

Embodied Rhythms: Interdisciplinary Perspectives on the Perception of Rhythm in Audiovisual and Immersive Media

An Introduction*

Adriano D'Aloia, Ruggero Eugeni, Maria Alessandra Umiltà**

ISSN: 03928667 (print) 18277969 (digital)

DOI: 10.26350/001200_000272

Creative Commons License CC-BY-NC-ND 4.0

Rhythm has always been a recurring theme in our tradition, without ever becoming its central focus¹.

1. The return of a ghost

If Derrida was right – if rhythm has haunted Western thought like a specter – then two features of that haunting stand out with particular clarity today.

First, the specter has been appearing with unusual insistence, and in many houses and castles at once, often forcing their inhabitants out of isolation to compare reactions and strategies. Setting the metaphor aside, the *unheimlich* return of rhythm can be observed in the most diverse fields: from literature to the visual arts, from music to discourse analysis, from philosophy to theology, and from the humanities to the experimental sciences, cog-

Contributo sottoposto a *double-blind peer review*.

* This introduction, and the special issue as a whole, is one of the outputs of the PRIN project “Movement Experience Through Rhythmic Organization in Audiovisual Representational Texts” (METRO_ART, 2022MRWN2K), funded by the Italian Ministry of University and Research (MUR), NextGeneration EU and Italia Domani programmes. The project was coordinated by Ruggero Eugeni (Università Cattolica del Sacro Cuore, PI), Adriano D'Aloia (Università degli studi di Bergamo) and Maria Alessandra Umiltà (Università di Parma). The authors wish to thank all the colleagues involved in the project.

** Adriano D'Aloia, Università degli Studi di Bergamo – adriano.daloia@unibg.it; Ruggero Eugeni, Università Cattolica del Sacro Cuore, Milano – ruggero.eugeni@unicatt.it; Maria Alessandra Umiltà, Università degli Studi di Parma – mariaalessandra.umilta@unipr.it.

¹ J. Derrida, “Désistance” [1979], in *Psyche: Inventions of the Other*, vol. II, Stanford (CA): Stanford University Press, 2008: 196-230 (223).

nitive neuroscience in particular. A growing number of multi- and interdisciplinary inquiries have taken shape in response to the attention that rhythm now demands².

Second, this return differs from earlier ones. Rhythm is shedding the somewhat rigid and outdated trappings of a more or less constraining structure and taking the form of fluid, modular and negotiable patterns that permeate the experience of human and non-human subjects and shape their trajectories at different scales. A series of questions follows directly from this new experiential status, and connects the various contemporary manifestations of rhythm: its 'embodied' character, that is, its reference to the body and especially to motor activity, movement and sensorimotor processes; its intersensory – or, in other terminologies, intermodal – dimension, which engages vision, hearing, and touch simultaneously, as well as proprioception and interoception; the question of the thresholds at which rhythmic perceptions and actions are triggered and of their scope, including the more or less tenable distinction between perceptible forms of movement and forms of its repetition; and the relation between personal rhythms and the dynamics of synchronization and attunement with others in everyday practices, in musical performance and listening, in the execution of dance movements, and so on. Last but not least, there is the question of how the 'old' rhythm understood as structure – which we might, somewhat simplistically, call 'meter', and which in audiovisual media is also called 'pace' – relates to the living, experienced rhythm of the present³: must we kill the father, or come to terms with him and grant that there is no rhythm without meter, and no meter without rhythm?

This issue of *Comunicazioni Sociali* does not claim to address all these questions, and certainly not to address them *directly*. The criterion that guided the selection and arrangement of the essays was instead to use the specific domain of visual, audio, audiovisual and extended-reality media as a testing ground for a theoretical, analytical and experimental reflection on rhythm

² Representative contributions to the recent revival on rhythm studies include: J. Henriques, M. Tiainen, P. Väliäho, "Rhythm Returns: Movement and Cultural Theory", *Body & Society*, 20, 3-4 (2014): 3-29; P. Cheyne, A. Hamilton, M. Paddison, eds., *The Philosophy of Rhythm: Aesthetics, Music, Poetics*, Oxford-New York: Oxford University Press, 2019; P. Crespi, S. Manghani, eds., *Rhythm and Critique: Technics, Modalities, Practices*, Edinburgh: Edinburgh University Press, 2020; S.J. Keyser, *Play It Again, Sam: Repetition in the Arts*, Cambridge (MA)-London: The MIT Press, 2025; M. Lussier, R.C. Sha, eds., *The Rise of Rhythm Studies: Mediating Dimension, Discipline, and Scale*, New York-London: Bloomsbury, 2026.

³ This fundamental distinction has a long and complex history: see C. Hasty, *Meter as Rhythm*, 20th anniversary edition, Oxford-New York: Oxford University Press, 2020.

within the current debate. The issue forms part of the output of a project devoted precisely to this set of problems and directed by the three editors, although it also hosts authors from outside the project's research units.

This introduction proceeds in six further steps. Section 2 explains why the media we consider constitute an exemplary and fruitful field for contemporary research on rhythm; section 3 introduces neurofilmology, which brings the theory and analysis of audiovisual media together with the contemporary neurocognitive sciences; section 4 examines what those sciences have established about rhythm and what audiovisual theory can draw from it; section 5 presents the essays collected here; and section 6 sketches the questions that remain open.

2. Cinematic media as an exemplary field for research on rhythm

There is hardly any need to recall how central rhythm has been to the theories and practices of cinema and film. The metaphor of film as 'visual music', in particular, has fueled a long series of contributions and an equally long series of critical discussions⁴. It is enough to note that for roughly a decade the 'experiential turn' in rhythm studies has also entered the debate on audiovisual media, bringing with it many of the concerns outlined above.

The starting point is the idea that the primary site for the analysis of rhythm is not the film but the forms of the viewer's experience. This assumption has also brought renewed attention to authors with a phenomenological background who had been somewhat forgotten, above all Jean Mitry⁵. From this common premise, however, scholars diverge on several points.

The first divergence concerns the textual elements responsible for the rhythmic modulation of the viewer's experience. Some scholars emphasize editing and shot duration⁶, while others insist on the complex, multi- and

⁴ L. Guido, *L'âge du rythme: cinéma, musicalité et culture du corps dans les théories françaises des années 1910-1930*, Lausanne: Payot, 2007. The metaphor of cinema-as-music has recently been reformulated from an experiential perspective by D. Kulezic-Wilson, *The Musicality of Narrative Film*, New York: Palgrave Macmillan, 2015.

⁵ J. Mitry, *The Aesthetics and Psychology of Cinema* [1963-1965], partial translation by C. King, Bloomington-Indianapolis: Indiana University Press, 1997. For a reassessment of Mitry's contemporary relevance, see A. Gaudin, "From Visual Rhythm to the 'Spatial Rhythm of the Visible': Toward a Musicality Specific to Cinema", *Itinéraires. Littérature, textes, cultures*, 2024, DOI: 10.4000/121sh; D. Lash, "Towards an Account of Rhythmic Phrasing in Narrative Film", *Screen*, 66, 4 (2025): 475-497.

⁶ See, for example, J.E. Cutting, A. Candan, "Shot Durations, Shot Classes, and the Increased Pace of Popular Movies", *Projections*, 9, 2 (2015): 40-62; J.E. Cutting, K. Pearlman, "Shaping Edits, Creating Fractals: A Cinematic Case Study", *Projections*, 13, 1 (2019): 1-22.

intersensory – or metasensory – nature of cinematic rhythms and on their effects at different scales of experience, which in turn raises the question of a hierarchy among them: “There are the rhythms of editing, certainly, but also of physical gestures and other movements, of shifting visual patterns, of speech, of music – not to mention questions of narrative rhythm and related phenomena”⁷.

The second concerns the elements that define rhythm. Studies focused on editing foreground durations, segmentations and groupings of elements; other approaches explore the link between rhythm and the management of energy flows and bursts, and therefore give priority to beats and to the visual and auditory accents of audiovisual flows⁸.

The third concerns the scope of the object. Does it make sense to study audiovisual rhythm in itself, as an autonomous phenomenon, or should it rather be analyzed in relation to broader ones? The two main candidates that have emerged are “forms of movement” and “modes of being in the sensible” on the one hand⁹, and the viewer’s temporal experience as a whole on the other¹⁰.

Finally, reflection on audiovisual media raises the question of the shaping power of textual structures, and thus of the relation between the forms of the film and the forms of the viewer’s lived experience – a relation described at times in the strong terms of determination and at others in the more fluid terms of mediation¹¹. The problem is not only theoretical but also episte-

⁷ Lash, “Towards an Account of Rhythmic Phrasing”: 478. On the interplay between image and sound, see L. Jacobs, *Film Rhythm after Sound: Technology, Music, and Performance*, Berkeley (CA): University of California Press, 2015.

⁸ I. Pollmann, *Cinematic Vitalism: Film Theory and the Question of Life*, Amsterdam: Amsterdam University Press, 2017; S. Shaviro, *The Rhythm Image: Music Videos and New Audiovisual Forms*, New York-London: Bloomsbury, 2023.

⁹ See, respectively, J. Schonig, *The Shape of Motion: Cinema and the Aesthetics of Movement*, New York: Oxford University Press, 2022, and D. Torlasco, *The Rhythm of Images: Cinema beyond Measure*, Minneapolis: University of Minnesota Press, 2021.

¹⁰ Y. Biró, *Turbulence and Flow in Film: The Rhythmic Design*, translated by P. Salamon, Bloomington: Indiana University Press, 2008; G. Uhlin, “Film Rhythm and the Aporetics of Temporality”, *Quarterly Review of Film and Video*, 36, 2 (2019): 104-124.

¹¹ The idea of rhythm as a structure of “mediation” between the film and its viewer recurs, with different nuances, in A. Hastie, “Rhythm and Clues”, *Film Quarterly*, 68, 2 (2014): 52-56; P. Väliäho, *Mapping the Moving Image: Gesture, Thought, and Cinema circa 1900*, Amsterdam: Amsterdam University Press, 2010; D. von Rüdiger, “Rhythm as the Intermediary of Audiovisual Fusions”, in A. Knight-Hill, ed., *Sound and Image*, London-New York: Focal Press, 2020: 65-82. On this issue see also Lash’s critical discussion, in “Towards an Account of Rhythmic Phrasing”, of R. Warner, “Audiovisual Rhythm and Its Spectator: *Moonlight* as Example”, in K. Stevens, ed., *The Oxford Handbook of Film Theory*, New York-Oxford: Oxford University Press, 2022: 421-444.

mological and methodological: does it make sense to advance hypotheses about the viewer's experience on the basis of an analysis of the texts that are supposed to determine it, if we possess no reliable model of the mechanisms of determination and of their effectiveness? And if not, how else can we gain access to the 'black box' of the rhythm actually lived and experienced by the viewer?

3. Towards a neurofilmological approach

One possible answer to this question comes from the attempts to establish a dialogue between theoretical and text-centered approaches on the one hand and the psychological, cognitive and neurocognitive sciences on the other, in the study of the viewer's experience of media and emerging audiovisual media. A brief detour through this field will make it clearer why, in our view, it offers a particularly productive vantage point on the issues raised by rhythm today.

Early attempts to ground cinematic experience in empirical models of perception took shape within what has been called *psychocinematics*, an interdisciplinary field that investigates how the formal properties of moving images – editing, camera movement, visual complexity, temporal organization – shape viewers' perceptual, attentional, emotional, and cognitive responses, using methods drawn from experimental psychology and psychophysiology¹². Within this framework, rhythm began to be treated not only as an aesthetic feature of film form but also as a measurable variable capable of modulating attention, arousal, emotional engagement and temporal experience.

Neurocinematics extended the dialogue further by introducing neuroimaging and physiological methods into the study of spectatorship. Uri Hasson and colleagues showed that carefully structured cinematic sequences elicit remarkably synchronized neural activity across viewers, suggesting that audiovisual rhythm functions as a powerful mechanism of attentional

¹² A.P. Shimamura, ed., *Psychocinematics: Exploring Cognition at the Movies*, Oxford-New York: Oxford University Press, 2013. See also M.J. Grabowski, ed., *Neuroscience and Media: New Understandings and Representations*, London-New York: Routledge, 2015; T. Nannicelli, P. Taberham, eds., *Cognitive Media Theory*, New York-London: Routledge, 2014. For an aesthetic approach inspired by the cognitive neurosciences of cinema, see M. Smith, *Film, Art, and the Third Culture: A Naturalized Aesthetics of Film*, Oxford-New York: Oxford University Press, 2017; J.M. Zacks, *Flicker: Your Brain on Movies*, New York-Oxford: Oxford University Press, 2015.

guidance and perceptual coordination¹³. Subsequent studies have extended these findings by examining how editing patterns, audiovisual pacing and rhythmic modulation affect eye movements, predictive processing, emotional regulation, physiological synchronization and embodied responses¹⁴. Rhythm thus appears not simply as a compositional strategy but as one of the principal means by which cinema orchestrates collective perception.

A complementary development came from the theory of *embodied simulation*, formulated by Vittorio Gallese and later applied to cinema together with Michele Guerra¹⁵. Drawing on research on the mirror neuron system and on embodied cognition, this perspective holds that cinematic experience rests on a pre-reflective sensorimotor simulation through which spectators internally reenact perceived actions, gestures, emotions and spatial dynamics. Rhythm thereby acquires a specifically corporeal dimension: the temporal organization of movement, editing, camera motion and audiovisual flow become one of the principal vehicles through which films establish an embodied resonance with viewers. Rhythm is thus not merely perceived; it is enacted through motor simulation and affective attunement.

These trajectories have converged within the broader framework of *neurofilmology*, which proposes an integrative model capable of combining empirical neuroscience, cognitive psychology, phenomenology, semiotics, film theory and media archaeology within a unified research programme¹⁶.

¹³ U. Hasson et al., "Neurocinematics: The Neuroscience of Film", *Projections*, 2, 1 (2008): 1-26. For a general overview, see C. Grall, R. Schmälzle, "Neurocinematics", in J. Van den Bulck, ed., *The International Encyclopedia of Media Psychology*, online, DOI: 10.1002/9781119011071.iemp0305.

¹⁴ J.P. Hutson et al., "What Is the Role of the Film Viewer? The Effects of Narrative Comprehension and Viewing Task on Gaze Control in Film", *Cognitive Research: Principles and Implications*, 2 (2017): 46; J.E. Cutting, "Narrative Theory and the Dynamics of Popular Movies", *Psychonomic Bulletin & Review*, 23, 6 (2016): 1713-1743.

¹⁵ V. Gallese, "Embodied Simulation: From Neurons to Phenomenal Experience", *Phenomenology and the Cognitive Sciences*, 4, 1 (2005): 23-48; V. Gallese, M. Guerra, *The Empathic Screen: Cinema and Neuroscience*, Oxford: Oxford University Press, 2020; V. Gallese, M. Guerra, eds., *The Neuroscience of Film*, special issue of *Projections*, 16, 1 (2022). For a broader discussion of this perspective, see also J. Fingerhut, K. Heimann, "Movies and the Mind: On Our Filmic Body", in C. Durt, T. Fuchs, C. Tewes, eds., *Embodiment, Enaction, and Culture: Investigating the Constitution of the Shared World*, Cambridge (MA)-London: The MIT Press, 2017: 353-377.

¹⁶ A. D'Aloia, R. Eugeni, eds., *Neurofilmology: Audiovisual Studies and the Challenge of Neuroscience*, special issue of *Cinéma & Cie*, 14, 22/23 (2014); A. D'Aloia, *Neurofilmology of the Moving Image: Gravity and Vertigo in Contemporary Cinema*, Amsterdam: Amsterdam University Press, 2021; R. Eugeni, "Neurofilmology: Semiotics, Cognitivism, Audiovisual Experience", in A. Biglari, ed., *Open Semiotics. Volume 3: Texts, Images, Arts*, Paris: L'Harmattan, 2023: 421-434.

Rather than treating neuroscience as an external explanatory framework for cinema, neurofilmology conceives audiovisual experience as a multi-layered phenomenon emerging from the continuous interaction of neural processes, bodily activity, symbolic organization, technological mediation and cultural practices. Rhythm is one of the privileged concepts through which these levels can be considered simultaneously: not only a formal principle of audiovisual composition or a neurocognitive mechanism of temporal prediction, but a relational process connecting cinematic structures, embodied perception, ecological environments and sociocultural forms of experience.

4. Rhythm between media theory and neurocognitive sciences

It follows that a neurofilmological approach does not confine the analysis of rhythm to the empirical study of the viewer's experience; it seeks categories and models that cut across the approaches of different disciplines. The value of this approach becomes apparent at two levels.

At the methodological level, scholars of rhythm in media and emerging audiovisual media have an extremely rich and multifaceted body of research to draw on. Neurocognitive studies have concentrated on more or less regular repetitions of beats, and, using a terminology not accidentally borrowed from musical analysis, distinguish among rhythm, beat, and meter.

A rhythm is a sequence of auditory events, the onsets of which are separated by time intervals. The beat is the sequence of regular, salient time positions that are perceived within the rhythm. Meter is the hierarchical organization of strong and weak beats¹⁷.

Responses to stimuli of this kind have been analyzed from several perspectives – associated neural events, recognition and discrimination, prediction, and rhythm production – generally grouped under the umbrella term ‘timing’.

As regards neural events, two aspects are particularly noteworthy. At the level of neural oscillations, “two frequency bands have been associated with rhythm perception: the delta band (1–3 Hz), which spans the rates at which the beat is perceived and is associated with temporal prediction, and the beta band (15–30 Hz), which is associated with the motor system and also with

¹⁷ D.J. Cameron, J.A. Grahn, “The Neuroscience of Rhythm”, in S. Hallam, I. Cross, M. Thaut, eds., *The Oxford Handbook of Music Psychology*, 2nd ed., Oxford–New York: Oxford University Press, 2016: 357–368 (358). See also L.A. Leow, J.A. Grahn, “Neural Mechanisms of Rhythm Perception: Current Findings and Future Directions”, *Advances in Experimental Medicine and Biology*, 829 (2014): 325–338.

temporal prediction”¹⁸. As regards the areas involved, “perceiving and producing musical rhythms activates brain areas traditionally associated with motor functions, including the supplementary motor area, premotor cortex, cerebellum, and basal ganglia”¹⁹. It is worth noting that certain motor areas – the dorsal part of the mid-premotor cortex in particular – are recruited even during the passive, non-motor reception of rhythms²⁰, which indicates that an embodied simulation of movement is an integral part of rhythmic perception and recognition.

Neurobehavioral findings confirm and enrich this connection between rhythm and movement. Different musical styles and tempos, and other rhythmic stimuli, have been shown to affect physiological rhythms, including electrocortical activity, heart rate and motor coordination; this form of synchronization, known as the ‘entrainment effect’, has been identified as a crucial mechanism for cognitive, motor and affective functioning²¹. Entrainment, however, is only the most elementary form of synchronization that rhythms make possible. Rhythms also allow a fluid and coordinated management of the interactions between a subject’s movements and those of the moving objects around them, primarily through the capacity to *predict* and anticipate dynamic patterns and their development²². And they serve as a powerful means of synchronization and attunement among the movements, actions and emotions of different subjects acting together in the same environment²³. Rhythm therefore also belongs to the field of social (embodied) cognition, as a central resource in the management of relations.

¹⁸ D.J. Cameron, J.A. Grahm, “The Perception of Rhythm”, in R. Hartenberger, R. McClelland, eds., *The Cambridge Companion to Rhythm*, Cambridge–New York: Cambridge University Press, 2020: 20-38 (26). See also H. Merchant, V. de Lafuente, eds., *Neurobiology of Interval Timing*, New York: Springer, 2016.

¹⁹ Cameron, Grahm, “The Neuroscience of Rhythm”: 358-359.

²⁰ J.L. Chen, V.B. Penhune, R.J. Zatorre, “Listening to Musical Rhythms Recruits Motor Regions of the Brain”, *Cerebral Cortex*, 18, 12 (2008): 2844-2854.

²¹ M. Barbaresi, D. Nardo, S. Fagioli, “Physiological Entrainment: A Key Mind–Body Mechanism for Cognitive, Motor, and Affective Functioning, and Well-Being”, *Brain Sciences*, 15 (2025): 3. See also L. Damm et al., “Why Do We Move to the Beat? A Multi-scale Approach, from Physical Principles to Brain Dynamics”, *Neuroscience and Biobehavioral Reviews*, 112 (2020): 553-584; M. Pranjic et al., “From Sound to Movement: Mapping the Neural Mechanisms of Auditory-Motor Entrainment and Synchronization”, *Brain Sciences*, 14 (2024): 1063; D.G. Schmid, “Prospects of Cognitive-Motor Entrainment: An Interdisciplinary Review”, *Frontiers in Cognition*, 3 (2024): 1354116.

²² S. Proksch et al., “Motor and Predictive Processes in Auditory Beat and Rhythm Perception”, *Frontiers in Human Neuroscience*, 14 (2020): 578546; A. Zalta et al., “Neural Dynamics of Predictive Timing and Motor Engagement in Music Listening”, *Science Advances*, 10 (2024): eadi2525.

²³ M.D. Greenfield et al., eds., *Synchrony and Rhythm Interaction: From the Brain to*

Film theory's appropriation of this vast body of research, however, appears to have run into a limit. The reader will have noticed that the rhythms discussed so far are exclusively auditory, even where they involve motor and tactile responses; it is no accident that many of these findings come from research on the neurocognitive – and sometimes therapeutic – aspects of listening to and performing music²⁴. At first sight, this creates a gap between neurocognitive research on rhythm and research on audiovisual media. Two developments are closing it. On the one hand, multisensory studies of rhythm – variously called “multimodal” or “cross-modal” – are expanding rapidly, particularly with respect to the interaction between auditory and visual stimuli²⁵; this concern now touches every area of rhythm research, from timing to prediction to forms of synchrony and attunement²⁶, and the heavy emphasis on music is being balanced by a growing interest in dance, both performed and observed²⁷, and in the audiovisual domain itself²⁸. On

Behavioral Ecology, theme issue of *Philosophical Transactions of the Royal Society B*, 376 (2021). The topic has clear phenomenological origins: see, for example, M. Pokropski, “Timing Together, Acting Together: Phenomenology of Intersubjective Temporality and Social Cognition”, *Phenomenology and the Cognitive Sciences*, 14, 4 (2015): 897-909. On the pre- or proto-semantic aspects of rhythm as a tool for attunement, see V. Cuccio, “Rhythm Synchronization and the Process of Meaning Construction: From Minimal Meaning to Epistemic Injustice”, *Philosophical Psychology*, forthcoming, DOI: 10.1080/09515089.2026.2680202.

²⁴ The literature is extensive; here we limit ourselves to a few representative references: S. Hallam, I. Cross, M. Thaut, eds., *The Oxford Handbook of Music Psychology*, 2nd ed., Oxford-New York: Oxford University Press, 2016; R. Hartenberger, R. McClelland, eds., *The Cambridge Companion to Rhythm*, Cambridge-New York: Cambridge University Press, 2020; J. London, *Hearing in Time: Psychological Aspects of Musical Meter*, 2nd ed., Oxford-New York: Oxford University Press, 2012; M.H. Thaut, D.A. Hodges, eds., *The Oxford Handbook of Music and the Brain*, Oxford-New York: Oxford University Press, 2019.

²⁵ N. Di Stefano, C. Spence, “Perceiving Temporal Structure Within and Between the Senses: A Multisensory/Crossmodal Perspective”, *Attention, Perception, & Psychophysics*, 87 (2025): 1811-1838; C. Spence, N. Di Stefano, “Mid-Level Audiovisual Crossmodal Correspondences: A Narrative Review”, *Multisensory Research*, 39 (2026): 99-137.

²⁶ J.A. Grahn, “See What I Hear? Beat Perception in Auditory and Visual Rhythms”, *Experimental Brain Research*, 220, 1 (2012): 51-61; S. Ohayon, I. Gordon, “Multimodal Interpersonal Synchrony: Systematic Review and Meta-analysis”, *Behavioural Brain Research*, 480 (2025): 115369; A. Kolesnikov et al., “Kinetic Cross-modal Correspondences and Felt (E)motion in a Novel Set of Musical Stimuli”, *Music & Science*, 6 (2023): 20592043231214686.

²⁷ O. Foster et al., “The Neuroscience of Dance: A Conceptual Framework and Systematic Review”, *Neuroscience and Biobehavioral Reviews*, 150 (2023): 105197; from a neuroaesthetic perspective, A. Orlandi, E.S. Cross, G. Orgs, “Timing Is Everything: Dance Aesthetics Depend on the Complexity of Movement Kinematics”, *Cognition*, 205 (2020): 104446.

²⁸ M. Rahmani, L.J. Romero Lauro, A. Pisoni, “Audio-Visual Entrainment Neuromodulation: A Review of Technical and Functional Aspects”, *Brain Sciences*, 15 (2025): 1070;

the other hand, several scholars of audiovisual media theory have drawn significant inspiration from this research and contributed to the revival of rhythm from an experiential perspective: Karen Pearlman has emphasized the embodied dimension of the perception of rhythm in editing²⁹; Thorbjörn Swenberg and Simon Carlgren have studied the interaction of visual and auditory rhythms in music videos³⁰; and Massimo Locatelli has reconstructed the history of film theory's interest in the neuropsychology of rhythm and has more recently used neurocognitive findings to explore the relation between cinema and dance³¹.

This overview makes clear why the study of media and emerging audiovisual media – and the neurofilmological approach in particular – is such a promising field for research on rhythm. Rhythm is a means of managing movement over time: on the one hand through the connection between multimodal perception and the planning, control and execution of movement, and on the other through the synchrony and attunement of individual organisms with the movements of the objects and subjects around them. Cinema, in turn, is a perceptual machine that displays a wholly distinctive multiplicity of movements and transformations – of subjects and objects on screen, of lighting and camera, of editing, speech and music – and is therefore capable of eliciting a rhythmic coordination of exceptional richness and complexity.

5. FROM FORMAL TO EMBODIED AND RELATIONAL RHYTHM

The essays collected here are not a series of independent case studies. Read in sequence, they trace a trajectory that progressively widens the meaning of rhythm: from its theoretical redefinition as a conceptual category, to its embodiment in perceptual experience, to its extension across spatial and technological contexts, and finally to its reformulation as a method of analysis.

X. Wang, C. Wöllner, Z. Shi, "Perceiving Tempo in Incongruent Audiovisual Presentations of Human Motion: Evidence for a Visual Driving Effect", *Timing & Time Perception*, 10, 1 (2022): 75-95.

²⁹ K. Pearlman, *Cutting Rhythms: Intuitive Film Editing*, 2nd ed., New York-London: Focal Press, 2016; K. Pearlman, "The Rhythm in Film Editing", in N. Carroll, L.T. Di Summa, S. Loht, eds., *The Palgrave Handbook of the Philosophy of Film and Motion Pictures*, Cham: Palgrave Macmillan, 2019: 143-163.

³⁰ T. Swenberg, S. Carlgren, "On-Beat/Off-Beat Visual Responses to Audio-Visual Asynchrony in Music Videos", *Projections*, 15, 2 (2021): 28-54.

³¹ M. Locatelli, "Paul Fraisse's Psychology of Rhythm: A Case for Filmology?", *Cinema & Cie*, 22, 38 (2022): 83-96; M. Locatelli, *Cinema e danza (1894-1944). Per una storia culturale del ritmo*, Milan-Udine: Mimesis, forthcoming. The authors are grateful to Massimo Locatelli for kindly providing an advance copy of this work.

The order of the issue follows this itinerary rather than disciplinary boundaries and registers the displacement of rhythm from an internal property of audiovisual form to a relational process unfolding across bodies, spaces, technologies and cultural practices.

The opening contributions undertake the most fundamental task: redefining rhythm itself. Rather than accepting inherited conceptions centered on montage, metrical organization or temporal succession, they reconstruct rhythm as a transversal category capable of connecting representation, perception and embodied experience.

Giulia Adriana Ceriani lays the theoretical foundation of the issue with a semiotic investigation of rhythm as a *figural matrix*. Moving beyond structuralist semiotics while remaining rooted in the Greimasian tradition, she argues that rhythm precedes linguistic articulation and operates as a pre-discursive operator mediating between biological regulation, perceptual organization and systems of signification. Rhythm is therefore neither mere repetition nor temporal regularity, but a generative principle that organizes the passage from bodily dynamics to cultural forms. By locating rhythmic processes upstream of the distinction between nature and representation, Ceriani provides the broad conceptual frame within which the following contributions can be situated.

Enrico Carocci moves from this semiotic foundation to cinematic narration, rethinking narrative pacing through embodied narratology and enactive theories of cognition. Revisiting classical narratological concepts such as scene, summary, duration and narrative speed, he argues that pacing cannot be understood solely as a structural relation between story time and discourse time: it also emerges as an experiential process through which spectators progressively come to inhabit narrative worlds. His analysis of Christopher Nolan's *Dunkirk* shows how rhythm organizes anticipation, immersion and temporal presence, relocating narrative temporality from textual architecture to embodied engagement. Rhythm thus becomes the experiential counterpart of the relational model introduced by Ceriani.

Simone Setzi approaches rhythm from the side of audiovisual production. Drawing on Dynamic Attending Theory, he describes rhythm perception as a form of "temporal attending" in which the nervous system continuously calibrates its expectations against periodic events in the environment. In the video for The Chemical Brothers' *Star Guitar*, directed by Michel Gondry, rhythm is externalized: the continuous movement of a train converts the spatial distribution of a landscape into a rigorous temporal sequence. As viewers learn the correspondences between visual objects and auditory beats, their experience becomes an active cycle of anticipation, sensory

feedback and perceptual recalibration. This spatialized tracking of time induces micro-anticipations and postural tensions, in line with neuroscientific findings that beat perception engages motor areas of the brain even in the absence of overt movement.

Having reconstructed rhythm as a conceptual and compositional principle, the issue turns to the way these structures become embodied in the spectator's experience. If the first essays ask what rhythm is, those that follow ask how rhythm is lived.

Francesco Brianzi proposes a comprehensive theoretical synthesis that reconceives cinematic rhythm as a process of embodied mimesis. Bringing together film theory, cinematics, neurofilmology, music cognition, entrainment research and artistic practice, he argues that rhythm cannot be reduced to editing patterns or shot duration alone but emerges from the dynamic integration of multiple audiovisual modalities operating across different temporal scales. Cinematic analysis provides the empirical basis for identifying the temporal architecture of Wes Anderson's films, with its recurrent patterns of pacing, shot duration and formal regularity; these measurements are then interpreted in a neurofilmological key, where rhythm is understood as a multimodal process arising from the interaction of editing, musical timing, camera movement, compositional symmetry, color, gesture and performative dynamics. Such configurations, Brianzi argues, generate processes of sensorimotor resonance through which spectators internally reenact the embodied creative gestures inscribed in audiovisual form. Rather than opposing quantitative analysis to phenomenological interpretation, his contribution shows how cinematic evidence can be integrated with theories of embodied simulation.

Carlotta Berti shifts the discussion from embodied rhythm to the ethics of embodied rhythm. Through a close reading of Artavazd Pelešjan's *Life*, he argues that cinematic rhythm is not simply a principle of temporal organization but a mode of embodied attunement. Bringing Margaret Tait's notion of the camera that "breathes with" the world into dialogue with Vivian Sobchack's theory of the cinesthetic subject and Bakhtin's concept of exotopy, her article shows how documentary rhythm emerges through the dynamic interplay of sensory proximity and ethical distance. Rhythm thus becomes the medium through which filmmaker, filmed reality and spectator participate in a shared yet asymmetrical field of embodied experience, where aesthetic form, perception and authorial responsibility continuously negotiate one another.

Moving from theoretical and textual analysis to empirical investigation, Ali Mehdi-pour examines how external metrical rhythms entrain the spec-

tator's sensorimotor system. Working within a neurofilmological framework and Event Segmentation Theory, he shows that the relation between objective cut density and self-reported embodied engagement is markedly non-linear: the mechanical accumulation of cuts does not by itself increase sensorimotor arousal. Embodiment is modulated instead by a temporal integration window: when inter-cut intervals fall within a threshold of roughly 2.5 seconds, discrete visual events cohere into a "rhythmic gestalt". Mediation analyses indicate that the physical frequency of cuts affects viewers only indirectly, the effect being entirely mediated by their subjective perceptual organization of rhythm. Cinematic rhythm thus operates as a higher-order cognitive and affective construct that scaffolds sensorimotor resonance and immersive transportation, shifting the explanatory weight from the physical stimulus to the spectator's active perceptual construction.

If Brianzi, Berti and Mehdipour investigate embodied synchronization under conventional viewing conditions, Francesco Parisi and Samuele Sartori examine situations in which ordinary sensorimotor integration is partially suspended. Under conditions of "sensorimotor reduction" – Ganzfeld environments, sensory deprivation, out-of-body experiences (OBEs) – ordinary multisensory congruence is attenuated, and endogenous rhythmic continuity becomes the primary organizer of the self. Magnetoencephalography (MEG) recordings during induced OBEs show that shifts in self-location are driven by specific oscillatory patterns: an increase in alpha-band (8–13 Hz) synchrony acts as an inhibitory 'gating' mechanism that suppresses the incongruent proprioceptive and vestibular signals normally anchoring the self to the physical body, while a reduction of high-gamma activity (61–90 Hz) in premotor and multisensory cortices attenuates bottom-up prediction errors. The embodied self, on this account, does not merely exist in time but is *rhythmically constituted*: the central nervous system uses oscillatory coherence to stabilize – or to reconfigure entirely – self-awareness, especially when external sensory input is minimal.

The following essays further expand the scope of rhythm by relocating it beyond the individual body. They examine how rhythmic relations emerge within architectural, technological and ecological environments, where embodiment becomes inseparable from spatial and collective experience.

Maxon Higbee opens this perspective by revisiting to Sergei Eisenstein's unfinished reflections on architecture as a generative model for cinematic representation. Drawing on Eisenstein's distinction between conceptual and perceptual modes of representation, Higbee argues that architecture and cinema share a common rhythmic logic grounded in the embodied organization of movement through space. Rhythm, on this view, is not a purely temporal

phenomenon tied to montage: it also operates spatially, through the sequential articulation of viewpoints, bodily trajectories, architectural affordances and perceptual transitions. Architectural experience thus becomes a dynamic process in which meaning unfolds through the rhythmic coordination of movement, orientation and sensorimotor engagement, and rhythm the mediating principle linking built environments, cinematic form and perceptual navigation. His contribution thus introduces the spatial and environmental dimension that becomes central to several of the essays that follow.

Donato Maniello investigates immersive museum environments based on Spatial Augmented Reality (SAR), in which digital projections are integrated into physical exhibition spaces without head-mounted displays, turning architecture and artifacts into dynamic interfaces for embodied interaction. Drawing on museum studies, interaction design, media archaeology and embodied cognition, he argues that rhythm constitutes a fundamental design principle governing the temporal orchestration of multisensory experience. Rhythm here does not emerge from the sequencing of audiovisual content alone, but from the continuous interplay between projection mapping, spatial configuration, visitors' bodily trajectories, attentional shifts and the adaptive timing of digital interventions; it regulates not only what visitors perceive but also how they move, pause, orient themselves and collectively inhabit the exhibition space. SAR thus reconfigures the museum as a responsive temporal ecology in which heritage, architecture, computational systems and embodied spectatorship are dynamically synchronized, and rhythm appears as an ecological and relational property of the exhibition experience.

Carlo Gioia and Tatiana Mazali extend the question to shared augmented reality as a relational and participatory medium. Building on the SHARED project developed at the Politecnico di Torino, and drawing on artistic research, micro-phenomenology, human-computer interaction and immersive media studies, they argue that rhythm is not embedded in digital content itself but emerges from the continuous coordination of embodied users, physical space, augmented visual layers and adaptive computational systems. Unlike cinematic rhythm, whose temporal organization is largely preconfigured, rhythmic organization in shared augmented reality unfolds through situated interaction, collaborative exploration and the reciprocal adjustment of participants within hybrid environments where physical and virtual dimensions remain inseparably intertwined. Rhythm thus becomes an emergent property of collective action and spatial negotiation, increasingly distributed across bodies, environments, interfaces and networked infrastructures.

Andrew Whitlock brings a comparable ecological perspective to techno music, moving from the solitary observer to a collective and participatory

environment. Through the process of “double refraction” and technologically mediated “cut and paste” sampling, techno tracks generate a continuous cycle of repetition and variation. Rhythm here works as a structural pulse that produces what Whitlock calls “embodied refraction”, that is, a process in which rhythmic information is internalized, interpreted and expressed as outward bodily movement by participants. The result is a feedback loop of energy exchange: the DJ provides the rhythmic input, participants respond with synchronized but individualized sensorimotor movements, and the DJ recalibrates the sound in response to this collective physical feedback. Rhythm thus exceeds the bounds of the individual nervous system and functions as a circulatory medium, binding bodies, technologies and the physical environment into a unified, intersubjective sensorimotor state.

The issue closes by turning from rhythm as an object of investigation to rhythm as a method of inquiry. Rather than asking what rhythm is or where it takes place, the final contribution asks how rhythm itself might become an analytical practice.

Lu Zeng develops the concept of *cinematic rhythmanalysis*, bringing Henri Lefebvre’s rhythmanalysis into dialogue with Dziga Vertov’s *Man with a Movie Camera*. Through a series of autoethnographic encounters with the film in classrooms, museums and on digital platforms, she argues that cinematic rhythm emerges not only within the audiovisual text but through historically situated acts of spectatorship. Contemporary viewing is increasingly fragmented across heterogeneous environments, rendering rhythm contingent on the interaction between films, bodies, institutional settings and everyday temporalities. By shifting attention from the rhythm inside the film to the rhythm of encounters with it, Zeng transforms rhythm from a property of audiovisual form into a critical practice, capable of integrating textual analysis, embodied experience, spatial context and media ecology.

6. A research agenda for embodied rhythms

Taken together, these contributions reveal the theoretical breadth of the concept of rhythm. Rather than converging on a single definition, they demonstrate that rhythm operates as a transversal category capable of connecting semiotics, narratology, neurofilmology, phenomenology, empirical aesthetics, architecture, museum studies, music studies, artistic research and immersive media. More importantly, their sequence outlines a coherent conceptual progression: rhythm is first redefined as a generative principle of meaning, then understood as an embodied mode of experience, then exam-

ined as an ecological process distributed across media environments, and finally reformulated as a methodological tool for analyzing situated practices of spectatorship. Rhythm thereby ceases to be understood primarily as an internal feature of audiovisual form and becomes a relational infrastructure through which images, sounds, bodies, spaces, technologies and spectators continuously negotiate meaning, attention, movement and experience.

At the same time, the collection brings into view the limits of current scholarship and the questions that remain open. Despite the growing convergence between film theory, cognitive science and empirical aesthetics, no comprehensive framework has yet emerged that fully integrates formal analysis, embodied phenomenology, neurophysiological evidence and the sociocultural dimensions of audiovisual experience. Existing studies often privilege one level of analysis – textual, cognitive, neural, ecological or technological – leaving the reciprocal interactions among them insufficiently explored. Precisely because it unfolds simultaneously across these levels, rhythm offers a privileged terrain for developing genuinely integrative models.

Several directions for future research emerge from this analysis. First, the empirical investigation of rhythm would benefit from increasingly multimodal methodologies, combining qualitative analysis with psychophysiological measures, eye-tracking, motion capture, hyperscanning and ecological observation, so as to examine how rhythmic structures are enacted rather than merely perceived. Second, the rapid expansion of immersive media – virtual, augmented and mixed reality, interactive installations, spatial computing, multisensory environments – calls for theoretical models able to account for forms of rhythm that are no longer organized by montage but emerge through bodily navigation, interaction and adaptive computational systems. Third, the growing diffusion of artificial intelligence in audiovisual production raises unprecedented questions concerning algorithmically generated rhythms, human-machine co-creation, and the extent to which computational systems may reproduce, transform or even anticipate embodied patterns of temporal organization.

The cultural and historical horizons of rhythm studies also need to be broadened. Much existing research remains centered on Western cinematic traditions and laboratory-based models of spectatorship, whereas comparative, intercultural and historically situated investigations could illuminate the plurality of rhythmic regimes that characterize different audiovisual cultures, exhibition contexts and media practices. Rhythm likewise invites further dialogue with fields that have so far remained largely peripheral to film studies, among them dance and performance studies, chronobiology, affective neuroscience, human-computer interaction, disability studies and the

environmental humanities, all of which offer complementary perspectives on temporal organization and embodied coordination.

The ambition of this issue, finally, is not to stabilize the concept of rhythm through a definitive theoretical model, but to demonstrate its heuristic productivity. Rhythm appears less as a problem to be solved than as a conceptual operator capable of generating new questions across disciplinary boundaries. If audiovisual experience increasingly unfolds within hybrid ecologies where biological bodies, computational systems, cultural practices and media environments continuously interact, rhythm may well provide one of the most promising frameworks for understanding how these heterogeneous dimensions come to be coordinated, however provisional that coordination may be. The challenge is therefore not simply to study rhythm as an object of inquiry, but to develop transdisciplinary approaches capable of grasping it as one of the fundamental modalities through which contemporary audiovisual experience is constituted, lived and transformed.