Paul Fraisse's Psychology of Rhythm: A Case for Filmology?

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This essay aims to discuss the topic of rhythm as presented by the classic psychologist and filmologist Paul Fraisse (1911-1994) in his founding studies, to understand its scope, and to consider the possible inheritance to be spent in contemporary research on film. I will first outline Fraisse's contribution to the psychology of rhythm, a model grounded both on the value of Gestalt organisation and on related dimensions of sensory-motor activation. Secondly, I will investigate contemporary thinking in this field, showing on the one hand how Fraisse's contribution still helps the psychology of music in defining rhythmic listening experiences, and on the other how the French scholar's multilayered notion of time perception finds legitimation in neuroscientific research on timing. Finally, I will delve into film theory. In particular, I will put forward the assumption that the sense of rhythm, due to its values of Gestalt organisation, plays a fundamental role in narrative and event-based viewing, enhancing it; yet, due to the dimensions of sensory-motor activation, sound rhythms, in particular, can induce both bodily and neural entrainment and constitute in film an auditive analogon of those embodied and enactive visual processes recognised by the most recent neurofilmological approaches.

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Rhythm is a Gestalt, but it is much more: a preferential mode of uniting perception and action, thze source of social manifestations and the basis of arts of succession and movement.

Paul Fraisse, *Is Rhythm a Gestalt?*

PAUL FRAISSE

Paul Fraisse (1911-1994), a French psychologist, who was a pupil of Albert Michotte van den Berck in Louvain and a collaborator with leading exponents of the French school of psychology of perception, made his mark on research into the experience of time as few other scholars of his age did, significantly contributing to founding the studies which after him came to be known as chronopsychology. In *The Psychology of Time* (1957) he demonstrated the existence of a multiplicity of temporal structures in the life of the individual, and shifted the attention of then nascent chronobiology from endogenous mechanisms to external conditioning,

making explicit the dimension of adaptation to periodicities connected both 'with the main biological activities of the organism, namely motility, rest and food' and with induced rhythms, 'which bear no relationship with organic alterations', hence induced in the laboratory or, hypothetically, attributable to social activity.[1]

Among social activities, Fraisse always attributed an important role in his studies to creative practices, such as music, supremely considered the art of time. Moreover, he also followed his master Michotte in the years of his filmological adventure, when between the end of the Second World War and the early 1960s he tried to establish a first methodological study with categories of the experimental psychology of the new media, primarily cinema.[2] Together with Germaine de Montmollin, another of Michotte's students, Fraisse conducted research into the understanding and memorisation of films for the Sorbonne filmology laboratories. As its starting point the research took the famous studies by Frederic Bartlett on the understanding of narrative and, as in this case, it strongly emphasised the active role of the subject in the cognitive process.[3]

Fraisse did not continue his film studies, but these early researches were useful to focus attention on the themes of the perception of time.[4] In *The Psychology of Time* he succeeded in defining some essential traits that are still the basis of research today: the twofold nature of the experience of time, based on both immediacy and duration, in fact on multiple durations (as we shall see in §3), and the organised nature of this experience directed towards synchrony and succession, such that the tick-tock of the clock would never become a tock-tick nor a waltz change its tempo.[5] The unity of the perceived succession between two minimum intervals, our clock or dance pattern, then forms what Fraisse calls 'the psychological or perceived present'.[6] The study of the experience of time would from then on focus on the measurement on the one hand of the subjective and intersubjective perception of duration, as a factor that qualifies every temporal experience,[7] and on the other of the dimensions relating to rhythm and repetition, as its structuring element.[8]

Indeed, in keeping with his chronopsychological studies, Fraisse recognised rhythm as being above all a perceptual process with its basis in Gestalt reorganisation. The perception of time, in relation to rhythmic phenomena, recognises pregnant forms, which tend to be perceived first or produce a greater perceptual impact. 'The reorganization takes the following two forms: differentiation, which sharpens the differences, and assimilation, which tends to diminish or suppress minor differences. Rhythmic reproductions are constituted by intervals having two values: short durations and long durations, which have a ratio of approximately 2/1; within each category, intervals are equal.'[9] The short duration acts as a structural basis of rhythmic understanding, close to the limit of immediacy and perceptible in the form of the 'collection' of stimuli; the long duration is constituted in relation to the short duration. It is the place of duration and the constitution of multiple durations.[10]

The repetition of the formal scheme in a succession of homogeneous groups separated by pauses, tending to last for long durations, is fundamental in the recognition of rhythms. The pause, as Fraisse notes, is conceptually different

from the interval, even when it consists of an identical time span. It is a linkage, at the limit 'analogous to the role of frame [...] in the case of spatial figures'.[11] While the structure in intervals of the single measure is related to the relationship between background and figure, the grouping and rhythm, albeit operating on the same Gestalt bases, through the pause-repetition mechanism, transfer the formal dynamism of the single unit to series of complex units that may require sensory-motor involvement by the subject. Psychological historians such as Fernández and Travieso have strongly emphasised this latter component in Fraisse's thinking about rhythm, namely the motor basis of rhythmic experience.[12]

We can distinguish three steps in Fraisse's research that establish the rhythmic experience as eminently linked to body motor sequences. Firstly, in his laboratory experiments, Fraisse recognized a spontaneous motor rhythm, which was set within the temporal arc of the perceived present, i.e. on average within the band between 15/20 and 150/200 hundredths of a second, with a preference for intervals close to 60 hundredths of a second.[13] A sort of basic rhythm, that of rocking or tapping the foot to the rhythm of music, that enables the subject to physically enter the rhythmic experiential field.[14] Next, he demonstrates that spontaneous rhythmisation is the result of a sensory-motor response or 'motor induction' at regular intervals that activates a precise system of anticipation of bodily movement with respect to the rhythmic beat. Cadences lower than 20 hundredths of a second and higher than 180 hundredths of a second, on the other hand, require conscious intervention and memory recall to maintain synchronisation.[15] Finally, he describes each rhythmic fraction included in the motor rhythm band as a place of spontaneous grouping, which allows its overall perceptual organisation on the basis of precise logics of intensity (accent) and succession (pause). The idea is that the accent elicits the repetition also of complex isochronous groups (the rhythmic experience) and that the rhythmic movement, or its outline, is synchronised with the accent.[16]

THE PSYCHOLOGY OF RHYTHM

The correspondence or circularity between a perceptual mechanism that generally responds to Gestalt laws of perception and a sensory-motor activation system that intervenes on the level of basic rhythmic synchronisation seems to lead us back to the contemporary debate. The psychological field today implicitly or explicitly refers to cognitive theories of time, generally based on the notion of an internal clock at the neurophysiological level and on attentional and decisional mechanisms at the psychological level.[17] But even researchers who share this paradigm address the problem of the relationship with the pre-cognitive dimension of experience, supplementing their research through a comparison with theoretical approaches of a markedly phenomenological nature, in which time on a psychological level is a function of the neurophysiological response or arousal.[18] Understandably, the latter have a strong impact on studies in the cultural field, where case studies raise issues that are difficult to relate

to the rigid protocols of laboratory research. A constructivist vision, based on the recognition of qualitatively different processes, such as that of Paul Fraisse, could certainly assist the dialogue. Three key concepts taken from the psychology of music should be reconsidered after neuroscientific verification.

Entrainment. The synchronisation of the sensory-motor response with the sound stimulus, especially in the presence of complexity or variations of the stimulus, is an emblematic case of this. Today we know that synchronisation, which we now refer to with the term entrainment, can occur at both a sensory and a neural level. Jones and Large, while working within an attentional model, conjecture, in the Dynamic Attending Theory, that the experience of listening to rhythmic stimuli develops a continuous and cyclical temporal experience, a transition from state to state and an internal resonance that dynamises the attentional effort.[19] More recently, Chen, Penhune and Zatorre shored up the idea that different motor areas underlie the perception of rhythms, while rhythm fosters functional connectivity between auditory and motor networks; in these fMRI-based studies, musical rhythm processing has been shown to activate (also) neural mirroring, in analogy to visual perception.[20] In the psychology of music, an attempt has recently been made to redefine the notion of entrainment by relating it to the associated experience of the topical and exciting moment of listening, and measuring it in terms of peak experience.[21] The peak can also be reached through other paths, for instance melodic ones, but a fundamental key seems to be that of rhythmic beat timing, and the system of rhythmic accents identified by Paul Fraisse comes across as a good example of the construction of peak experiences.

Anticipation. The most recent studies have also confirmed Fraisse's intuition of the anticipatory character of the sensory-motor response to the rhythmic stimulus. David Huron, in his influential ITPRA model, strongly insists on the centrality of the expectation-prediction system as a cue to understanding the music experience.[22] Working in an evolutionary perspective, Huron stresses that rhythm not only concerns low-order relationships (short rhythmic motives) but also higher-order relationships (meters), whereas 'the basis for temporal perception is not periodicity — but predictability', as it is an accurate prediction of the biological goal of expectation.[23] A fundamental part of contemporary research rests on this premise. More specifically, the actual coupling between the auditory system and the dopamine system (referred to as the reward system) has been theorised, and in particular the two-phase structure of this coupling. In laboratory tests, a peak of pleasure felt while listening to a much-loved piece of music was connected to the activation of one sub-portion of the striatum. But a first anticipatory phase occurred a few seconds before in a different sub-region of the striatum.[24] This occurrence indicates that the pleasure of the musical experience is to all intents and purposes built, at the neurophysiological level, on the interplay between expectation and resolution, an interplay that rhythm and repetition can expand and reiterate endlessly.

Attention. The complexity of higher-order structures or musical meters has been widely debated. For Justin London, metrical experience 'involves our

initial perception as well as subsequent anticipation of a series of beats that we abstract from the rhythm surface of the music as it unfolds in time'.[25] London interestingly proposes a model, the Many Meters Hypothesis, which considers meter as a kind of "learnable" entrainment, a synchronization of our attention and response to the rhythms of the musical environment which we are exposed to. London openly admits his debt to Paul Fraisse. Thus, physical involvement can develop within metrically complex compositions and a universe of different possible interpretations, styles, and arrangements.[26] From a purely neurophysiological point of view, it has also proved possible to describe a double circuit that integrates a typically bottom-up path, that of listening to music, with a typically top-down path, that of memorisation and recall.[27]

THE NEUROSCIENCE OF TIMING

At this point, we need to delve into the core component of our rhythmical experience, assuming with contemporary research that the notion of timing describes our ability to live in time through the perception of rhythms and intervals. At this point the topic stops being purely a musicological one.

Today we define the rhythmic perception that arises from the constant interaction between the auditory and motor systems of our mind, directed towards the recognition and anticipation of temporal organisations of experience, as beat-based timing.[28] The beat is understood as the value of the psychological response to the rhythmic sequence and therefore epitomises in itself the organising value of the clicking of the metronome and that of a sensory-motor activation mechanism.[29] In beat timing, succession and repetition seem to be a training ground for many important challenges that arise from it. These challenges above all concern the temporal structuring of perception itself, first, and clearly describe some characteristics of our involvement, namely a) the predictivity of experience. We already know that one of the 'miracles' of human cognition of time is the ability to anticipate rhythms (which enables us to dance, for example);[30] b) its duration: the cyclical nature of the rhythm makes it possible to prolong the sensory-motor response and timing;[31] and c) its permanence: we are capable of maintaining the sense of the rhythm that we have experienced for many cycles after the stimulus has ceased.[32]

The pattern of repetition, as we have seen, is not attributable only to the simplest rhythms, but also to complex meters and events stimulating predictive or attentional behaviours. We need to introduce a second timing level, called interval timing, in which one analyses the system of recognition of complex rhythmic temporal experiences and assesses their duration.

As concerns this dimension, to date we have far fewer laboratory observations. We can still only consider this issue on the level of hypotheses. However, in recent years, scientific research has widely explored different scales for assessing the passing of time (or in general the experience of time). In particular, while musical rhythm, like the rhythm of language, is related to a scale of

milliseconds/seconds, many activities in our daily lives are related to the scale of seconds/minutes, which psychologists often refer to in terms of interval timing, and which recurs in the most explicitly aware activities involving the cognitive system.[33] Studies of this kind, again, tell us of the central role played by memorisation and learning processes in the musical experience.[34]

The sense of individual time is therefore constructed starting from the synchronisation of different time frames, which include times of long-duration (such as the circadian rhythms regulating the alternation between sleeping and waking), all of which, in the light of recent analyses of neuroimaging, work on a semi-autonomous basis.[35] In any case, in a logic of layering of the neural activation systems of the rhythmic and temporal sense, the perception of temporally organised stimuli is reinterpreted in terms of a binary functioning in different neural regions: on the one side an accumulation mechanism, which can correspond to the traditional internal clock, rhythmically organises the entry of stimuli (though they may not be rhythmic in origin), and therefore it can activate attentional and/or memorisation mechanisms. On the other side a comparison mechanism re-processes the data of the internal clock in the light of analogue or parallel systems and of the mnestic activity, and allows for an estimation of different complex intervals.[36]

If this is the case, despite the methodological issues that exploring the level of interval timing raises, perhaps it is not out of place to take as a first working hypothesis that the idea of enjoying audio-visual media (listening to music or watching a movie) is an essential training ground for a psychology of rhythm and apply it to complex segments and repetitions with a duration of seconds and minutes: meters and hyper-meters on the one hand, shots, scenes, sequences, musical insertions on the other. Music and film share the power to accumulate modules organised by rhythm but based on intervals and durations organised in the order of seconds and minutes (the order of our internal clocks engaged in interval timing), and to refine our power of comparison (of rhythmic-temporal dimensions).

Starting from these strongly embodied images and sounds we shall nonetheless finally restore a cognitive dimension of the sense of rhythm, especially where the perception of durations and times implies evaluations. Evaluating and deciding, hence reasoning on a temporal basis, is a process that in turn acts on the neurophysiological mechanisms of timing, in keeping with a logic that could be defined as re-entry: the decision-making system ultimately intervenes on the internal clocks — whatever their form or scale — and modifies their computation.[37]

FOR A FILMOLOGY OF RHYTHM

The basic assumption of this essay actually concerns the usefulness of reference to Fraisse's work in contemporary research on film and the moving image. Film culture has always dealt with the problem of rhythm, both as a

question of style, and as a tool to get the audience involved. Cultural historians have shown how there is a qualifying link between the sense of modernity embodied by cinema and its avant-gardes in the first half of the 20th century, and the visual rhythms with which directors and editors experimented on multiple levels.[38] The 'founding fathers' of film theory all gave ample space to reflection on rhythm, influencing subsequent debates: Béla Balázs' film aesthetics, on which generations of directors were trained, prescribes a relationship of a musical type (harmony, counterpoint) between the 'rhythm of the shots', that is the degree of dynamism of the image, and the 'rhythm of the montage'.[39] In the sound era, by the mid-1930s, film rhythm was widely understood as the product of editing sound and image and of synchronizing multiple layers or strata of temporal development in an effort to gain control over the image.[40] Film semiotics was later able to systematise the many possible regimes of inner- and inter-textual relationships apt to govern narrative film rhythm.[41]

Sergei Eisenstein has proposed the broadest and most refined reflection on cinematic rhythm, integrating the different rhythmic codes into a unitary concept of vertical editing. Vertical editing aims to involve the viewer 'mechanically' in a sensuous experience. The Russian director found his first inspiration in the primordial and tribal rhythm of the drum, and then broadened his observation to more complex rhythms of multiple cultural expressions. The most evident break with respect to Balázs and the classic style of montage can be found in the principle of the 'opposite movement' (*otkaznoe dviženie*) or mutual contrast between the elements, which enhances the impact of film rhythm by emphasizing its own dialectical process.[42] The Eisensteinian perspective influenced later reflection on the potential of film for rhythmic involvement. We can distinguish between broad categories of intervention: one of a meta-psychological nature, one of phenomenological inspiration, and one in the cognitivist area.

The first, which probably arises from Christian Metz's founding observations on the fetish of technology,[43] is best defined in Raymond Bellour's most recent work.[44] For Bellour, film has a corporeal quality that produces the constant illusion of a sensory, almost hypnotic 'agreement' with the spectator's body. Bellour relies on Daniel Stern's concept of the 'present moment', which is in turn indebted to French phenomenology and Paul Fraisse's 'psychological present'. In Stern a timing correspondence stems from the immediateness of any relationship, starting from the first face-to-face contacts of the child.[45] For Bellour, film gives us the illusion of a similar immediate, bodily correspondence. Rhythm defines here the 'transmodal character' of this correspondence, ensuring the coordination of sound and image.[46]

The conclusions of the authors of the second line of thinking are indeed not far off: for example Vivian Sobchack also stresses the embodied character of rhythmically expressed 'temporal reciprocity'.[47] And already according to Jean Mitry the phenomenological perspective accounts for the subjective and sensorial value of rhythmic experience: rhythm is an intentional structure, which opens up to the construction of meaning through a perceptual experience. Notably, Mitry states that this experience must be interpreted with psychological tools

like those enunciated by Paul Fraisse, from the subjective value of rhythmic perception to the binary Gestalt principle of assimilation and differentiation (see earlier in §1).[48]

The psychological implications of the experience of rhythm have also been considered in the third area of study. In this case, a multi-layered notion of rhythm, as inherited from Paul Fraisse, could offer a point of balance between models for understanding film experience which, by analogy with what happens in the more general framework of the psychological and neuroscientific debate, underline the cognitive challenge of film comprehension and narrative,[49] and models that have strongly reassessed the pre-cognitive and embodied dimensions of the act of viewing.[50] The Event segmentation theory postulates that continuity editing matches our brain's use of discrete representation to predict the immediate course of events, and to create an internal, interconnected representation in memory.[51] David Bordwell, though, from a clear cognitivist point of view, has insisted on the affective intensification effects of modern editing rhythm in terms of cutting pace,[52] while Torben Grodal has brought back the effectiveness of the filmic experience to the body rhythms ('fluctuations') of the viewer.[53] On this basis, Karen Pearlman has suggested reconsidering the work of the editor as a real technique of the body, assigning to rhythm the task of raising tension and release.[54] This reflects also Walter Murch's influential considerations on the 'natural' cut, based both on the actor's movement and the viewer's blinking of the eyes.[55] In this respect, research into mirror neurons has had a strong impact and enabled authors like Gallese and Guerra to strongly anchor film viewing to a Simulation theory: mirror neuron activation pushes us to an embodied simulation of the character's action and camera movements.[56] The work of Eugeni, Balzaretti, Cavaletti, and D'Aloia demonstrates how in film viewing 'the body schemata of movement and action possess an intrinsic temporal dimension', and that this temporal dimension is expressed 'both in terms of speed and duration'.[57] The Italian authors questioned the influence of different editing rhythms (neutral, classical, intensified) on time perception.

All these contributions solicit a 'somatic intelligence' of rhythm in film and the moving image,[58] allowing us to extend its semiotics from a logic of control and sense strata to a logic of dynamic resonance and 'production of affects'.[59] Overall, though, they prevalently come across as being focused on visual factors, probably the most immediate and the easiest to test. An additional strand of research we need to consider is therefore research on film music. On the one hand, related studies place great weight on the aspect of emotional activation of the original musical soundtrack.[60] On the other hand, general reflections on affective intensification have been also related to dimensions such as those of the spatialisation of sound[61] and the amplitude of usable frequencies following the introduction of noise reduction. The richness of timbre and sounds and noises of the contemporary film soundtrack, and, last but not least, the volume of sound in the cinema seem to enhance the emotional involvement of the audience.[62]

Conversely, there are few specific and dedicated in-depth laboratory studies

on the auditive dimensions of film rhythm, or on multimodal and cross-modal rhythm processing, an exception being the recent work by Swenberg and Carlgren. Here, once again, it has been proved that 'the relationship of the visual beat to the musical beat affects human viewers' visual perception of the edits', by enhancing both continuity and discontinuity effects.[63] Carol Vernallis also aptly described the particular 'responsiveness' of video music editing to musical rhythms.[64] This allows me to take a step further.

Paul Fraisse had already studied the relationships between visual stimuli and sound stimuli, and his consolidated starting point lay in the basic differences between the two sensory systems: e.g., the response to the sound stimulus is faster than the visual one, the sound stimulus seems longer than a visual one of equal duration.[65] These observations are substantiated by contemporary psychological and neuroscientific studies, which confirm the greater accuracy of the timing in auditory stimuli than in visual ones. Sound appears to be a more immediate instrument, but also a more precise mechanism.[66] The signals of the visual organisation require a longer time to re-process and also a longer time to learn in childhood.[67] We could refer to an auditive efficiency, in respect to visual perception. The French scholar further reported a fundamental qualitative difference between visual rhythm perception and sound rhythm perception. Listening allows a direct connection and synchronisation between the bodily response and rhythmic stimuli (entrainment), while vision allows only formal recognition of repetitions and symmetries that tend not to lead to a synchronised bodily response.[68] Jean Mitry confirmed this view, affirming that film bases its rhythm on "discontinuous forms", and therefore cannot achieve bodily synchronization through visual means only, if not on very particular occasions. An example of this would be the master sequence of the Teutonic Knights in *Alexander Nevsky* (Sergei Eisenstein, 1938).[69] Eisenstein himself, criticising the complex scene of the religious dances in *Storm over Asia* (Vsevolod Pudovkin, 1928), noticed that in this case the visual editing just foregrounded an abstract cadence of spatial repetitions and combinations (metric montage, in his terms). He explicitly asked here for a musical track, in order to gain real rhythmical effectiveness.[70]

We can then put forward a second working hypothesis regarding the role of sound rhythms in film and the moving image. Rhythmic aptitude in listening, due to the automatisms of sensory-motor activation and synchronisation that constitute it, seems to be functional to film experience in the same way as the embodied and enactive visual processes recognised by the most recent neurofilmological theories are. That is, not only as simple emotional reinforcement, as in the case of a melodic commentary, but as a bodily scheme of action and movement, which allows an embodied and enactive response to the stimulus. The differences between the visual and the auditive-induced involvement need, indeed, to be stressed: in the first case, neural mirroring and simulation involve a personal relationship with a represented subject or action, while rhythmic entrainment does not require it. Furthermore, we might think that this response is not simply simulated but shared, with the body of the

text and the spectator community's bodies. An impulse of extreme power and intensity. The limitation of the hypothesis lies in the lack of laboratory evidence, but the studies mentioned previously in support of the Dynamic attending theory (§2) seem to confirm at least its legitimacy. For now, we have confirmation of phenomena of both sensory and neural entrainment.

CONCLUSIONS

We have enough material to draw a conclusion, in a first attempt to delineate a Rhythmic Involvement Theory for audiovisual Media Experience (RITMEx). According to Fraisses' founding definitions, and later debates on the psychology of rhythm, the neuroscience of timing, and the theory of film and the moving image, RITMEx can state at least that:

1. Rhythmic involvement in audiovisual media experiences is grounded both on a value of Gestalt organisation and on related dimensions of sensory-motor activation (§1) and is generally to be interpreted as a training ground for our multilayered *timing* skills (§3).

2. Rhythmic involvement can be traced back to two different ways of experiencing audiovisual media: on the one hand, a dynamic mode, closely but not necessarily related to style-centered filmmaking, music videos, and social media contents, where rhythm itself ensures *entrainment* and embodied *anticipation* (§2). On the other, a narrative or event-related one, closely but not necessarily related to continuity editing, that exploits the enhancing effects of rhythmic stimuli in order to reinforce *attentional focusing* and low and high-order cognitive *prediction skills* (§2 and 4).

3. *Sound* rhythms are more effective than visual ones in beat timing and short interval timing; they can induce both bodily and neural entrainment and consequently a dynamic mode of experience. They are a grounding element in a 'somatic' relationship to the body of the film or any moving image viewed. They can nonetheless also have enhancing, empowering, or even contrapunctual value in narrative or event-based experiences (§4).

Notes

[1] Paul Fraisse, *Psychologie du temps* (Paris: Presses Universitaires de France, 1957), eng. ed. *Psychology of Time* (New York: Harper and Row, 1963), 28.

[2] On the filmological enterprise in post-war Paris and its relationship with psychology, see at least *Cinémas*, 19.2-3 (special issue *La filmologie, de nouveau*, ed. by François Albera and Martin Lefebvre, 2009).

[3] Paul Fraisse and Germaine de Montmollin, 'Sur la mémoire des films', *Revue Internationale de Filmologie*, 9 (1952), 37–69 (69). See also Frederic Charles Bartlett, *Remembering: A Study in Experimental and Social Psychology* (Cambridge: Cambridge University Press, 1932), 64–84.

[4] In the course of the above-mentioned study, Fraisse collected data on the judgment of duration that enabled him to subsequently demonstrate that the judgment of duration of single actions which one is called on to make directly tends to underestimate the time taken. This contrasts with the judgment of duration of complex activities, not clearly addressed and of which in particular one is a spectator: 'For a spectator the interest, although real enough, does not give the task unity. The act of perception has its end in itself and not in an objective to be reached or a task to be carried out.' Fraisse, *Psychology of Time*, 228.

[5] Fraisse, *Psychology of Time*, 98. 'Humans tend to perceive an isochronous stream of identical sounds as having alternating strong and weak notes — the "tick tock" phenomenon'. J. Daniel Cameron and Jessica A. Grahn, 'Perception of Rhythm', in *The Cambridge Companion to Rhythm*, ed. by Russel Hartenberger and Ryan McClelland (Cambridge: Cambridge University Press 2020), 20–38 (21).

[6] Fraisse, *Psychology of Time*, 84–85.

[7] Fraisse, Estimation and Perception of Time, *Annual Review of Psychology*, 35 (1984), 1–36.

[8] Fraisse brought together all of his studies on rhythm in a monograph published in France in 1974, *Psychologie du rythm*e, which was soon translated into Italian, of which only an abridged version is available in English, collected by Diana Deutsch in the first edition of her influential Psychology of Music: Paul Fraisse, 'Rhythm and Tempo', in *The Psychology of Music*, ed. by Diana Deutsch (New York: Academic Press, 1982), 149–180. We will refer here to the Italian edition: Fraisse, *Psycologie du rythme* (Paris: Presses Universitaires de France, 1974), it. ed. *Psicologia del ritmo* (Roma: Armando, 1979).

[9] Fraisse, 'Is Rhythm a Gestalt?', in *Gestalttheorie in der modernen Psychologie*, ed. by Suitbert Ertel, Lilly Kemmler and Michael Stadler (Darmstadt: Steinkopff, 1975), 227–232 (231).

[10] Fraisse, *Psicologia del ritmo*, 82. Note that the distinction between a short and a long time is still the basis of one of the fundamental tasks in psychological research into time, termed temporal bisection: John Wearden, *The Psychology of Time Perception* (London: Palgrave Macmillan, 2016), 71–83.

[11] Fraisse, 'Is Rhythm a Gestalt?', 229.

[12] Marcos Fernández and David Travieso, 'Paul Fraisse y la psicología del ritmo', *Revista de Historia de la Psicología*, 27.2-3 (2006), 31–43.

[13] Fraisse, *Psicologia del ritmo*, 52.

[14] Ibidem, 43–47.

[15] Fraisse particularly stresses that they involve systematic errors in response, ibidem, 50–58.

[16] Fraisse, *Psicologia del ritmo*, 67–68. 'These productions would have a perceptual regulation (grouping and structuration) but the basis would be motoric', Fraisse, 'Is Rhythm a Gestalt?', 232.

[17] In general, I refer to John Wearden's compendium, and to the page he devotes to the relation between attention and timing, 88–102.

[18] The works of Droit-Volet stress the importance of sensory-motor states in the perception of time, e.g. Sandrine Gil and Sylvie Droit-Volet, 'Emotional Time Distortions: The Fundamental Role of Arousal', *Cognition and Emotion*, 26.5 (2012), 847–862, and in general the discussion in Wearden, 105–115.

[19] Mary Riess Jones, 'Time, Our Lost Dimension: Toward a New Theory of Perception, Attention, and Memory', *Psychological Review*, 83.5 (1976), 323–355; Edward W. Large and Mary Riess Jones, 'The Dynamics of Attending: How People Track Time-varying Events', *Psychological Review*, 106.1 (1999), 119–159. For a critical discussion of Dynamic Attending Theory and an updating of its neuroscientific foundations: Anna-Katharina R. Bauer, Manuela Jaeger, Jeremy D. Thorne, Alexandra Bendixen and Stefan Debener, 'The Auditory Dynamic Attending Theory Revisited: A Closer Look at the Pitch Comparison Task', *Brain Research*, 1626 (2015), 198–210.

[20] Joyce L. Chen, Virginia B. Penhune and Robert J. Zatorre, 'Moving on Time: Brain Network for Auditory-

motor Synchronization is Modulated by Rhythm Complexity and Musical Training', *Journal of Cognitive Neuroscience*, 20 (2008), 226–239, and 'Listening to Musical Rhythms Recruits Motor Regions of the Brain', Cerebral Cortex, 18.12 (2008), 2844–2854.

[21] Alf Gabrielsson, John Whaley and John Sloboda, 'Peak Experiences in Music', in *The Oxford Handbook of Music Psychology*, ed. by Suan Hallam, Ian Cross and Michael Thaut (Oxford and New York: Oxford University Press, 2016), 745–758.

[22] 'A mnemonic for the sequence of five expectation-related responses: Imagination response, Tension response, Prediction response, Reaction response, Appraisal response.' David Huron, *Sweet Anticipation: Music and the Psychology of Expectation* (Cambridge and London: The MIT Press, 2006), 7–18 and 416.

[23] Ibidem, 199.

[24] The striatum is a subcortical nucleus of the telencephalon, involved in many cognitive functions, including the motoric and reward systems. Valorie N. Salimpoor, Mitchel Benovoy, Kevin Larcher, Alain Dagher and Robert J. Zatorre, 'Anatomically Distinct Dopamine Release During Anticipation and Experience of Peak Emotion to Music', *Nature Neuroscience*, 14.2 (2011), 257–262.

[25] Justin London, *Hearing in Time: Psychological Aspects of Musical Meters* (Oxford and New York: Oxford University Press, 2004), 4.

[26] 'A listener's metric competence resides in her or his knowledge of a very large number of context-specific metrical timing patterns', ibidem, 152–153.

[27] Yue Ding, Yang Zhang, Wenjing Zhou, Zhipei Ling, Juan Huang, Bo Hong and Xiaoqin Wang, 'Neural Correlates of Music Listening and Recall in the Human Brain', *Journal of Neuroscience*, 39.41 (2019), 8112–8123.

[28] 'This beat-based form of sensory-motor timing allows humans to flexibly extract a regular temporal structure from a range of rhythms, from simple isochronous sequences, in which all the intervals are identical, to more-complex meters like those of waltzes, marches, and sambas.' Virginia B. Penhune and Robert J. Zatorre, 'Rhythm and Time in the Premotor Cortex', *PLoS Biology*, 17.6 (2019), 1–6 (1). See also, for a general description and bibliographic overview, Cameron and Grahn, 'Perception of Rhythm.'

[29] Cameron and Grahn, 'The Neuroscience of Rhythm', in *The Oxford Handbook of Music Psychology*, ed. by Suan Hallam, Ian Cross and Michael Thaut (Oxford and New York: Oxford University Press, 2016), 357–368.

[30] For example, in the laboratory, the participants required to drum while listening to a rhythm anticipate the finger stroke by approx. 50 ms: Li-Ann Leow and Jessica A. Grahn, 'Neural Mechanisms of Rhythm Perception: Present Findings and Future Directions', *Advances in Experimental Medicine and Biology*, 829 (2014), 325–338 (327). On the neurophysiological level, studies based on electroencephalographic research have also shown how, when listening to isochronous rhythms, the oscillations of the beta wave range appear to indicate 'anticipation of regular, expected tones', because they end after the sound, but reappear before the next sound. See Cameron and Grahn, 'The Neuroscience of Rhythm', 362.

[31] 'If a sound is predictably repeated, induced responses may be observed around the time of the expected sound, and may occur even if the sound is omitted', ibidem, 363.

[32] See again Penhune and Zatorre, 2019.

[33] 'Time estimation refers to processing in the range of seconds and minutes and is generally seen as the conscious perception of time.' Michael D. Mauk and Dean V. Buonomano, 'The Neural Basis of Temporal Processing', *Annual Review of Neuroscience*, 27 (2004), 307–340 (309).

[34] Benjamin P. Gold, Marcus T. Pearce, Ernest Mas-Herrero and Alain Dagher, Robert J. Zatorre, 'Predictability and Uncertainty in the Pleasure of Music: A Reward for Learning?', *Journal of Neuroscience*, 39.47 (2019), 9397–9409.

[35] Note that, rather than referring to dedicated circuits, the most recent proposals are theorising that on the neurophysiological level timing is an intrinsic property of every neural circuit. Cf. Hugo Merchant and Victor de Lafuente, 'Introduction to the Neurobiology of Interval Timing', in *Neurobiology of Interval Timing*, ed. by Hugo Merchant and Victor de Lafuente (New York: Springer, 2016), 1–13 (10).

[36] 'Accumulator and comparator functioning of the internal clock are mediated by distinct as well as partially overlapping neural regions', Elaine B. Wencil, H. Branch Coslett, Geoffrey K. Aguirre and Anjan Chatterjee, 'Carving the Clock at Its Component Joints: Neural Bases for Interval Timing', *Journal of Neurophysiology*, 104.1 (2010), 160–168 (160).

[37] Hedderik van Rijn, Bon-Mi Gu and Warren H. Meck, 'Dedicated Clock/Timing-circuit Theories of Interval Timing and Timed Performance', in *Neurobiology of Interval Timing*, ed. by Merchant and de Lafuente, 75–99

(76).

[38] Laurent Guido, *L'Age du rythme. Cinéma, musicalité et culture du corps dans les années 1900-1930* (Lausanne: Payot, 2007), Michael Cowan, *Technology's Pulse: Essays on Rhythm in German Modernism* (London: School of Advanced Study, 2011).

[39] Béla Balázs, *Der sichtbare Mensch oder die Kultur des Films* (Frankfurt a.M., Suhrkamp 2001), 50 (my translation).

[40] Cf. Lisa Jacobs, *Film Rhythm After Sound: Technology, Music, and Performance* (Berkeley and Los Angeles: University of California Press, 2015).

[41] Cf. at least the grounding project of a grande *syntagmatique*, Christian Metz, *Film Language: A Semiotics of the Cinema* (Oxford and New York: Oxford University Press, 1974). More recently, Eugeni proposed to articulate film rhythms in three components: segmentation of the visual and sound continuum, evaluation of the reciprocal lengths of the segments, and detection of visual and sound accentuation, Ruggero Eugeni, *Semiotica dei media. Le forme dell'esperienza* (Roma: Carocci, 2010), 86ff.

[42] Sergei M. Eisenstein, *Il metodo* (2002), vol. 1 (Venice: Marsilio, 2018), 183 and 203. A keen scholar of Eisenstein's work, Jean Mitry, has included the entire classic debate on montage in a broader reflection on rhythmic styles, Jean Mitry, *Esthétique et psychologie du cinéma*, vol. 1 (Paris: Éditions universitaires, 1963).

[43] 'Cinema in its physical state', Metz, 'Le signifiant imaginaire', *Communications*, 23 (1975), 3–55 (52).

[44] Raymond Bellour, *Le corps du cinéma. Hypnoses, émotions, animalités* (Paris: P.O.L., 2009).

[45] Daniel N. Stern, *The Present Moment in Psychotherapy and Everyday Life* (New York and London: Norton&C., 2004), 32–33.

[46] Bellour, 162–163.

[47] Vivian Sobchack, *Carnal Thoughts: Embodiment and Moving Image Culture* (Berkeley and Los Angeles: University of California Press, 2004), 116.

[48] Mitry, *Esthétique et psychologie du cinéma*, vol. 2 (Paris: Éditions universitaires, 1965), 166–171.

[49] See at least David Bordwell, *Narration in the Fiction Film* (Madison: University of Wisconsin Press, 1985), and more recent studies of the neuroscientific foundation such as James E. Cutting and Ayse Candan, 'Movies, Evolution, and Mind: From Fragmentation to Continuity', *The Evolutionary Review*, 4.3 (2013), 25–35, Tim J. Smith, 'Attentional Theory of Cinematic Continuity', *Projections: The Journal for Movies and Mind*, 1 (2012), 1–27.

[50] For an overview, see *Psychocinematics: Exploring Cognition at the Movies*, ed. by Arthur P. Shimamura (Oxford and New York: Oxford University Press, 2013), *Neurofilmology: Audiovisual Studies and the Challenge of Neuroscience*, ed. by Adriano D'Aloia and Ruggero Eugeni, *Cinéma & Cie*, 22-23 (2014), and Dan Shaw, 'Mirror Neurons and Simulation Theory: A Neurophysiological Foundation for Cinematic Empathy', in *Current Controversies in Philosophy of Film*, ed. by Katherine Thomson-Jones (London and New York: Routledge, 2016), 148–162.

[51] Jeffrey M. Zacks and Khena M. Swallow, 'Event Segmentation', *Current Directions in Psychological Science*, 14.2 (2007), 80–84.

[52] Bordwell, *The Way Hollywood Tells It: Story and Style in Modern Movies* (Berkeley: University of California Press, 2006).

[53] Torben Grodal, *Moving Pictures: A New Theory of Film Genres, Feelings and Cognition* (Oxford: Clarendon Press, 1997), 42.

[54] Karen Pearlman, *Cutting Rhythms: Shaping the Film Edit* (Burlington and Oxford: Focalpress, 2009).

[55] Walter Murch, *In the Blink of an Eye: A Perspective on Film Editing* (Los Angeles: Silman-James Press, 1995), 69.

[56] Vittorio Gallese and Michele Guerra, *The Empathic Screen Cinema and Neuroscience* (Oxford and New York: Oxford University Press, 2019). For a criticism of the Simulation theory of film: Malcolm Turvey, 'Mirror Neurons and Film Studies: A Cautionary Tale from a Serious Pessimist', *Projections: The Journal for Movies and Mind*, 3 (2020), 21–46.

[57] Ruggero Eugeni, Stefania Balzarotti, Federica Cavaletti, Adriano D'Aloia, 'It Doesn't Seem_It, But It Is. A Neurofilmological Approach to the Subjective Experience of Moving-Image Time', in *The Extended Theory of Cognitive Creativity: Interdisciplinary Approaches to Performativity*, ed. by Antonino Pennisi and Alessandra Falzone (Cham: Springer, 2020), 243–267 (257).

[58] Pearlman, *Cutting Rhythms*, xvii.

[59] Cf. Roger Odin, 'Du spectateur fictionalisant au nouveau spectateur: approche semio-pragmatique', *Iris*, 8 (1988), 121–139 (128), and Warren Buckland, *The Cognitive Semiotics of Film* (Cambridge: Cambridge University Press, 2009) 106.

[60] See Annabelle Cohen, 'Film Music from the Perspective of Cognitive Science', in *The Oxford Handbook of Film Music Studies*, ed. by David Neumeyer (Oxford and New York: Oxford University Press, 2014), 96–130, and Lars Kuchinke, Hermann Kappellhoff and Stefan Koelsch, 'Emotion and Music in Narrative Films: A Neuroscientific Perspective', in *The Psychology of Music in Multimedia*, ed. by Siu-Lan Tan, Annabel J. Cohen, Scott D. Lipscomb and Roger A. Kendall (Oxford and New York: Oxford University Press, 2013), 118–138.

[61] Mark Kerins, *Beyond Dolby (Stereo): Cinema in the Digital Sound Age* (Bloomington: Indiana University Press, 2011).

[62] Jeff Smith, 'The Sound of Intensified Continuity', in *The Oxford Handbook of New Audiovisual Aesthetics*, ed. by John Richardson, Claudia Gorbman and Carol Vernallis (Oxford and New York: Oxford University Press, 2013), 6581–6630.

[63] Simon Carlgren, 'On-Beat/Off-Beat: Visual Responses to Audio-Visual Asynchrony in Music Videos', *Projections: The Journal for Movies and Mind*, 1 (2021), 28–54 (28).

[64] Carol Vernallis, 'The Kindest Cut: Functions and Meanings of Music Video Editing', *Screen*, 42.1 (2001), 21–48 (21).

[65] A classic test of cross-modal interference in temporal and rhythmic perception to which Fraisse refers concerns the superimposition of a sound stimulus on an interval between visual stimuli in the so-called 'Kappa effect', an illusory perceptual time dilation. Fraisse, 'Estimation and Perception of Time', resp. 6 and 14.

[66] See, including a general bibliography, Frank R. Schab and Robert G. Crowder, 'Accuracy of Temporal Coding: Auditory-visual Comparisons', *Memory & Cognition*, 17.4 (1989), 384–397.

[67] Pierre S. Zélanti and Sylvie Droit-Volet, 'Auditory and Visual Differences in Time Perception? An Investigation from a Developmental Perspective with Neuropsychological Tests', *Journal of Experimental Child Psychology*, 112.3 (2012), 296–311.

[68] Fraisse, *Psicologia del ritmo*, 56–57.

[69] Mitry, *Esthétique et psychologie du cinéma*, vol. 2, 170–171.

[70] Eisenstein, 'The Fourth Dimension in Cinema (1929)', in *Selected Works*, vol. 1 (London: British Film Institute, 1988), 186ff.