Entangled Realities

Emerging Performances of Relating Humans, Sonatars, and Spaces

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ABSTRACT

This article investigates music performances with audiovisual components in extended reality setups that are not score based, but composed, emerging from a discursive process of interrelating human performers and computational counterparts such as virtual performance partners, virtual instruments, and potentials related to particular spaces. Rooted in notions of earlier avant-garde music and digital games, the performances are understood to emerge from a bottom-up process of relating human-technological agencies. A dichotomy of preexistent physical and virtual realities that would be extended or mixed is consequently replaced by a notion of *entangled* realities, as the artistic reality of the artwork emerges with the performance.

A body of contemporary musical and audiovisual art practices is composed to emerge from interactions of human and computational performers in extended physical and virtual reality spaces [1]. Composing rulesets that establish fields of potentials and possible relations for human and computational performers within the spaces allows for altered ways of realizing and experiencing art. Realizations of these compositions often emerge within the fields of possibilities opened by the specific configurations of extended realities rather than being the result of a linear score or text. This text investigates the specific aesthetic implications of indeterminacy implied by compositions combining elements from virtual reality, digital games, and electroacoustic music and builds on theorizing in these fields. Therefore, the field of investigation is distinct from practices of real-time improvisation with computational counterparts, a rich tradition building on work by George Lewis [2] and others [3].

Terrain Study (2018) by Christof Ressi exemplifies many characteristics of this type of composition. An "audio-visual composition for solo instrumentalist and virtual reality system" [4], it is composed of a human performer on a physical stage as well as virtual performance partners populating a virtual reality environment. The physical performance space relates to the virtual performance space, with the latter projected onto a screen. The human performer, wearing a VR headset, performs in both the physical and virtual spaces. The view of the headset is duplicated on the screen for the audience seated in front, with a spherical ambisonic loudspeaker array providing surround sound. The virtual space is populated by computational sonic performers, represented as spheres, with which the human performer interacts by approaching. Instead of being laid out in a musical score, the performance emerges through interactions of the human and computational performers within a basic ruleset that the composition provides for them as well as for their physical and virtual environment.

Similarly, *Anna & Marie* by Marko Ciciliani (premiered at Donaueschinger Musiktage in 2019) comprises both a virtual 3D space and a physical performance space with screen projections of the performers' first-person perspectives in a virtual game world as well as live instruments functioning as interfaces and a link between realities. Two performers explore an "ergodic" story in a 3D environment and shape the composition in a joint process of decision-making and activity in the provided realities [5]. A third example is *Trois Machins de la Grâce Aimante* (2019), a virtual reality string quartet by Rob Hamilton [6], in which musicians wear VR headsets while playing virtual instruments on VR interfaces. In a reversal of the traditional string quartet, the players sit, backs to each other on stage, while their virtual alter egos face each other in VR. From the audience's perspective, the string quartet is present on stage as well as on the projected virtual reality space. Designed by Hamilton, the virtual instruments extend the expressive range of the traditional string instruments and provoke augmented bodily movements by the performers.

Although these compositions differ in their artistic goals and materials, they share similar features; all are composed of both virtual and physical performance spaces in which human and computed potentials interact. These compositions provide the human performers and autonomous

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computational performers different degrees of freedom for those whose materiality and activity contributes to the performance. The computational contributions to the performance include special virtual instruments, virtual performance partners, or affordances related to the spaces. The interplay between these performers and spaces can generate a process whereby the specific reality of the artwork emerges from the relating of virtual and physical realities. Questions arise about how these artistic practices provoke different ways to perform and to experience an artwork. How does an audience's experience of the performed composition differ from their experience of more traditional forms of music? And how does the artwork offer new ways of understanding?

Karen Barad's thought process provides an analytical perspective of this type of artwork. For Barad, relations are not derived from given and previously constituted actualities but instead actualities, in their semantic and ontological significance, are themselves an effect of ongoing relations in and with the world [7]. This process of mattering involves a nonlinear dynamism of becoming [8], of resolving ontological and semantic indeterminacy [9], and of actualities reaching concretization from ongoing activities, practices, and relations. As agency is something done and not something possessed [10], for the class of artistic practices discussed in this article, agency means an active partaking in the composed material-discursive process of realizing the artwork. For Barad, relating as well as being active and responsive are basic ontological principles of the world not limited to, or centered around, humans [11], and include nonhuman biological and technological entities. Subsequently, digital materialism too has shown that virtual or computational entities are effects as well as contributors to material-discursive practices [12].

By accepting agencies of different kinds and origins, this essay pursues an understanding of how the artworks emerge in a bottom-up process of becoming. Before exemplifying the argument with aspects of *Terrain Study*, in the following sections I first provide theoretical background from twentieth-century avant-garde music, literature, and digital games.

FIELDS OF POSSIBILITY, ERGODICITY, AND EMERGENCE

By the middle of the twentieth century, composers such as Karlheinz Stockhausen (*Klavierstück XI*, 1957), Henri Pousseur (*Scambi*, 1957), Pierre Boulez (*Constellation-Miroir*, 1958/1959), and Earle Brown (*Twenty-five pages*, 1953) had already challenged the traditional paradigms of determinacy and linearity in musical performance with compositions that provided only a framework of rules. Instead of using fixed scores, they asked for an active role of performers in taking different paths in the "field of possibility" [13] of a musical composition. Umberto Eco would later use the term "work in movement" for this class of musical works [14]. By the end of the century, Espen J. Aarseth introduced the term *ergodic literature* to describe a literary category of similar features. Ergodic texts require a "nontrivial effort" by the reader to pass through a nonlinear text [15]. A historical example of a text considered ergodic is the *I Ching*, or Book of Changes, of early China. Traditionally used for divination, it was later famously applied by John Cage to compose *Music of Changes* (1951) and subsequent works. Coins are used for chance operations to select symbols according to which interpretation is generated by the diviner. From basic rules and two elements, a line and a broken line, forming 64 symbols, a complex system emerges allowing diverse significations to emerge from the *I Ching*.

With such an ergodic text—more recent examples include cybertext or digital games—exercising a nontrivial effort on the grounds of the provided ruleset means exceeding mere reading. This nontrivial effort in performing what we will call an ergodic musical composition implies exceeding the mere realization of a score and asking the performer to make choices. This concept became particularly influential in digital games theory and was developed toward an understanding of a field of possibilities of the game world in which the player actively engages [16].

Making decisions is fundamental not only for non-player characters of digital games but also for the virtual performance partners of the compositions investigated in this text. A shared process of rule-based activity and reciprocal relations is established from which the temporal artwork emerges. Here, writing, designing, or composing means providing a ruleset and setup for the process to unfold. It implies not only using the Book of Changes for composing *Music of Changes* but also composing a Book of Changes of all possible actions for performers to use.

RELATING AND SEDIMENTATION

The digital racing game series *Forza Racing* [17] demonstrates how an ergodic ruleset can establish a process of relating human and computational performers from which a virtual-physical reality emerges. In this game, the player's opponents in the field of drivers are based on driving data collected during prior performances by other human players. The resulting Drivatars [18] are stripped of cultural attributions and register only crucial human activities: the player's activity and responsiveness in the game world, enunciated by their driving behavior. Further building on Barad's ideas [19], the relations of Drivatars and humans can be understood to affect all relating entities, meaning that the ongoing (partial) prehensions are always interrelated and that there are no one-way paths. The term *prehension* derives from the work of Alfred N. Whitehead [20] and helps us to avoid a human-centered notion of perception by accepting human perception as one sort of prehension but also including other forms of recognizing that are not necessarily related to mind, humans, or even living beings. As Steven Shaviro puts it, the earth would prehend the sun by the received energy, and a stone would prehend the earth to which it falls [21]. Prehension "is the reaching out, grasping and 'seizing' of different types of objects" that are incorporated as data [22]. As the prehended data from other entities are integrated in the entity, the actual entity itself (Drivatar or human) emerges from its enfolded relations with the environment.

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In the designed reality of the game world, Drivatars then relate with human players by competing in races. From the temporal field of iterative activities and relations of humans and Drivatars, further human-computational Drivatars emerge. The activity of the human driver is thereby affected by past activities realized through the present race performances of competing Drivatars. The human drivers adapt their driving by being responsive, by relating with Drivatars' past, and by enfolding the prehensions. This establishes an iterative sedimentation process of prehensions that occur in acts of relation, distributing prehensions and prehensions of prehensions throughout the field of possible activities. The process challenges linearity: The present's discursive activities relate to the past's sedimented activities and let the reconfigured futures-enabling field of possible activities emerge.

As an enfolding of human activity by algorithmic processing, the Drivatars are consequently tightly bound to technology. Yet Drivatars are, strictly speaking, not the result of relations between hardware and biological organisms. They emerge from a dynamism of how humans and virtual algorithmic processing reciprocally relate in a shared field of possible activities. They are sedimented enunciations of potential that affect how further potentials may or may not be enunciated. This is how actual entities emerge from a bottom-up process from their relating as sedimentations of their being active and responsive, and how humans and computational performers discursively enact the reality of the game world.

With the application of Barad's notion that activity and relating [23] are fundamental ontological activities not limited to humans, dichotomous categories of humans and computer performers become unhelpful for examining our category of ergodic artworks. The performers of the investigated musical worlds, as well as in *Forza Racing*, undoubtedly have different configurations. Humans and Drivatars have different abilities of perceiving, of knowing, and of ways they relate to others. However, in an ontology that does not favor any one entity over another, they all follow the same set of underlying rules. A notion of intelligibility that accommodates the different degrees and manifestations of how things perceive, understand, and are active in the world blurs the boundaries between artificial and nonartificial intelligence. The analysis of computed performers escapes the realm of simulation. It allows for acknowledging them as equal contributors to an emerging artwork and for investigating them in a composed process of reification just like their counterparts who happen to be human. As human and nonhuman entities both emerge from the process of sedimenting prehensions in the ludic reality, they moreover emerge through relating with their environment rather than as a given subject independent from this world. All activity-responsiveness and all prehensions of objects are related in the dynamic procedural field of possibilities of the emerging artwork. The iterative microscopic relations let Drivatars and humans surface from entangled physical and virtual activity. From this bottom-up process, a similarly entangled game reality emerges on a macroscopic level.

TERRAIN STUDY

Terrain Study's [24] (Fig. 1) computational performers prehend how the human performer plays their instrument as opposed to driving data. As computational performers, they share characteristics of Drivatars but are sound oriented in their relating to a sonic environment. Adapting the earlier model, we call them *Sonatars*. Sonatars and human performers move in a spatial field unfolded by the mixed-reality setup of the composition. While Sonatars, represented by spheres, float slowly in arbitrary movements above the terrain of the virtual performance space (Fig. 2), tracking sensors translate the human performer's movement in the physical performance space to the virtual performance space.

In technical terms, a Sonatar in *Terrain Study* records the human performer's instrumental play whenever both reach a certain proximity in virtual space. The Sonatar then repeats the recorded sound in a loop. By actively approaching them, the human performer can either "fill" them with the sound of their playing or erase their prior recording. In interacting and sonic prehension, Sonatars enfold the musical activity of the human performer. The Sonatars' actual being and their potential for activity is changed in that event.

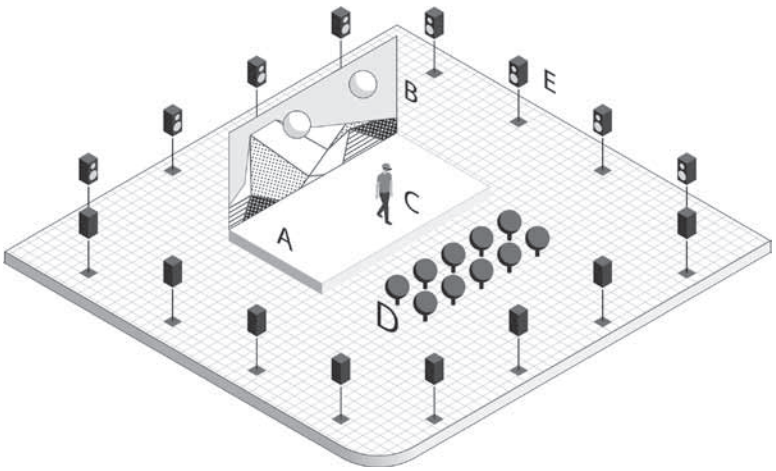

Fig. 1. The spatial formation of *Terrain Study*. (a) Physical performance space; (b) screen projection of the virtual performance space. (c) performer wearing a VR headset; (d) audience; (e) ambisonic surround sound. (© Andreas Pirchner)

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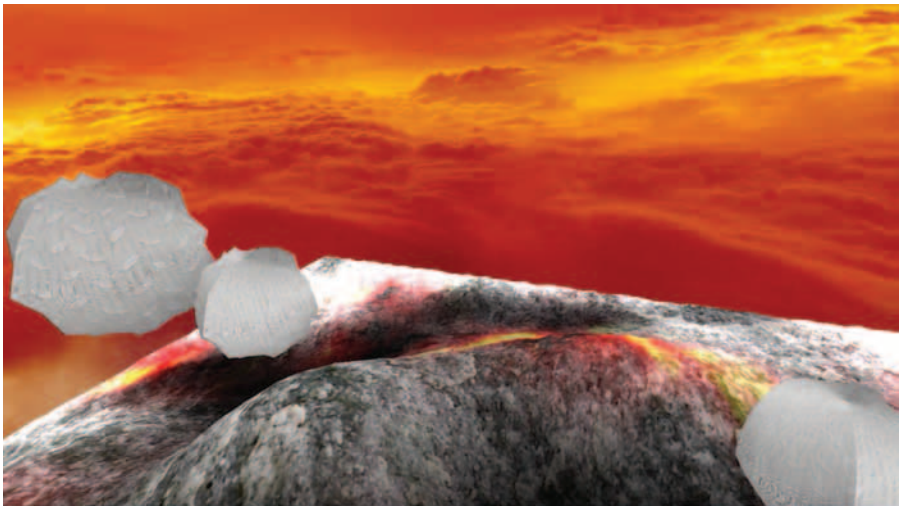

Fig. 2. Sonatars floating above the terrain. (© ndbewegtbild)

The playback of Sonatars floating closer to the performer is rendered louder than the playback of those at a further distance. Approaching them allows the performer to affect to what extent Sonatars, and thereby which iterations of the sonic past, matter in the emerging sonic reality. The Sonatars' repetition of the prehended past is never identical to its bygone "original" event, because each iteration takes place in a differentiated field of sonic contexts and agential relations. Additionally, the performer will play differently depending on which prehensions and which constellation of sonic past constitute the relations and context for their musical enunciations in the present. In other words, the sonic past affects what is more likely to be enunciated musically in the present. The ongoing interrelations of the sonic past with current events change the field of possible futures. As we have seen in *Forza Racing*, the dynamics of the temporal audiovisual structure of *Terrain Study*'s actual performance emerge from temporal relations of musical activity, prehension, and enfolding. In this process, the field of possible relations continuously both narrows and widens.

As the title *Terrain Study* indicates, spatiality and the terrain of the virtual performance space bear the potential of relating to human and computed performers. The square terrain has narrow spatial limitations emphasizing the sense of an experimental setup the word *study* in the title implies. Using a technique from digital games, the terrain is composed of tiles displaying different symbolic material qualities like "lava" or "rock" (Fig. 3a). In proximity, Sonatars and terrain relate, and the Sonatars' playback is affected by the materiality of the tiles. While the materials affect the density of the sound synthesis and the altitude affects the pitch of the Sonatars, their shape is influenced by the loudness (radius) and the spectrum (jagged) of their sampled sound sequence (Fig. 3). As the performance progresses, the height differences of the terrain increase, which results in a more diverse topography. Space becomes an active participant in the interplay that constitutes the material-discursive process from which the performance emerges. Sonatars are concretions of the process's sonic sedimentations, constituted through the history of their prehensions of human play and their relations with the terrain. With the quantity of Sonatars increasing and the terrain's increasing irregularity, the performance world of *Terrain Study* emerges in a gradual progression from a pure, empty, and ordered state to an increasingly populated, complex, and distinctive condition.

While acts of relating among human performers are well known in traditional forms of music (e.g. between members of a string quartet), *Terrain Study* differs. The human performers interrelate with specific responsiveness of Sonatars and the composed ruleset of the virtual environment, which

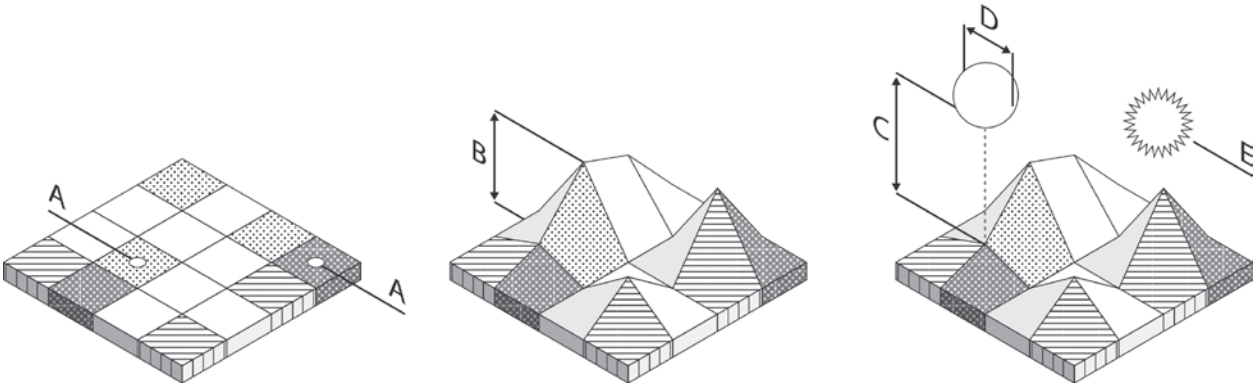

Fig. 3. Relations of Sonatars, sound, and terrain: (a) Materialities of the terrain; (b) changing topography; (c) altitude; (d) size; (e) shape of sonic actors. (© Andreas Pirchner)

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Fig. 4. Reconfigurations of the performer. (© ndbewegtbild)

differs fundamentally from familiar rules of physical performance spaces. From these interrelations, different bodily behaviors of the performer emerge:

- Turning the head(set), the performer directs the projection of the virtual performance space, performing the virtual space for the audience, and becoming more of a director than a musician. See video at 00:57, 10:30, 12:35, and Fig. 4 (bottom-left).
- Exploring by walking, stepping up and down the terrain, prehending the sonic actors. See video at 5:40, 13:26, and Fig. 4 (bottom-right).
- Relating by crouching and turning toward the sonic actors. See video at 7:00, 8:10, 8:43, 8:58, 10:45, 11:10, and Fig. 4 (top).

None of these gestures are indicated in a score; they emerge from the composed space of possibility through the relating of human performer, Sonatars, and terrain. The performers' reconfigurations demonstrate the reciprocal nature of relating. Microscopic prehensions among virtual and physical realities promote the macroscopic entanglement of the performance realities.

By moving their head, the human performer translates the subjective sonic reality of their VR headset to the setup's ambisonic loudspeaker array, thereby shaping the auditory space in physical reality for the audience. The physical sonic space becomes a spatial augmentation of the virtual sonic reality enfolded in the performer and their activity. The human player *performs* the reification of auditory reality for the audience.

In an underlying process spanning *Terrain Study*, the ruleset of the virtual performance space evolves from representing the logic of an external physical world toward an existence according to its own ontological rules. In the final moments of *Terrain Study*, the musical performance becomes entirely dependent on the performer's play. Sound and sedimented musical enunciations uphold the dissolving space (Fig. 5, right). Composer Christof Ressi describes this as "a shift from 'I am a part of

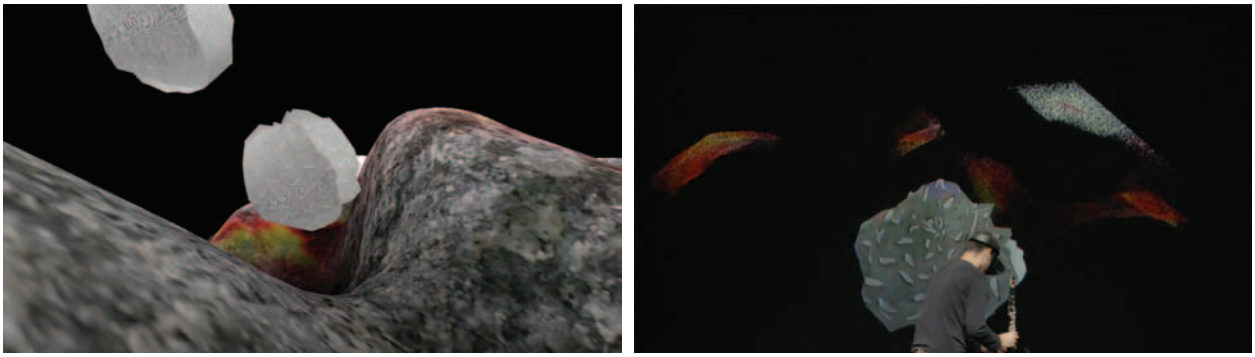

Fig. 5. (left) Elevation affecting playback; (right) Disintegration, space becoming dependent on performer. (© ndbewegtbild)

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this space' to 'I am space'" [25], summing up the process as leading from microscopic human-technological relations to macroscopic entangled realities.

EMERGING REALITIES

Ergodic compositions such as *Terrain Study* are clearly rooted in historical forms of compositions "in movement," concepts of emergence, and the freedom of a space of possible activities. However, through the introduction of virtual reality and the entanglement of spatialities through human performers and Sonatars, new forms of musical enunciation emerge. As the human performer relates not just with provided units of musical material but also with the environment, spatial configurations, and Sonatars, the realization of the composition becomes a complex dynamic process of interrelating activities. This process is profoundly bottom-up, with the macroscopic actual entities emerging from microscopic relations and being derived from a process of sedimentation of the interplay of agencies within the composed material-discursive formation of the artwork. These works of art cannot be thought of as separate from the discursive practices that constantly reconfigure and define what is possible to be expressed musically, from how the actual entities of the performance emerge from sedimented relations and musical activity, and from how these actual entities subsequently materialize the performance of the artwork.

This artistic reality, emerging from sedimented performances, can no longer be categorized as virtual or physical; it becomes one artistic reality related to sound and produced musically by interrelations of human performer, Sonatars, and terrain. In this sound-oriented ergodic artwork, a dichotomy of preexistent physical and virtual realities would consequently be replaced by a notion of entangled realities as the artistic reality emerging with the performance. *Terrain Study* exemplifies a category of compositions evoking emerging and entangled realities.

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