DjembeDance: Multimodal rhythm in music and dance from West Africa

1. Excellence

1.1 State of the art, knowledge needs, and project objectives

The ambition of DjembeDance is to **advance the methodology and demonstrate the scientific relevance of the nascent field of empirical choreomusicology** (integrated music and dance studies). The approach is to **provide a comprehensive case study of multimodal rhythm in West African drum ensemble music and dance**. The project will build on an exceptionally large, technologically advanced, and culturally rich **corpus of multimedia recordings of djembe drumming and dance performance from Mali**, which was collected by the PI in 2018. DjembeDance will curate this corpus, analyse it with cutting-edge computational analysis tools, and triangulate the corpus analysis by additional qualitative and experimental psychological methods. The project aims to **push the theorization of rhythm from its reliance on predominantly auditory/music-based perspectives to multimodal concepts**. Achieving these objectives with an African case study holds the potential for significant academic impact, given the cultural bias and lack of diversity characterising the behavioural and cognitive sciences (Henrich et al., 2010). Since the djembe drum has spread globally over the past decades, DjembeDance also can develop a powerful societal impact, e.g., in the field of music pedagogy.

In Mali, the concept "djembe" designates a goblet-shaped drum and a musical and corresponding dance genre. Djembe music and djembe dance are never performed in isolation and together are conceived of as a coherent, unified genre. Djembe performances are held on ritual and social occasions such as wedding celebrations, where drumming and dancing come along with singing, rattle-playing, and hand-clapping. The music-making and the audience are arranged in a single spatial unit, a circle surrounding the dance arena. A participatory interaction order invites each individual in the circle to take the dance floor and thus temporarily take on the central lead performance role, coordinated by regulations and on-the-spot negotiations of turn-taking (Polak, 2007, 2021; Figure 1). The interaction of musicians, dancers, and audience members is rhythmically coordinated to an extreme degree.

Figure 1: Djembe performance in a rural village in southern Mali (2019). (A) Drum ensemble receives two dancers. (B) Dancer engages with two drummers. (C) Music-making extends from drumming to rattle-playing to hand-clapping by audience members.

The temporal coordination of joint action (entrainment) is generally recognised as a critical function of rhythm, some basic components of which may be present in other species (Wilson & Cook, 2016), but the structural complexity, expressive multimodality, and fundamentally social usage of which is distinctive of homo sapiens (Repp & Su, 2013; Mogan et al., 2017; Clayton et al., 2020). However, concepts such as pulse, beat, and metre, which inform this field, have been mainly developed in music studies (Lerdahl & Jackendoff, 1983; London, 2012), from which they were then extrapolated to other types of behaviour, such as dance (Fitch, 2016), and sensory modalities such as visual perception (Su, 2014). This **reliance on concepts derived from rhythm research in mainly one modality of communication (music) and sensation (auditory) is problematic given the fundamental multimodality and multisensory integration of human communication** (Levinson & Holler, 2014) **and perception** (Spence, 2007). In this context, the prevalent understanding of dance as an entrained response to musical rhythm underestimates the fact that dance itself, too, is highly expressive rhythmic behaviour, the visual perception and bodily feeling of which also involves beat induction (Su, 2014;

Phillips-Silver & Trainor, 2008) and can engender further entrained responses. Such effects are well-acknowledged today but have been studied to a degree much smaller than what has been achieved in music research. This bears the risk of over-weighing features typical of musical rhythm and underestimating or remaining unaware of features that are characteristic of other modalities or multimodally interacting or integrated behaviours and experiences, such as music for dance (Veroli & Vinay, 2017; Stepputat & Seye, 2020; Haugen, 2021; Jordan, 2021).

In this situation, it is key to not only proceed further with experimental laboratory research in multimodal rhythm perception, which is increasingly underway (Levitin et al., 2018), but also to **add momentum to the empirical study of multimodal rhythm in the "naturalistic" contexts of socially situated performance practices.** An ideal approach to this end would be to **advance empirical choreomusicology** and work toward its establishment as a critical field of research. DjembeDance approaches these objectives through a comprehensive interdisciplinary case study of djembe drumming and dance performance from Mali.

1.2 Research questions and hypotheses, theoretical approach, and methodology

At the core of DjembeDance is the computational analysis of an exceptionally large, culturally rich, and technologically advanced set of multimedia recordings made by the PI in 2018, the DjembeDance multimedia corpus. This corpus integrates 8-track audio with 2-camera video and one full-body inertial motion-capture (mocap) system (XSENS Link), tracking the movements of one dancer per session at a temporal resolution (240Hz) that is sufficient for advanced timing research. The recordings feature four different ensembles, each consisting of three drummers and at least four dancers; each ensemble was recorded twice on two consecutive days. Three ensembles were urban professionals performing live in a studio setting, while the fourth involved a rural village community in a public social event (Figure 2). The DjembeDance multimedia corpus has a running time of more than ten hours. It comprises a repertoire of 23 traditional djembe drum/dance pieces, 13 of which are present three to fifteen times, allowing for comparative analysis. It is accompanied by another corpus of ethnographic field recordings of the same artists performing the same repertoires in the context of public events curated by the project manager in 2019 and 2020.

Figure 2: Field recording for the DjembeDance corpus (2018). (A) PI changes battery and SD card in preparation for replacing a camcorder while monitoring the mocap recording of a dancer visualised in real-time on a notebook. (B) Motion-tracked dancer (wearing a sensor-hosting suit) spurs on and claps along with other dancers. (C) Motion-tracked dancer mimics an animal with sticks representing front-runs. (D) One clip-on microphone and one piezo pickup are attached to the membrane of each drum.

The combination of ecological validity (representativity of real-life settings), technical sophistication, systematic design, and large sample size lends the DjembeDance corpus an unprecedented quality in the field of corpus studies of performance arts. It is of particular value to the project that the PI already made the recordings in 2018. The DjembeDance project will create academic value of great importance by curating and using these previously untapped recordings. It will **triangulate** the core approach of **computational corpus analysis**, on the one hand, with extensive **ethnomusicological/choreological music and dance analyses** and, on the other hand, with **psychological experiments based on stimuli developed from the recordings**. This interdisciplinary and robust approach allows the project to promise novel insights into the basic features of rhythm in human expressive performance. In what follows, I first break down this ultra-broad interest into three interrelated research questions (RQ1,2,3), then formulate three hypotheses (H1,2,3), and finally describe the project's approach in four work packages (WP1,2,3,4).

RQ1: Are the basic rhythmic features of djembe music mirrored in djembe dance? West African drum ensemble music is among the ethnographically and musically best-studied genres worldwide (Chernoff, 1979; Agawu, 2006; Locke, 2011). This includes djembe drumming due to the PI's research (Polak, 2000, 2007, 2012). In particular, djembe rhythms alone have been studied empirically by computational analyses of corpora of audio recordings (Polak, 2010; Polak et al., 2016; London et al., 2017; Jacoby et al., 2021) and psychological experimentation (Polak et al., 2018). The above research elicited the following three key findings: (1) Djembe drumming shares a cluster of related features with West African drumming genres that count as the hallmark characteristic of African rhythm, namely, polyrhythm and cross-rhythm. (2) Djembe drumming shows asymmetric ("swung") beat subdivisions, broadly comparable to what has been found in jazz (Benadon, 2006) and samba (Haugen & Danielsen, 2020), and related to long-standing debates about asymmetric metres in Nordic including Norwegian folk dance music (Haugen, 2021). (3) The synchronisation between the different players in djembe ensembles is more precise than measured in any other music genre until today (Clayton et al., 2020). The players' mutual timing adaptations correcting for unavoidable errors and intended tempo fluctuations are role-based: the highly variable lead drummer (soloist) adapts to the little or minimally variable accompanists more strongly than vice-versa (Jacoby et al., 2021). DjembeDance asks whether these three features of djembe drumming – (1) poly/cross-rhythm, (2) swung subdivision, (3) precise ensemble synchronisation through role-differentiated mutual adaptation – also are characteristic of djembe dancing.

RQ2: Are there basic rhythmic features distinctive of djembe dancing? While choreomusicological theory has proposed sets of qualitatively different types of music-dance relationships, such as congruence vs contrast or parallelism vs counterpoint (Jordan, 2000, 2021), pioneering studies in empirical choreomusicology have focused primarily on the search for congruence/parallelism (e.g., Naveda, 2011; Haugen, 2021). The project also asks whether there are basic rhythmic features in djembe dancing that are *not* also present in djembe music and may contrast or form counterpoint relationships with the drumming.

RQ3: Are there basic rhythmic features in the composite multimodal djembe performance that emerge only from the interaction or integration of music and dance? Any potential findings regarding distinctive features of dance rhythm (RQ2) can be expected to interact with co-present features of musical rhythm. Thus, DjembeDance needs to explore their interaction and integration systematically.

The following **three hypotheses** (H1,2,3) are grounded in what is known about djembe music (RQ1) but also consider predictions of possible findings on the dancing (RQ2) and the dance-music interaction (RQ3).

H1: Ethnomusicologists have long assumed that West African cross-rhythms, e.g., 2:3 relationships between concurrent pulse streams in different ensemble parts, involve metric ambiguity (Locke, 2011) or polymetre (Chernoff, 1979). Correspondingly, it has been assumed that African dance is polycentric and realises polymetric musical cross-rhythms in the dancers' different body parts (Thompson, 1974; Welsh-Asante, 1998). However, musicologists of West African descent have argued against the perceptual reality of polymetre (Nzewi, 1997) and claimed that West African dance steps consistently support a regular 4-beat metre (Agawu, 2006). Kofi Agawu further argued that polymetre represents a Euro-American invention that served ethnomusicology in its endeavour to construct African music and dance as radically different: Europe's premodern "other" (Agawu, 2003). These conflicting arguments combine rhythm-analytical with political and ethical aspects; together, they form the most long-standing and lively debate about African music and dance since the 1950s. Strikingly, it has never been the focus of any dedicated study, neither qualitative nor quantitative, whether West African dancing indeed does either parallel musical cross-rhythm and polymetre or, on the contrary, a coherent 4-beat metre. DjembeDance thus has a unique chance to make a seminal contribution to an iconic debate by providing an empirically robust case study explicitly addressing the issue in question. Based on the PI's personal experience as a djembe dance drummer, the hypothesis is that djembe dance systematically parallels a coherent 4-beat metre, consistent with Agawu's claim. Evidence in support of this hypothesis would speak to RQ1: cross-rhythms are found in the music but *not* in the dancing; to RQ2: djembe dancing conveys a regular beat and metric hierarchy which is *not* found in the music; and to RQ3: in contrast to the results of African music studies (including the PI's own prior research, e.g., London et al., 2017), the integration of polyrhythmic music and beat-based dancing makes djembe music-dance performance appear much less different to the principles of rhythm and metre in European genres than previously assumed. If

true, this would suggest that the exaggerated difference ascribed to African rhythm partly derives from a music/musicology-biased perspective that underestimates the multimodal nature of rhythm.

H2: Non-isochronous ("swung") fast pulsations at the level of the beat subdivision are commonly conceived of as expressive deviations from regular metric frameworks, for instance, in jazz research (Benadon, 2006). By contrast, musicological research has claimed that in some musical genres, including Malian djembe drumming (Polak, 2010; Polak et al., 2016), swung subdivisions represent a stable structure of the repertoire rather than an expressive variation contingent on performance. Consistent with the latter claim, the project hypothesises that swung subdivisions also occur in djembe dancing. Support of this hypothesis would have implications for metric theory, where recent advances (London, 2012) contradict the long-assumed constraint for metric fast pulses at the level of beat subdivision to be isochronous.

H3: The study of interpersonal entrainment in music ensembles is a growing field of research (Clayton et al., 2020) but has rarely been extended to music-dance interaction. It is plausible to assume that individual timing and ensemble synchronisation will be less precise in dance than in music due to more substantial physical and kinematic constraints and a lack of auditory feedback in dancing. DjembeDance nevertheless hypothesises that keeping time together in djembe performance does not involve only dancers adapting to musicians but equally involves musicians adapting to dancers. Empirical testing of this hypothesis through measurements of musicians' and dancers' local tempo adjustments and reciprocal timing adaptations therein will allow us to reconsider the prevalent conceptualisation of dance as a response to music and perhaps revise it by adding the complementary perspective of music as a response to dance (cf., Chernoff, 1979).

The project's approach to addressing the above research questions and hypotheses requires the interaction of four different work packages (WP): a theoretical, a qualitative, an experimental, and a computational one.

WP1: Theoretical development The first work package will develop the theorisation of multimodal rhythm in the project. The PI will engage in a literature survey on rhythm studies in various disciplines, including ethnomusicology, ethnochoreology, empirical musicology, dance cognition, movement science, and psychology of perception. After the doctoral and postdoctoral fellows have joined the team, the task will be to establish common ground and shared understandings, across modalities and disciplinary perspectives, of basic analytical concepts, e.g., pulse, beat, and metre; rhythmic accent and grouping; and groove and swing. These concepts have been established and elaborated mainly in the study of music (London, 2012; Danielsen, 2018) but hold the potential to be extended to dance (Jordan, 2000, 2021).

WP2: Qualitative choreomusicology The second work-package concerns qualitative analyses. The focus is on music and dance analysis of recordings from the DjembeDance corpus. In addition, the PI and PhD fellow will conduct fieldwork in Senegal to investigate the practice of djembe music and dance performance in its socio-cultural context. (The original plan to do fieldwork in Mali was cancelled due to the worsening of political stability and the security situation in the country. Prioritizing risk avoidance, "plan B" was activated, which consists of inviting artists from Mali to travel to neighbouring Senegal and work with them there.) This is necessary for methodological reasons, for example, to assess which pieces and musical phrases/dance steps in the recorded corpus can be considered typical. Furthermore, it is essential to consider the culture bearers' practices and opinions (e.g., local pedagogy and aesthetics) to form plausible theoretical concepts for rhythm analysis.

WP3: Experimental psychology The third work package experimentally tests rhythm perception in auditory (drumming), visual (dance), and audio-visual (drumming and dance) representations of djembe performance. Participants from Mali will perform a synchronisation tapping/clapping tasks on stimuli constructed from selected audio and video/mocap recordings excerpts. The results will allow us to estimate the temporal granularity of rhythm perception across modalities, the location of rhythmic accents in complex sounds and dance gestures, and the location of metric beats relative to rhythmic phrases/gestures.

WP4: Computational corpus analysis The fourth work package is dedicated to the computational analysis of the DjembeDance corpus, informed by considerations of ethnomusicology and ethnochoreology (WP2) and

psychology of perception (WP3). Video and mocap raw data (approx. 2TB) will be re-rendered to open-source file formats balancing quality and file size and synched to the audio based on physical clapperboard signals recorded in all media. Discrete symbolic information (timing, pitch/timbre) will be extracted from the multi-track audio recordings; all events will be accorded a metric position status based on experts' manual annotation of metric cycle start points (Polak et al., 2016; Jacoby et al., 2021). A toolbox will be developed to flexibly analyse and visualise mocap data as animated point-light figures (Laczkó & Jensenius, 2021) in parallel to video, audio, and symbolic data.

Machine learning dimension reduction techniques will uncover low-dimensional but still rich representations of the dancing body, avoiding reductionist approaches such as relying on single isolated body parts. Position, velocity, and acceleration will be explored as criteria for identifying rhythmic accents or "anchor points" (Burger et al., 2014) in dance gestures. Descriptive statistics of the temporal alignment of rhythmic accents in the dance movement with various layers in the musical ensemble rhythm will then allow testing H1, whether multimodal djembe rhythm supports a metric beat hierarchy or instead suggests metric ambiguity, and H2, whether subdivision timing structure is congruent or incongruent across modalities. Linear causal modelling will compute mutual timing adaptations and estimate coupling strengths and directionalities amongst musicians and dancers, allowing for an estimation of crossmodal ensemble entrainment (H3).

Advanced AI techniques, including supervised and unsupervised machine learning and clustering methods, will explore hitherto unforeseen temporal structures in the music and especially in the dance, potentially recognising unimodal or bimodal patterns that may inspire new research questions and hypotheses.

Each of the four work packages consistently grants music and dance the same type and degree of focus. This systematic parallelism in research perspective (Fig. 3), in conjunction with the multimethod approach realised in the four different work packages (Fig. 4), promises to elicit novel insights into the relations, interactions, and integration of both domains and the multimodal nature of rhythm therein.
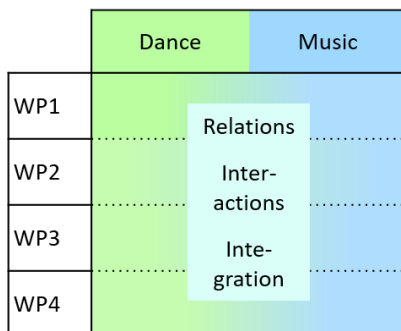

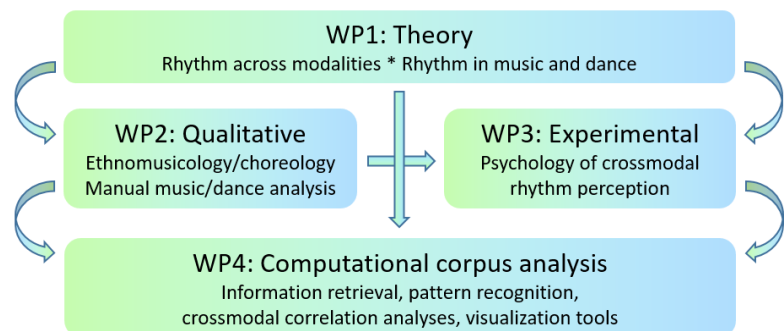Figure 3: Dual research perspective across WPs

Figure 4: Scheme of basic information flows between WPs

Risk management The recording of a technically sophisticated multimedia corpus with mobile studio equipment in fieldwork conditions in Mali was a significant risk involved in DjembeDance. However, this is solved, as the PI already collected the recordings in 2018. The original formulation of the risk management plan considered that further fieldwork (WP2) may be hampered by conditions of medical crisis (e.g., COVID-19) or political instability in Mali. The latter unfortunately has come true, so that fieldwork will be carried out in neighbouring Senegal instead.

WP3: In cross-cultural contexts, psychological experimentation can be problematic, especially with populations with low degrees of formal education, as in Mali. The project minimises this risk by relying on behavioural tasks such as synchronisation tapping and not, for instance, psychophysical discrimination tasks. The close resemblance to vernacular behaviours such as hand-clapping, and minimal dependence on semantic concepts, make synchronisation tapping an apt experimental paradigm for cross-cultural application, including in Mali (cf. Polak et al., 2018).

WP4: The potential risk that djembe dance analysis will not provide sufficiently distinct rhythmic accents (i.e., clear temporal markers) for direct comparison with musical accents is low, as djembe dance uses a lot of quick shifts of weight or jumps at the beat level plus fast footwork and partly also rapid movement in shoulder, breast, and arms. In this context, salient acceleration peaks and end-points in positional trajectories can be expected to define rhythmic anchor points (cf. Burger et al., 2014).

Interdisciplinary approach DjembeDance is strongly interdisciplinary along the dimensions of research materials (music and dance) and particularly methodologies (ethnographic interpretation, psychological experimentation, and computational corpus analysis). Alongside opportunities for novel perspectives, this also bears the risk of miscommunication and incompatibilities. However, the PI has successfully coordinated interdisciplinary teams in the past. Furthermore, the project will profit from a strongly multidisciplinary Local Expert Group and Scientific Advisory Board, whose members have successfully directed large-scale interdisciplinary projects (e.g., A. Danielsen, M. Clayton, and N. Jacoby). This assures that DjembeDance will provide the best possible benefit while dealing with the potential problems of interdisciplinarity.

Ethical considerations and data management The recordings in Mali in 2018 were made in accordance with the Helsinki declaration and covered by the ethics approval of the Max Planck Institute for Empirical Aesthetics (MPIEA), Germany. Artists recorded in studio sessions were well paid and gave informed consent. In addition, culturally sensitive ethics procedures were developed and applied in the case of recording public social events: consent was asked from local authorities; traditional spokespersons (*griots*) announced the recording process, and public consent was given through acclamation; ritual and financial gifts were offered to the event-hosting local cultural association. A separate approval of personal data collection according to the standards of UiO and the Norwegian Agency for Shared Services in Education and Research will be obtained for further behavioural research, including fieldwork and psychological experiments. The data transfer from MPIEA (Germany) to RITMO/University of Oslo (Norway) was legally regulated in a data transfer agreement signed by both institutions. RITMO will host the DjembeDance corpus in Norway according to national privacy and security standards. Later, the corpus will be published in a scientific data repository, and accessible copies will be returned to performers and their communities in Mali.

Gender and diversity perspectives The balanced focus of DjembeDance on mostly female dancing and mostly male drumming allows for gender-balanced recruitment of research participants in Mali and also works against the male bias in academic and popular representations of West African culture in Europe. While computational musicology is strongly male-biased, female representation is better in ethnomusicology/ethnochoreology. Consistent with RITMO's Diversity Action Plan, DjembeDance will take measures to avoid male over-representation when recruiting the project team and particularly the two research fellows (PhD and Postdoc). Furthermore, the PI is aware of the burning problem of structural racism inherent in academia, including music and dance research, and will address this by securing BIPOC representation in the core of the project team (research fellows). In addition, African representation will be established by hiring a research assistant in Mali (MA, 2 years 50%, 1 year 20%) who will pursue a PhD project at a Bamako university in parallel with his/her work for DjembeDance.

1.3 Novelty and ambition

DjembeDance is highly innovative in three regards. The first concerns cultural diversity. Choreomusicological theory has repeatedly suggested rhythm as a particularly plausible and productive aspect for the study of music-dance relationships (Felföldi, 1995; Jordan, 2000, 2021; Kaminsky, 2014; Haugen, 2021), and **West African drumming and dancing globally count as core examples of rhythmic excellence in human performance, but rhythm has never been studied cross-modally in this vast area**. Second, the project is the first to **apply computational methods to a music-dance dataset compiled in the spirit of systematic corpus curation**. Specifically, the DjembeDance corpus goes beyond existing data sets in the field in several respects: its large scale and systematic construction, representing the repertoire of a style performed by different ensembles; its equal focus on music and dance through parallel multitrack audio, two-camera video, and mocap recording; and its ecological validity by recruiting full-fledged music and dance ensembles spontaneously interacting during both live studio sessions and real-world social events. These design features will allow the project to advance the level of scientific rigour in the field by estimating the relative contribution of various otherwise intractable yet potentially fundamental factors, e.g., different repertoires within a style/genre, individual performers, ensembles, and performance roles (e.g., solo vs group dance). Third, **DjembeDance is the first choreomusicological project combining corpus analysis with qualitative and psychological methods**. This will allow for a depth of theoretical synthesis and methodological triangulation, which goes beyond what single-researcher projects or looser forms of collaboration can achieve.

2. Impact

2.1 Potential for academic impact of the research project

In choreomusicology, DjembeDance will set reference standards for the culturally sensitive and systematic curation of multimedia corpora and their multi-method analysis. It will demonstrate the relevance of the nascent field by contributing directly and significantly to long and hotly debated issues in the humanities and the sciences, for example, African polymetre and cognitive constraints on rhythm-metre relationships. A further impact can be expected on the dimension of cultural diversity, as the lack thereof involves a cultural bias towards the Global North, which has been identified as a major methodological problem in the human sciences (Henrich et al., 2010). In this context, it would be a solid political statement if, in a technologically advanced and scientifically promising field of research, the standard reference could be laid down in a landmark case study from Africa. Finally, at the general level of theorising rhythm in human expressive behaviours, the robust evidence that the project promises to provide can motivate a shift of the prevalent conception of dance as essentially a response to music towards a conceptualisation of music-dance relationships as bidirectional and interactive, and of rhythm as essentially multimodal.

2.2 Potential for societal impact of the research project

DjembeDance targets several of the UN's Sustainable Development Goals. It involves job opportunities (#8) with local musicians, dancers, and academic research assistants in Mali, reducing inequality and poverty (#1,10). Djembe drumming is popular worldwide today due to the processes of cultural globalisation. This has lifted the genre's previously marginalised status in the country (Polak, 2000) and contributed to the culture bearers' communities' cultural identity and well-being (#3,11). Academic research does play a role in this respect. In the past, the Malian state broadcast (ORTM) in its weekly folklore show had used ethnographic videos from the PI's earlier projects. The same can be expected for DjembeDance.

In Europe, the djembe drum is mainly used for percussion music in the classroom and drum circles for rhythmic community experience; at the same time, it inevitably also functions as an emblematic representation of "African" culture. DjembeDance can positively affect the much-needed scientific grounding of djembe pedagogy in the Global North (see below, Activities). This impact can occur on the level of theory, e.g., emphasising the multimodal nature of djembe performance. In addition, impact on pedagogy can be embodied in the materials DjembeDance will provide to the public, particularly the corpus of recordings in combination with tools that allow online access, interactive navigation, and dynamic visualisation of characteristics of the pieces within the corpus; this can help reveal to teachers and students of West African percussion the richness and particularities of rhythm in djembe music and dance, and their interactions.

2.3 Measures for communication and exploitation

Oral presentation and publication The approach and findings of DjembeDance will interest researchers in several disciplines. Therefore, team members will present at international conferences across a range of target communities, including ethnomusicology and ethnochoreology (e.g., ICTM World Conference, ICTM Study Group for Ethnochoreology, SEM, AAWM), music cognition (e.g., ESCOM/ICMPC, SEMPRE), computational musicology (e.g., ISMIR, FMA), and the cognitive and performance sciences of rhythm (e.g., RPPW, TRF). Likewise, we plan to publish the results in music/dance-oriented journals in the humanities (e.g., Ethnomusicology, Yearbook for Traditional Music, Journal for Music Theory, Dance Research) and the sciences (e.g., Music and Science, Music Perception). In addition, we will aim to target general audiences with one summary research paper (e.g., Proceedings of the Royal Society B) and one target article with multiple commentaries and responses (e.g., Current Anthropology); the latter will emphasise the issue of cross-rhythm and polymetre in African performance to focus methodological discussion and instigate theoretical debate.

Activities DjembeDance will host a week-long djembe summer workshop for professionals and students in the field of music and dance education. Project team members will present their key findings; the PI, with a team of invited artists from Mali (three drummers and three dancers), will give practical djembe performance and pedagogy classes and illustrate the relevance of academic findings therein. A general emphasis will be

to communicate the decidedly multimodal characteristics of djembe performance in its West African context of origin and consider the implications of this basic fact for the community-building effects associated with djembe performance in Mali and in the Global North.

During their stay in Oslo, the Malian drummers and dancers will also participate in research projects beyond DjembeDance, further contributing to the cultural diversification of technologically advanced music and dance research at RITMO.

Moreover, DjembeDance will host the biannual symposium of the ICTM Study Group on Sound, Movement, and the Sciences (SoMoS 2024), which will spotlight the project and the RITMO cluster at large.

3. Implementation

3.1 Project manager and project group

The **Project Manager**, Rainer Polak, is a senior researcher who has successfully attracted funding and led interdisciplinary research projects at universities and research institutes in Germany. Polak is experienced in writing for music/dance-specific and general audience journals, reviewing and editing, and advising students and early career researchers. He is considered a leading international expert on West African drumming in anthropology, ethnomusicology, music theory, empirical musicology, and cognitive psychology. His research systematically includes and makes prominently visible for the first time African performance genres and research participants in empirical research in rhythm perception and production. This already has had a considerable impact, for instance, on the theory of metre to embrace the cognitive possibility of non-isochronous "swung" pulse-trains functioning as metric reference frameworks (London, 2012). Polak also has worked professionally as a djembe dance-drummer in Mali and taught djembe music in Germany, Austria, and beyond, e.g., at CODARTS University of the Arts, Rotterdam (NL). The **Project Owner** (RITMO/Department of Musicology) at UiO is committed to hosting the project and developing this area of research and has therefore **hired the project manager** (Polak) as of June 1, 2022.

In addition to **directing the project**, the Project Manager will be **responsible for theoretical development** (WP1) **and ethnomusicological and music analysis components** in qualitative choreomusicology (WP2), psychological experimentation (WP3), and computational corpus analysis (WP4). Polak also will conduct fieldwork in Mali and co-supervise the PhD student.

The **Project Group** will include two research fellows (1 PhD, 1 Postdoc) and research assistants in Oslo as well as in Mali; a temporary researcher (6 months) will help get the project off the ground.

- **PhD** (100%, 3 years) will have a background in **ethnochoreology and dance analysis**. The fellow will focus on qualitative dance analysis (WP2) and inform cognitive and computational dance analyses (WP3,4).
- **Postdoc** (100%, 3 years) will have a background in music and dance **information retrieval and computer science,** including AI/machine learning, preferably with knowledge of human movement science. The fellow will be responsible for the computational analysis of rhythm in music, dance, and music-dance relationships (WP4) and contribute to qualitative and cognitive analyses (WP2,3).
- **Researcher** (100%, 6 months) experienced in human motion analysis (dance or sports) based on 3D motion capture will drive the integration of this technologically challenging and least standardized method at the very beginning of the project, ensuring its usability across the project team.
- Students in Oslo will work as **research assistants** in domains including data infrastructure and visualization, video annotation, interview transcriptions, internet presence, and organisation of events.
- **Research assistant based in Bamako** (50%, 2 years; 30%, 1 year) will be a **Malian national** with an MA degree and experience in organising, conducting, and managing research. The assistant will prepare and accompany fieldwork in Mali; communicate with local authorities; recruit participants; conduct, transcribe, and translate interviews; and conduct experiments, among other duties. (WP2,3).

A **Local Expert Group** at RITMO (UiO) will closely accompany the project, advising the team members, collaborating directly on work packages, and co-authoring research papers:
- Prof. Anne Danielsen (dance music and rhythm studies): theory (WP1), co-supervision of PhD student

- Prof. Bruno Laeng (psychology of crossmodal perception): experimental design and analysis (WP3)
- Dr. Olivier Lartillot (music information retrieval, computational music analysis): automated transcription, visualisation, and analysis toolbox for music (audio) and dance (mocap) data (WP4)
- Prof. Alexander Refsum Jensenius (audio-visual rhythm, movement science): mocap analysis (WP4)

In particular, WP4 will benefit significantly from the internationally leading expertise in audio/video/mocap-based information retrieval, analysis, and visualisation of music and movement data, which is an outstanding strength of RITMO (Jensenius, 2013; Danielsen, Haugen, & Jensenius, 2015; Lartillot, Nymoen, Câmara, & Danielsen, 2021; www.uio.no/ritmo/english/projects/mirage/).

An international **Scientific Advisory Board** (SAB) will meet two times in Oslo to help steer the project and exchange with the project during small-group and one-to-one virtual meetings in between. The broad inter-disciplinary composition of DjembeDance is represented in the board:

- Prof. Kofi Agawu: African music, musicology, and music theory (Graduate Center, CUNY, US)
- Prof. Martin Clayton: ethnomusicology, rhythm, and entrainment (University of Durham, UK)
- Prof. Mats Johansson (University of South-Eastern Norway)
- Prof. Sylvia Antonia Nannyonga-Tamusuza: African music and dance (Makerere University, Uganda)
- Prof. Gediminas Karoblis: ethnochoreology, dance analysis (NTNU, Trondheim)
- Dr. Siri Mæland: dance analysis (Norwegian Centre for Traditional Music and Dance, Trondheim)
- Dr. Elina Seye: African dance, ethnochoreology (University of Helsinki, Finland)
- Prof. Kate Stevens: music and dance cognition (University of Western Sydney, Australia)
- Prof. Peter Keller: joint action coordination, social psychology of music (Aarhus University, Denmark)
- Prof. Alan Wing: movement science (University of Birmingham, UK)
- Dr. Nori Jacoby: music cognition and computer science (MPI for Empirical Aesthetics, Germany)
- Prof. Justin London: music theory and cognitive science (Carleton College, US)

Several SAB members will also contribute directly to the project: Karoblis will co-supervise the PhD student; Mæland will help to develop an integrated music-dance notation system (WP2); Jacoby will assist with computational analyses, including AI/machine learning methods (WP4); London will be a visiting researcher at RITMO on a sabbatical (fall 2023), contributing to theorisation (WP1) and experimental design (WP3).

3.2 Project organization and management

Work Plan The Gantt chart outlines a sketch of the project structure

Year	2023		2024				2025				2026				2027	
Quarter	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Milestones	M1		M2	M3	M4	M5			M6			M7		M8		M9
WP1 (Theoretical)	▓	▓	▓	▓										▓	▓	▓
WP2 (Qualitative)			▓	▓	▓	▓	▓	▓	▓							
WP3 (Experimental)		▓	▓	▓	▓	▓	▓	▓	▓							
WP4 (Computational)			▓	▓	▓	▓	▓	▓	▓							
Team member periods — Researcher		▓	▓	▓												
Team member periods — Postdoc			▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓		
Team member periods — PhD		▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓			
Team member periods — RA (Mali)		▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Team member periods — RA (Oslo)			▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓

Milestones

- M1 Establishing the project (recruiting, ethics, data infrastructure, project website); Recruits' arrival
- M2 First field-trip to Mali (PhD and PI, WP2), including piloting the psychological experiment (WP3); First exploration of information retrieval and rhythmic accent definition in corpus data (WP4)
- M3 First SAB meeting with the project group
- M4 First computational analyses (WP4)
- M5 Second field trip to Mali (PhD, PI), including psychological experimentation (WP3)
- M6 Djembe Summer Workshop
- M7 Submission of music/dance-specific papers; Publication of software toolbox; Submission of PhD thesis; Final SAB meeting
- M8 PhD thesis defence; Submission of general-audience papers, monograph, and special issue
- M9 Project closure (final report and webpage, corpus publication, follow-up project conceptualisation)

Deliverables

- D1 Open source publication of the DjembeDance corpus (PI, Postdoc)
- D2 Toolbox for automated djembe music and dance information retrieval, visualization, and analysis
- D3 Peer-reviewed research papers in music/dance-related journals (approx. 4)
- D4 Two peer-reviewed summary and theory papers in high-profile general-audience journals
- D5 PhD thesis submitted (PhD fellow)

Research infrastructure and environment The RITMO Centre will host the project; RITMO is an RCN-funded Centre of Excellence at UiO, gathering a uniquely interdisciplinary group of about 60 researchers from music-related humanities, social sciences, and engineering disciplines. This is an ideal environment for Djembe-Dance to bridge the gap between ethnomusicology, ethnochoreology, computational musicology, and movement science. Particularly noteworthy is how the project would profit by having an internationally-leading concentration of skills in computational musicology and multimodal (audio-visual) rhythm research and the methodology of motion-tracking (mocap) therein. Alongside standard services such as administration, workplace, and a library which UiO commits to providing, the facilitation of data management and storage support from the IT services at RITMO/UiO will be of particular importance since the project is based on an extensive data set of digital recordings, the DjembeDance corpus.

Organisation and management structure The project team will meet weekly to follow the research progress closely and identify and resolve problems early to keep the research flowing. Monthly seminars will discuss literature, reflect on and manage work progress, and develop publication plans and materials. In addition to intra-project activities, team members will participate in all weekly, monthly, and semi-annual centre-wide formats for researcher-group exchange. The doctoral student will be trained in the Department of Musicology at UiO and join the RITMO Career Development Program, which formally advises and accompanies early career researchers in making plans and appropriating skills to successfully present and establish themselves after graduation within or without academia.

References

Agawu, V. K. (2003). *Representing African music: Postcolonial notes, queries, positions*. Routledge.

Agawu, V. K. (2006). Structural analysis or cultural analysis? Competing perspectives on the "standard pattern" of West African rhythm. *Journal of the American Musicological Society*, *59*(1), 1–46.

Benadon, F. (2006). Slicing the beat: Jazz eight-notes as expressive micro-timing. *Ethnomusicology*, *50*, 73–98.

Burger, B., Thompson, M. R., Luck, G., Saarikallio, S. H., & Toiviainen, P. (2014). Hunting for the beat in the body: On period and phase locking in music-induced movement. *Frontiers in Human Neuroscience*, *8*, 903.

Chernoff, J. M. (1979). *African rhythm and African sensibility*. University of Chicago Press.

Clayton, M., Jakubowski, K., Eerola, T., Keller, P. E., Camurri, A., Volpe, G., & Alborno, P. (2020). Interpersonal entrainment in music performance. *Music Perception*, *38*(2), 136–194.

Danielsen, Anne (2018). Pulse as dynamic attending: Analysing beat bin metre in neo soul grooves. In Scotto, Ciro; Smith, Kenneth M. & Brackett, John (Eds.), *The Routledge companion to popular music analysis*. Routledge.

Danielsen, A., Haugen, M. R., & Jensenius, A. R. (2015). Moving to the beat: Studying entrainment to micro-rhythmic changes in pulse by motion capture. *Timing & Time Perception, 3*(1-2), 133–154.

Felföldi, L. (1995). The connection of dance and dance music: Over- or under-estimation of their significance. In G. Dąbrowska (Ed.), *Dance, ritual and music* (pp. 189–194). Polish Society for Ethnochoreology.

Fitch, W. T. (2016). Dance, music, meter and groove: A forgotten partnership. *Frontiers in Human Neuroscience*, *10*, 64.

Haugen, M. R. (2021). Investigating music-dance relationships: A case study of Norwegian telespringar. *Journal of Music Theory, 65*(1), 17–38.

Haugen, M. R., & Danielsen, A. (2020). Effect of tempo on relative note durations in a performed samba groove. *Journal of New Music Research*, *49*(4), 349–361.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Most people are not WEIRD. *Nature*, *466*, 29.

Jacoby, N., **Polak**, R., & London, J. (2021). Extreme precision in rhythmic interaction is enabled by role-optimized sensorimotor coupling: Analysis and modelling of West African drum ensemble music. *Philos. Trans. Royal Soc. B, 376*, 20200331.

Jensenius, A. R. (2013). Some video abstraction techniques for displaying body movement in analysis and performance. *Leonardo, 46*(1), 53–60.

Jordan, S. (2000). *Moving music: Dialogues with music in twentieth-century ballet*. Dance Books.

Jordan, S. (2021). Introduction. Music and dance: Special issue on choreomusical analysis. *Journal of Music Theory*, *65*(1), 3–9.

Kaminsky, D. (2014). Total rhythm in three dimensions: Towards a motional theory of melodic dance rhythm in Swedish polska music. *Dance Research*, *32*(1), 43–64.

Laczkó, B., & Jensenius, A. R. (2021). Reflections on the development of the Musical Gestures Toolbox for python. *Proceedings of the Nordic Sound and Music Computing Conference.*

Lartillot, O., Nymoen, K., Câmara, G. S., & Danielsen, A. (2021). Computational localization of attack regions through a direct observation of the audio waveform. *The Journal of the Acoustical Society of America, 149*(1), 723–73.

Lerdahl, F., & Jackendoff, R. (1983). *A generative theory of tonal music*. MIT Press.

Levinson, S., & Holler, J. (2014). The origin of human multi-modal communication. *Philos. Trans. Royal Soc. B, 369*, 20130302.

Levitin, D. J., Grahn, J. A., & London, J. (2018). The psychology of music: Rhythm and movement. *Annu. Rev. Psychol.*, *69*, 51–75.

Locke, D. (2011). The metric matrix: Simultaneous multidimensionality in African music. *Analytical Approaches to World Music*, *1*(1), 48–72.

London, J. (2012). *Hearing in time: Psychological aspects of musical meter* (2. ed.). Oxford University Press.

London, J., **Polak**, R., & Jacoby, N. (2017). Rhythm histograms and musical meter: A corpus study of Malian percussion music. *Psychonomic Bulletin & Review*, *24*(2), 474–480.

Magill, J., & Pressing, J. (1997). Asymmetric cognitive clock structures in West African rhythms. *Music Perception*, *15*(2), 189–222.

Mogan, R., Fischer, R., & Bulbulia, J. A. (2017). To be in synchrony or not? A meta-analysis of synchrony's effects on behavior, perception, cognition and affect. *Journal of Experimental Social Psychology*, *72*, 13–20.

Nannyonga-Tamusuza, S. A. (2015). Music as dance and dance as music: Interdependence and dialogue in Baganda *baakisimba* performance. *Yearbook for Traditional Music*, *47*, 82–96

Naveda, L. A. (2011). *Gesture in samba: A cross-modal analysis of dance and music from the Afro-Brazilian culture*. [PhD dissertation thesis]. Ghent University, Ghent.

Nzewi, M. E. (1997). *African music: Theoretical content and creative continuum.* Institut für Didaktik populärer Musik.

Phillips-Silver, J., & Trainor, L. J. (2008). Vestibular influence on auditory metrical interpretation. *Brain and Cognition*, *67*, 94–102.

Polak, R. (2000). A musical instrument travels around the world: Jenbe playing in Bamako, West Africa, and beyond. *The World of Music*, *42*(3), 7–46.

Polak, R. (2007). Performing audience: On the social constitution of focused interaction at celebrations in Mali. *Anthropos*, *102*(1), 3–18.

Polak, R. (2010). Rhythmic feel as meter: Non-isochronous beat subdivision in jembe music from Mali. *Music Theory Online*, *16*(4).

Polak, R. (2012). Urban drumming: Traditional celebration music in a West African city (Bamako). In E. S. Charry (Ed.), *Hip hop Africa: New African music in a globalizing world* (pp. 261–281). Indiana University Press.

Polak, R. (2021). Presenting yourself through dance: Participatory and presentational aspects of dance performance at local festivities in southern Mali. In V. Apjok, K. Povedák, V. Szőnyi, & S. Varga (Eds.), *Dance, Age and Politics: Proceedings of the 30th Symposium of the ICTM Study Group on Ethnochoreology* (pp. 67–82). University of Szeged.

Polak, R., Jacoby, N., Fischinger, T., Goldberg, D., Holzapfel, A., & London, J. (2018). Rhythmic prototypes across cultures: A comparative study of tapping synchronization. *Music Perception*, *36*(1), 1–23.

Polak, R., Jacoby, N., & London, J. (2016). Both isochronous and non-isochronous metrical subdivision afford precise and stable ensemble entrainment: A corpus study of Malian jembe drumming. *Frontiers in Human Neuroscience*, *10*, 285.

Repp, B. H., & Su, Y.-H. (2013). Sensorimotor synchronization: A review of recent research. *Psychon. Bull. Rev.*, *20*(3), 403–452.

Spence, C. (2007). Audiovisual multisensory integration. *Acoustical Science and Technology, 28*(2), 61–70.

Stepputat, K., & Seye, E. (2020). Introduction: Choreomusical perspectives. *The World of Music*, *9*(1), 7–24.

Su, Y.-H. (2014). Audiovisual beat induction in complex auditory rhythms. *Acta Psychologica*, *151*, 40–50.

Thompson, R. F. (1974). *African art in motion: Icon and act*. University of California Press.

Veroli, P., & Vinay, G. (Eds.). (2017). *Music-Dance*. Routledge.

Welsh-Asante, K. (Ed.). (1998). *African dance: An artistic, historical, and philosophical inquiry*. Africa World Press.

Wilson, M., & Cook, P. F. (2016). Rhythmic entrainment: Why humans want to, fireflies can't help it, pet birds try, and sea lions have to be bribed. *Psychonomic Bulletin & Review*, *23*(6), 1647–1659.