* suggests a quarternary pattern yoked to a slower pulse level at half the speed. Both the highly repetitive nature of the *tantan* pattern and the fact that it occurs in other pieces in this style lend credence to this interpretation.

Finally, the looser metrical organization in the final section, which involves a greater tolerance for timing variabilities within and among the various parts, may also be due to aesthetic choice. For example, the performers may simply enjoy and prefer the rhythmic feel created by this constellation of timing features.

This analysis of Dansa is necessarily incomplete, as we have not included the actions of the dancers and their interactions with the drummers. Dansa is, first

and foremost, music for dancing, and its tempo-based form provides a scaffold for an extended and increasingly energetic dance. The tempo shifts in Dansa increase the beat rate, which is the most salient rhythmic cue for the dancers. At the same time, while the increases in bpm are important, the degree of event density is also important, since these increases in density "energize" the beat itself as well as the overall rhythmic pattern. As shown in Table 8.2, this event density is quite high in all three sections of Dansa, with durations of the fastest subdivision layer mostly falling in the range of 120–200 ms. Nevertheless, here too the sequence of tempo-metrical types across the three sections involves a stepwise increase: The guaternary subdivision in Section 1 has, on average, durations of about 200-230 ms, the ternary subdivision in Section 2 about 135-155 ms, and the binary subdivision in Section 3 about 120-130 ms. Interestingly, this increase of metric event density at the fastest pulse level and the increase of the tempo in terms of the beat rate are not only congruent in terms of their direction—rising stepwise across the three sections of the piece-they also are roughly proportional in terms of their magnitude of change. The contrast between Sections 1 and 2 in both beat and subdivision rates is stronger than the contrast between Sections 2 and 3. Clearly, the three different tempo-metrical types and their sequential arrangement in the piece are designed to increase the overall rhythmic energy generated by the beat and subdivision rates. This shows how tempo, or absolute duration itself, can be the basis for structural variation—much like changes in harmony, melody, or rhythm-which the players use to generate musical form.

Finally, we want to sound a note of caution regarding the influence and impact of temporal constraints on rhythm perception and performance. A cognitive constraint such as the 100-ms limit for the fastest subdivision can make a given rhythmic pattern more or less plausible in actual performance, but it cannot wholly determine or explain what is actually done, nor why. As noted earlier, other West African drumming repertoires involve metric subdivisions that fall well below 100 ms. Thus, these constraints are highly context-dependent. Nevertheless, our study of Dansa has shown meter to be strongly correlated with tempo, a relationship that depends on universal human perceptual constraints on the one hand, and contingent, style- and repertoire-specific musical form, on the other.

## List of video samples

Video samples 8.1 and 8.2 illustrate the two types of recordings in our corpus: studio versus live. Each sample presents its respective performance/recording in its entirety.

**Video 8.1.** Studio performance of Dansa (Recording 2 of our corpus). The running time is 9:13, the change from Section 1 to Section 2 takes place at 2:49, and the change to Section 3 at 5:53. *Line-up*: Toutou Sacko (left): hook drum/ accompaniment bell; Sambou Kante (center): *jembe* accompaniment; Koly Sacko (right): lead drum/bell. Videography and audio recording: Rainer Polak.

**Video 8.2**. Performance of Dansa recorded in a community celebration context (Recording 7 of our corpus). The playing time is 16:53, the change to

Section 2 occurs at 7:49, and to Section 3 at 11:25. *Line-up*: Toutou Sacko: lead drum/bell from 0:00 to 3:50, hook drum/accompaniment bell from 3:50 to end; Koly Sacko: hook drum/accompaniment bell from 0:00 to 3:50, lead drum/bell from 3:50 to end. Sambouba Sissoko, Mamadou Bagayoko, Kambon Sidibe, Moussa Fayinke, and Sambali Makalu: *tantan*. Modi Keita Luntandi Damba, Dua Kanouté, and Terema Kanouté: vocals. Djati Kuyate, Adama Diabate, and many members of the Diallola village community: dance. Rainer Polak: videography and audio recording.

Samples 8.3–8.11 represent brief excerpts (10–15 seconds) taken from samples 8.1 and 8.2. They illustrate the different subdivision layers and timing patterns present in each section of Dansa. In order to direct the reader's attention to the specific instruments in question, we muted the audio tracks of the other instruments in the ensemble.

**Video 8.3**. Two *tantan* players with pairs of sticks play an ostinato shuffle rhythm maintaining a binary long-short subdivision in Section 1; a third player striking the same drum with bare hands performs denser ternary, and quaternary rhythms.

**Video 8.4**. The second *dundunba*'s accompanying bell (left) and the *jembe* (center) play an asymmetric ternary subdivision in Section 1.

**Video 8.5**. The lead drum and bell (right) use an asymmetric quaternary subdivision in Section 1.

**Video 8.6**. The hook drum and its bell accompaniment, the *jembe*, and the lead drum/bell all manifest a binary long-short subdivision in Section 2.

Video 8.7. The lead drum and bell play out a ternary subdivision in Section 2.

**Video 8.8**. The *tantan* player with sticks to the right side realizes a ternary subdivision in Section 2.

Video 8.9. The *jembe* maintains a binary long-short subdivision in Section 3.

**Video 8.10**. The *tantan* stick players perform an asymmetric four-stroke pattern in Section 3.

**Video 8.11**. The second *dundunba*/bell player features the accompanying part in Section 3.

#### Note

1 Drummers in the musical traditions under study here are always male; thus, we do not use gender-inclusive language in this respect.

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