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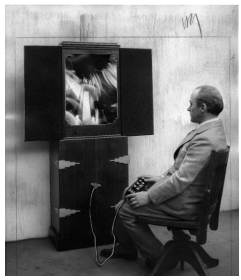
Performativity as a Perspective on Sound-Image Relations and Audiovisuality

The notions of performativity and performance can unfold in different understandings deriving from distinct disciplinary approaches, artistic fields or cultural contexts. It is this very lack of conceptual clarity that also represents a potential, namely for exploring their different conceptions in order to provide a particular reading on the confluence between the visual and auditory as a theme of creative exploration. Rather than aiming at stabilizing these concepts, this narrative derives from three main ideas of performativity. It begins by approaching the notion of a performative analogy between sound and image, as an operative logic of visual and musical performance, moving toward the coupling, transformation, or direct manipulation of sound and image through technological means that already points towards the process-based and interactive nature of digital computational audiovisuality. It then addresses the concept of interactive performativity of user and system, which is tied to a creative engagement of the audience (as user) in exploring the operative and productive possibilities of a system. Emancipating from the notion of human authorial control towards a transfer of agency to the system, as a machinic (and potentially autonomous) performance, finally, the notion of performativity is explored as a quality of digital computational systems as aesthetic artifacts.

Performative analogy

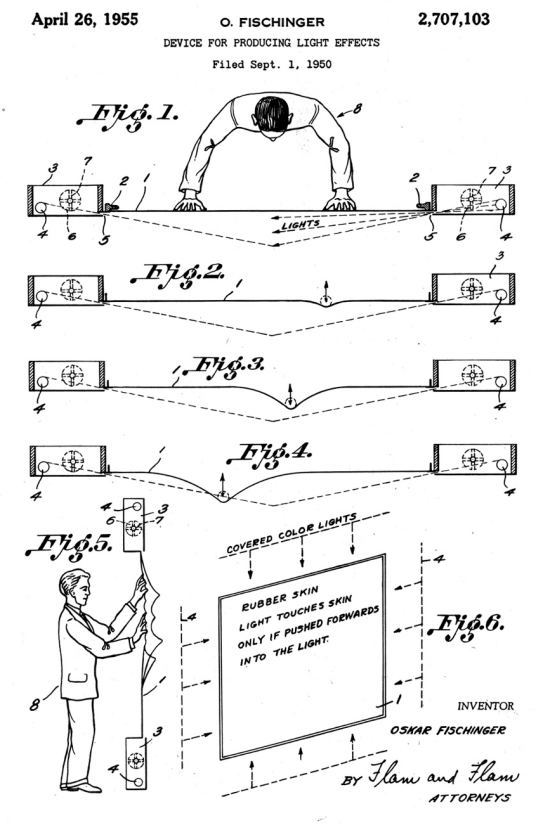
The idea of a performative analogy is tied to a specific path of the history of sound-image relations that particularly crosses artistic motivations, technological inventions and changes in the theoretical and practical foundation on which these relations rest. This concerns the development of experimental devices such as color-organs and related apparatuses for correlating the visual and auditory. This tradition owes reference to French Jesuit priest and mathematician


Mary Hallock-Greenewalt, *Sarabet*, 1919.

Thomas Wilfred, *Home Clavilux*, 1930.

Charles Dockum, *Mobilcolor II*, 1942.



Oskar Fischinger, Lumigraph Patent, 1955.

Louis-Bertrand Castel, who around 1725 designed a *Clavecin Oculaire* that would perform color as a *musique muette*. Influenced by models of color-tone analogies such as those proposed by Aristotle or Athanasius Kircher, Castel sought to give color a lively quality in correspondence to the notes of the Western musical scale, through a substitution of sounds by colors. His project was a first practical implementation (aimed at validation) of a model of color-tone analogies, which in turn also emancipated from holistic models of correspondences (as a global harmony) concerning specifically the visual and auditory realms.[1] Castel aspired to a "mathematically, physically and aesthetically compelling model of correspondence", and in this sense, linked theory, perception and device (Daniels 2011, 12). However, these color-tone analogies were essentially subjective, in theory and in practice, as a manipulable and controllable relation through a visual music performance device.

From then onward the history of correspondences between the visual and acoustic also becomes a history of technological invention and aesthetic experimentation seeking to correlate the two realms. The emergence of color-organs and related apparatus in the 18th century, and their improvements as a result of technical innovations in the 19th century, culminated with their proliferation in the beginning of the 20th century.[2]

Following Castel's tradition numerous artists and inventors developed devices that either produced light in correspondence to musical notes simultaneously, or explored the aesthetic quality of color and light in a purely visual manner. The former can be exemplified by Bainbridge Bishop's *Color Organ*, patented in 1893, Mary Hallock-Greenewalt's *Sarabet* (1919), Alexander László's *Sonchromatoscope* (1925) or even Lloyd G. Cross's *Sonovision* (1968). Artists such as Alexander Wallace Rimington, with his *Colour-Organ* (1893), or Bainbridge Bishop with the concept of painting music (1877) explored free forms of association, while others explored a free play of color and light, as seen from Thomas Wilfred and his *Clavilux* (started in 1919), Vladimir Baranoff-Rossiné's *Piano Optophonique* (1920), Zdeněk Pešánek's *Spectrophone* (1926), Charles Dockum's *MobilColor Projectors* (started in 1936), to Fischinger's *Lumigraph* performances (of the 1950s). Within these developments, there is a gradual shift from strict models of color-tone correspondence towards an exploration of free forms of association, and ultimately, a free play of light and color as a new art form totally emancipated from music, namely proclaimed by Thomas Wilfred as the art of *Lumia*.

These investments however had a limited impact that was tied to their very diversity. On one hand – moved by fascination rather than proof – almost every artist or inventor developed his own model of correspondences, therefore canceling each other out. On the other hand, these devices remained tied to their creators as performance instruments. Their history nevertheless reveals the main traits of a performative analogy between the musical and the visual, as the "real forerunners of performative visuals", of their "real-time production and manipulation" as a performative act (Naumann 2011). They entail an expansion of the visual arts into time and space, defying habitual means of representation and perception. This concerns the visual, in its development in time, but also its extension into space through projected light, as something immaterial, existing in time, moving, and filling space.

New media new art forms

The idea of an expansion of the visual in time has its continuity as artists embraced the emergent medium of film conquering new possibilities for aesthetic creation. Music provided the model for the development of a time-based art form and, as Walter Ruttmann proclaimed in 1919, a new form of "painting with time" emerges as a way of bringing an entirely new kind of life feeling into artistic form, as a rhythm of optical events. His animated film *LightPlay Opus 1* (1921) made of single-frames painted on glass, was one of the first finished and publicly exhibited "absolute films", followed by a long tradition of abstract animations devised in analogy to musical concepts, such as those developed by Vikking Eggeling, Hans Richter and later Oskar Fischinger or Mary Ellen Bute.

However, the immutable nature of a film as a fixed artwork contrasts with the live production of optical events explored with color-organs and similar devices, and ultimately, film and light projections. In this sense, the concept of *Raumlichtmusik* (space light music) and the multiple film projections devised by Fischinger in the 1920s (initially for Alexander László) optimized as a "Form-Play" accompanied by live music,[3] can be seen as a predecessor to the light-shows of the 1950s, such as Jordan Belson's *Vortex Concerts*, a series of electronic music concerts illuminated by various visual effects (Moritz 1997).[4] Being presented in a special domed theater, this involved not only the live (real-time) performance of both sound and image as well as their spatialization; principles that would find continuity in expanded cinema and multimedia performances of the 1960s and 1970s.[5]

Electronic unicity of the audiovisual – interaction as performance

The audiovisual, in its simultaneity and combination, is already an integral component of the everyday in the middle of the twentieth century; a media-technological-based ubiquity that concerns not only the side of reception (with television, radio, cinema), but also the side of artistic production.[6] The logic of the technological apparatus begins to dominate sound-image relations through the exploration of film as a perception device (its material foundations and operative processes) and an exploration of video (and the electronic unicity of the audiovisual) emphasizing interaction (Lista 2004).[7]

In contrasts to the discrete material nature and metric formal principles of film the "constant flux of electronic signals", in its "processual immediacy", allows for a real-time manipulation of the audiovisual (Spielmann 2010). This is reflected in the way that Nam June Paik transfers the principles of Cage's experimental music to "electronic television", arguing that "INDETERMINISM and VARIABILITY is the very UNDERDEVELOPED parameter in the optical art", and therefore "a new decade of electronic television should follow the past decade of electronic music" (qtd. in Daniels 2005).[8] However, due to the lack of recording technology these first experiments were with modified TV sets, directly manipulated by the audience through a number of acoustic-oriented inferences in the image process. Paik thus "inaugurates the road to manipulable images through sound" (Kwastek 2010, 165). In this sense, while music provided a model for the temporal structuring of abstract film, electronic sound would provide the operative model for video, through interference and interaction.

The new electronic medium then represents a new stage in the machine-supported manipulation of sounds and images, where the direct manipulation of real-time processes is paramount. As Peter Weibel stresses, "…the signal itself is no longer a carrier for depicting the object world but rather the image itself; autonomous worlds of sound and image that can be manipulated by both the observer and the machine. An artificial world of sound and images is emerging, one which can be generated by machines alone" (1992, 17).

Video is defined by its manipulation of electronic signals and, as Spielmann (2010) explains, it can be simply signal processing rather than recording. Artists soon engaged in an exploration of these aspects through the development of video synthesizers and image processing techniques,[9] assuming them as instruments for real-time manipulation – as a means to perform a work – and

Nam June Paik, *Participation TV* in Exposition of Music – Electronic Television, 1963.

Stephen Beck, *Direct Video Synthesizer*, 1972.

Steina Vasulka, *Violin Power*, 1970-1978.

occasionally live performance. For example, Stephen Beck used his direct video synthesizer for *Illuminated Music* (1972-73), where he created a visual flow (with a compositional structure) allowing for variations in the ways it was performed; a parallel visual discourse that follows a strategy reminiscent of color-organ performances.[10] Yet, similar to what happened with these devices, the size and cost of analog video synthesizers rendered them unpractical as live performance tools.

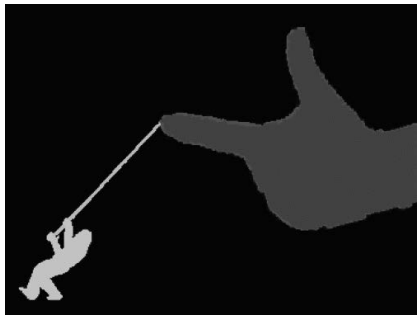
This strategy nevertheless emphasizes an operative and performative analogy that is tied to the very nature of the electronic medium. As Woody Vasulka stated, "there is an unprecedented affinity between electronic sound and image-making. (…) this time the material, i.e. the frequencies, voltages and instruments which organized the material were identical" (1992).[11] This "unicity" of the raw material of video, "noise, as an unformed electronic signal", forms the basis of electronic audiovisuality (Spielmann 2010, 318). It is this technical continuity between sound and image that allows a conception of video as interaction device (Lista 2004, 74). However, contrary to the forms of audience interaction promoted by Paik, in the work of Steina Vasulka, for example, *Violin Power* (1970-78), interaction is applied to the creative process, while playing the video as an instrument, as a performative act. This performance of the work, more than an analogy, emphasizes a performative connection between sound and image, through direct interference and interaction.

As Spielmann argues, by exploring the "transformative characteristics" of electronics, its "process-oriented, multidimensional and open-ended audiovisuality", the Vasulkas emphasize a contrast between video and previous audiovisual media, while also bridging the way to algorithmic audiovisuality (2004, 8).[12] These strategies thus find their continuity, and are further extended, with digital technologies as the functions of previous media are transposed and enhanced, namely concerning the creation and direct manipulation of images and sounds. Taking on this idea, we can also identify other paths of development that concern conceptually distinct phases in the use of computers as an artistic medium (Weiss 2005). From the perspective of audiovisuality, they correspond to the creation of audio-visual forms through computational means, and to the creation of interactive experiences articulated through images and sounds.

On one hand, we are referring a creative domain that "relies on computer software as its medium, and is primarily concerned with (or is articulated through) relationships between sound and image" (Levin 2010, 270). On the other hand,

Lillian Schwartz at the Bell Laboratories, 1974.

Laurie Spiegel at the Bell Laboratories, ca. 1978.



Myron Krueger, *Videoplace*, 1969-1975.

we are addressing "process oriented and participatory forms that involve the manipulation of acoustic and visual information by the audience" (Kwastek 2010, 163). These domains ultimately converge within the broad spectrum of digital computational (software-driven) audiovisuality and interactivity.

Digital computational audiovisuality and interactivity

One of the pioneers of the use of the computer for articulating relations between the visual and auditory was John Whitney, who was interested in the music-like qualities of abstract dynamic form. He finds in the computer a means to define precise compositional relations, initially, as mathematically structured animations devised in relation to pre-existing music.[13] As computer technology evolved, Whitney was able to fully develop his idea of a "digital harmony", where "tone-for-tone, played against action-for-action" (qtd. in Levin 2010, 279), as demonstrated in *Spirals* (1987) or *MoonDrum* (1989).

In continuity with these experiments, artists used computers to produce abstract films in relation to musical concepts (often mixing computer generated imagery with animation), namely Lillian Schwartz,[14] who soon transferred these experiments to a live performance context with *On-line* (1976), where computer generated visuals were accompanied by musical improvisations. By the same time, Laurie Spiegel develops the *VAMPIRE* (1974-1976), a *Video and Music Program for Interactive Real-time Exploration/Experimentation*[15] that included a number of controls to modulate and perform image and sound parameters in real-time. Even if it remained confined to the laboratory, Spiegel defines it as an "unrecordable room sized live performance visual instrument" (Spiegel 1998). This notion of live performance is dissociated from the idea of the live production and presentation to an audience, but rather addresses the performative act of creation of the work while interacting with a system. This leads us to another view of performativity as a quality of the performance of both system and user.

Interactive performativity (user-system)

The notion of performativity is used by Levin (2010) in order to address one of the main principles or themes that motivate the development of audiovisual software. This notion is related to interactivity as one of the main features or "aesthetic possibilities" of digital computational art forms that are particularly prospective or speculative in exploring the creative possibilities of software. The

notion therefore encompasses a wide diversity of interactive systems, while highlighting what they share as artworks that explore how a "feedback loop can be established between the system and its user(s) – allowing a user or visitor to collaborate with the system's author in exploring the possibility-space of an open work, and thereby to discover their own potential as actors" (Levin 2010, 271).

In contrast with the performative analogies and works mentioned earlier, we now invoke both the notion of a performative act as a connection between the visual and auditory, and the transfer from passive reception to active participation or performance of the work. These are ideas that, according to Shaw-Miller (2010), can be traced back to aspects explored by Fluxus and Intermedia art, namely through the concepts (derived from music) of notation and performative actions or events that could ultimately be executed by the audience. Concerning this shift towards an active role of the audience, it is also possible to evoke Paik's work, as previously mentioned, in its openness to interference and indeterminacy through audience interaction (in contrast with vicarious forms of interaction). Therefore, rather than mere instruments for performance, we are addressing audiovisual interactive systems as aesthetic artifacts – as open works which offer an open field of possibilities for the users to explore, and also as meta-works that allow the user to perform their outcomes.[16]

These are interactive artworks that are "only experienced properly when used interactively to produce sound and/or imagery" (Levin 2010, 275), however, their creators are not necessarily or primarily concerned with the creation of sounds and images, but with their role as responses to interaction. This can be illustrated with David Rokeby's interactive installation *Very Nervous System* (1986-1990), motivated by the idea of developing intuitive physical forms of interaction with computers, where sound is both "an extension of the body", and a "physical reality which one encounters with the body" (Rokeby 1990).[17] As an interactive audience-activated environment, this work is reminiscent of Myron Krueger's responsive environments, explored as a "new art medium based on a commitment to real-time interaction between men and machines". Initiated in the 1970s his *VideoPlace* installation was gradually perfected, as a "continuous experimentation in interactive art", using various techniques of image processing to mediate the interaction while also introducing audio responses (Krueger 2003, 387). Yet, in contrast to Rokeby's aims of intriguing the user exclusively with the immediacy of sound responses to their bodily movements, Krueger sought to

define a precise attribution of cause and effect: "It is the composition of these relationships between action and response that is important… The beauty of the visual and aural response is secondary" (Krueger 2003, 385). Taking on this idea, we retrieve a path of development that concerns the artistic use of the computer, not merely for articulating relations between the visual and auditory, but rather for developing interactive experiences articulated through images and sounds.

Performative systems as aesthetic artifacts

The view of performativity thus shifts from instrumental or productive connotations towards the quality of the relational activity between technological artifact and user over time. Interactivity itself is the subject matter, rather than a mere possibility or attribute of a system. We can therefore consider these systems performative in that they depend on the user to perform by using "participatory human action" or "human performances" as a "primary input stream for controlling or generating audiovisual experiences" (Levin 2010, 275), and as interactive artworks, or playable *(jouable)* systems that are performed by their users – thus emphasizing the "performative dimension of [their] experience" (Boissier 2004, 15).

The notion of interactive performativity then addresses digital computational (software-driven) systems that entail the mapping of human data to images and sounds. As such, these are "computationally variable works" (rather than fixed), since "processes are defined in a manner that varies the work's behavior", in this case, particularly with human input (Wardrip-Fruin 2006, 398).[18] Sound and image then become the means through which the user interacts and the products of interaction – as the system's surface (visual and auditory) modes of expression and communication – as tangible expressions of processes or operations performed by the work, with the participation of the user.

If we address the potential diversity of "performative systems" these may involve different interfaces and operative possibilities (and kinds of human actions they promote), as well as means of interaction and productive possibilities. Ultimately, each system devises a specific way of governing the behavior, or of generating, visual and auditory elements, and in this process, its specific way of including or even depending on the user (Ribas 2012). According to this, they can be seen as apparatuses (comparable but different from instruments) whose "operative possibilities" and "functionality" as "production devices" are potentially

"unique and novel" to the user, thus inciting their creative exploration. It is this uniqueness that renders this exploratory activity, and the "reflection of one's one exposure to [the system], a rich aesthetic experience in its own right" (Kwastek 2009a, 5).[19]

As an action based aesthetic experience, interaction entails that the users assume an active and constructive role in the creation of their own experience. Accordingly, this view of performativity implies a transfer of agency (from the creator of the system) towards both the audience as user and the system itself. In this sense, a system's agency can be understood as its ability to act and change its state, while adapting to its environment.[20] So we can think of the transfer of some degree of agency to the system as an ability to act by incorporating information (namely user input) and performing accordingly; hence, to interact, as a reciprocal ability to act and influence each other. In this case, it is expressed both as a "machinic reactive agency" tied to its modes of liveness and immediacy (Kwastek 2009b), and as a transfer of agency to the audience as user, or as an "aesthetic pleasure" that arises from interaction when it enables "meaningful action" leading to "observable results" (Murray 1997, 153).

The notion of performance, as argued by Boden and Edmonds, then replaces that of artwork, since each of its occurrences can vary considerably from one occasion to another (2009, 41).[21] What we experience are the results of continuous and ongoing computations which give us not objects, but instances or occasions for experience. So we can think of the work as a process (as an activity performed in time), and of the work as a system that includes the user. This view puts to the fore what Broeckmann (2005) or Jaschko (2010) define as the "processual and performative aesthetic qualities" of machinic creations as aesthetic artifacts.

Performativity as an aesthetic quality

As suggested by Broeckmann the aesthetic experience of electronic and digital artworks hinges, to a large extent, on non-visual (or non-sensorial) aspects, or "machinic qualities", such as "generativity, interactiviy, processuality, performativity". This understanding of process refers to the "time-based evolution and transformation of …sequences of events", as results of ongoing computations. According to this view, software processes are non-visual (or rather non-sensorial) occasions that give form to images and sounds, as an actualization of the work. The notion of process then conflates with that of performance; a term used

to designate both the "quality of a technological artifact in operation" (an execution system) and the "live" dimension of a presentation – "the making present (and perceivable) of the results of an execution" as the momentum of aesthetic experience (Broeckmann 2005).[22]

In order to further discuss this concept of performativity as an aesthetic quality of the experience of digital computational artifacts (as machinic creations), we can return to the principles or themes of creative exploration mentioned by Levin. Beyond the notion of interactive performativity we then move towards generativity, while emphasizing a shift from human-based-operations towards machinic autonomy.[23]

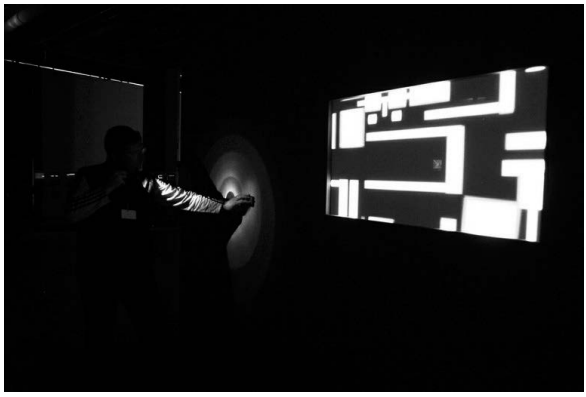
The principle of generativity refers to the potential autonomy of a system to "produce animations and/or sound from its own intrinsic rule-sets" (Levin 2010, 277), meaning that the work does not depend on external data (but may include it), since processes are defined in a manner that varies the work's behavior, "randomly or otherwise" (Wardrip-Fruin 2006, 398). From this perspective, generative autonomy draws attention to the "rules of creation" of the work as artistic constraints (Bootz 2005). The artist specifies rules as "recipes for autonomous processes" that develop in time, in a self-organizing manner, potentially leading to unforeseeable results, which are not completely predictable neither by artists or user (Boden & Edmonds 2009; Galanter 2006). As such, the work occurs while running, as a unique performance whose rules of creation, or procedural logic, can only be grasped through careful observation or close interaction.

Creative possibilities and aesthetic qualities

These principles highlight creative possibilities of a medium where "data and process are the major site of authoring" (Wardrip-Fruin 2006, 381), but beyond the possibility of mapping any given input data or source information into a visual and auditory form, the notions of generative autonomy and interactive performativity emphasize the possibility to create dynamic audiovisual behaviors. In this sense, we address artifacts whose subject matter is not necessarily tied to relations between the visual and auditory. However, by exploring the possibilities of software, they propose potentially unique, dynamic configurations of images and sounds.

This can be exemplified with Levin's work, from *AVES: Audiovisual Environment Suite* (2000) to the *Manual Input Workstation* (Levin & Liebermann, 2004),

Golan Levin and Zachary Lieberman, *The Manual Input Workstation*, 2004-2006.



Antoine Schmitt, *The World Ensemble Installation*, 2006-2007.

as works that explore "the aesthetic possibility of using the computer for the primary goal of building feedback systems around participant action" and "not transforming sound into image (or vice versa)" – as stated by the author, one unique possibility of the use of the computer as an artistic tool is the ability to "create behavior" (Levin 2009). In his case, these are mostly reactive and interactive behaviors, in contrast to Antoine Schmitt, for example, who explores the creation of autonomous behaviors in his *ensembles*, namely *The World Ensemble* (2006). Accordingly, sound and image are intentionally reduced to a minimal expression; as the tangible expressions of programmed entities they only acquire meaning through action. In this context, interaction becomes a means of testing the behavior of a system that potentially runs autonomously, in a self-organizing and often unpredictable manner.

These works also reveal different forms of user engagement through interaction – either as a means of exploring the system's variable behavior, or as a means of exploring its productive possibilities – or as a form of influencing, or of defining, its audiovisual outcomes. By extension, and in contrast to the notion of interactive performativity discussed before, generative autonomy implies the transfer of some degree of creative autonomy to the system, as detached from the direct control of its creator (or even other external factors). An alternative way of putting this is considering that agency, rather than pertaining to the user, is attributed to the system, when understood as the "property of an autonomous entity that is its capacity to act in or upon the world" (Jones 2011). And just as a human being has the capacity to sense its environment, making decisions and operate on it, a system can be imbued with these properties; again, in the very sense that Murray ascribes to it – taking action leading to meaningful results, while "exerting power over enticing and plastic materials" (1997, 153).

On one level, what is emphasized is the possibility to create behavior, whether autonomous or interactive. Sound and image become the tangible expression and consequence of a dynamic process, emphasizing processuality and performativity as generativity and interactivity. Consequently, on another level, what becomes defined as a distinctive quality of these systems is the dynamics of their behavior. In contrast to other time-based forms of audiovisuality, they not only have a transient, but also a variable nature, in each occurrence or in response to interaction. In other words, these works' content "is their behavior and not merely the output that streams out" (Hunicke et al. 2004, 1).

Performance and modes of expression

Implied in this view is the idea that beyond the "retinal beauty" of audiovisual sensory perceivable results, the "iconographic level" (Broeckmann 2005) or beyond the "rhetoric of the surface" (Bootz 2005), digital computational works entail a conceptual level tied to the cognitive recognition of the formal processes they carry out (cf. Jaschko 2005; Whitelaw 2010).[24] We then move towards an aesthetic level that is tied to their "procedural rhetoric" or "the practice of using processes expressively" (Bogost 2008, 122-124). Sound and image become a surface expression of "expressive processes", which, according to Wardrip-Fruin (2006), are those that more evidently contribute to (or define) the works' meaning and expression.

These notions highlight the subordination of audiovisuality to procedurality, and ultimately, how sound and image as aesthetic materials, subsume to the performative aesthetic quality of these works, as works that occur while running as processes performed in real-time – as live processes or activities taking place in the "here and now" as "unique moments and situations in progress" that result in a "strong sensation of immediacy and presence" (Jaschko 2010). In other words, the expression and experience of these works is shaped by the modes of "liveness" (temporal simultaneity) and 'presence' (spatial co-attendance) together with their visual and auditory realization (Kwastek 2009b, 93).

Consequently, from the idea of an audiovisual aesthetics, we move toward an aesthetic of process and performance, and from systems *for performance* towards *the performance* of these systems as aesthetic artifacts, in their different degrees of autonomy and interactivity. Therefore, in order to understand the distinctive qualities of these systems as aesthetic artifacts we must consider not only their audiovisual (or sensorial) qualities of expression, but also their procedural ones, or the procedurally enacted dynamic (and often indeterminable) behavior that defines their meaning and experience.

1. As Jewanski explains, "color-sound correspondences appeared in prehistoric times as components of complex symbolic or cosmological analogies. In connection with the planets and different spheres of human existence, (…) in the sense of a global harmony. From the ancient world onward, the number of analogical models was incrementally reduced and the first separate color-tone analogies were developed. These then also led to a definition of color harmonies through the transfer of the musical theory of consonance and to the establishment of a theory of harmony in painting" (Jewanski 2010b, 340).
2. Factors leading to the proliferation of color organs and kinetic light apparatuses in the twentieth century include developments in electricity, renewed interest in Pythagorean and theosophical ideas of harmony and cosmic order, as well as beliefs in synesthesia and studies in sensory physiology (Jewanski 2010a).
3. They consisted of abstract films, colored light projections, and painted slides: three side-by-side movie projections with two overlapping projectors to add extra colors, and complementary changing slide-projections.
4. According to Belson *Vortex* was a "new form of theater based on the combination of electronics, optics and architecture. Its purpose is to reach an audience as a pure theater appealing directly to the senses. The elements of *Vortex* are sound, light, color, and movement in their most comprehensive theatrical expression. These audio-visual combinations are presented in a circular, domed theater equipped with special projectors and sound systems. In *Vortex* there is no separation of audience and stage or screen; the entire domed area becomes a living theater of sound and light" (qtd. in Keefer 2009).
5. The path of development from color-light instruments to multimedia performances and environments concerns "the simultaneous mobilization of multiple media" that challenges "the modernist drive towards media specificity", while entailing the real-time performance of multiple projections and music filling space; a principle that extends to expanded cinema and multimedia immersive environments (see James 2010).
6. As Daniels argues, "electronics changed both audiovisual perception through mass-media and artistic practices of working with audiovisual material" (2009, 250).
7. The former strategy entails a play with the fixed materiality of film, its discrete units and operative processes for structuring audio-visions – as artificially constructed sound-image relations (Chion 1994) – in a conceptual affinity with the formal and processual principles of minimalism, "based on repetition premised on reception", transposed to media-technological procedures (Buchmann & Bellenbaum 2010). This is particularly evident in the *flicker* films of the 1960s and 1970s, such as Peter Kubelka's *Arnulf Rainer* (1958-60), Tony Conrad's film *The Flicker* (1966) or even the locational film installation *Shutter Interface* (1975) by Paul Sharits. These works aimed at making the spectator conscious of the preconditions of film technology by playing with his perceptual apparatus, while extending the audiovisual experience into space by implicating the audience in an active perceptual and physical activity.
8. This is achieved in the exhibition *Exposition of Music – Electronic Television*, in 1963, through an interactive repurposing of the broadcasting functions of TV, and reproductive functions of record players and tape recorders that were directly manipulated by the audience.
9. Examples include Paik (with Shuya Abe), who began building analog video

synthesizers, as video equivalents of audio synthesizers, that allowed one signal to be used to control another signal in real time. Video synthesizers were also used to alter live camera sources, as well as in self-contained setups to generate abstract imagery (Alexander 2010). With Stephen Beck's *Direct Video Synthesizer* (1970) waveforms could be produced by oscillators, also allowing the creation and influence on elements like color, form, movement, and even the illusion of depth. Similarly, video processors, such as the *Rutt/Etra Scan Processor* (1973) made the control and modulation of electronic signals possible through the analysis of the smallest units in video, its waveforms (Spielmann 2010, 316).

10. This was a live performance on a large screen video projection where Beck interpreted the music with a visual time-based flux of images. This line of developments of audiovisual live performance can be seen as deriving in VJing strategies (involving the live manipulation or creation of [often] abstract imagery) evocative of color organ performances, lights shows and liquid projections, or even comparable to image collages of the 1960s light shows. Similarly live cinema emerges as a more loose visual narrative in parallel to the musical (see Alexander 2010).

11. The author completes this statement affirming that "The first video instruments were inspired by the architecture of audio instruments, and the first organization of images was negotiated in similar ways. With feedback, which all these instruments possess generically, the preliminary nomenclature of generated images was established" (qtd. in Dunn 1992, 12).

12. Namely, by testing computers for "internal image generation" on an algorithmic basis and "external image processing" as digital data (Spielmann 2004, 8).

13. Such as *Permutations* (1966-1968) assisted by Jack Citron at IBM Labs, or *Arabesque* (1975), assisted by Larry Cuba. However, in the 1960s the processing capability of computers did not yet allow for the generation of complex imagery in real-time, so Whitney had to use the computer to create frames that were animated on film. Only in the 1980s with the advent of personal computing and real-time graphics was he able to directly map these animations to music. He related the periodic parameters of music to those of the visual domain, as a form of "'computational periodics' (…) a new term which is needed to identify and distinguish this multidimensional art for eye and ear that resides exclusively within computer technology" (Whitney 1976).

14. Assisted by Ken Knowlton at Bell Laboratories, Schwartz produced animations developed in collaboration with computer musicians, namely F. Richard Moore, *Pixillation, Enigma, Apotheosis, Affinities, Galaxies* and *Mathoms* (1970-77) or Max V. Mathews with *Mis-Takes* (1972).

15. The *VAMPIRE* was one of the first computer systems (then a room-sized computer) for synthesizing both animation and sound in real-time. It included animation routines by Ken Knowlton and was built on the basis of the *GROOVE* computer music system, created by Max Mathews.

16. They are not seen as instruments or tools used merely for the production of audiovisual results, nor as instruments for performance (in a traditional sense), used solely by their creators, but rather as systems for the audience to perform.

17. The installation used "video cameras, image processors, computers, synthesizers and a sound system to create a space in which the movements of one's body create sound and/or music" (Rokeby 1990).

18. In accordance with a non consensual use of the terms "digital" and "media" we opt to make reference to audiovisual "artifacts", "works" or "systems" (or even work-as-system), whose nature is digital but whose specificity is *computational*, as suggested by Wardrip-Fruin (2006) or Manovich (2008), who proposes to focus on "software" (and its operations) rather than "media". These are software-driven, or digital computational works, where "computation is required [not only in the authoring process, but also] during the time of reception by the audience", namely supporting interaction (Wardrip-Fruin 2006, 398).

19. And as the author states, also as an open-ended exploratory activity that goes beyond mere entertainment value.

20. Agency can be seen as the ability "to act in or upon the world (…) having made a decision, to carry out (or execute) that decision". And while "interaction implies reciprocal actions or influences of two (or more) entities upon each other, where an entity is some kind of organized object of multiple components that has some degree of autonomy and agency", autonomy implies that "an entity can stand alone in some sense, making decisions based on its own knowledge of its situation" (Jones 2011).

21. Similarly the authors assume that we may "speak not of the 'artwork' but of the 'art system' – where this comprises the artist, the program, the technological installation (and its observable results), and the behaviour of the human audience" (Boden & Edmonds 2009, 41).

22. As Jaschko (2010, 130) asserts, process is a "central aesthetic paradigm" of generative and interactive artworks, since "live processes… generate unique configurations and dynamics", performed either by the system, or by system and user. Process and performance are then two essential qualities of the machinic.

23. These principles include interactivity rephrased as performativity; processuality (the character of algorithmic processes) rephrased as generativity; transmediality rephrased as the transmutability of digital data (Levin 2007; 2010). Transmutability (comprising visualization and sonification practices) stresses the possibility to map any input data or source information into visual and auditory form. While this term accents the translation processes performed on non-process elements of the work (data and its audiovisual rendering), the principles of interactivity, performativity and generative autonomy bring to the fore the processes carried out by the work. When generativity appears associated to processuality it opposes the mere algorithmic creation of static results; it emphasizes processes (whose structures are algorithms, as they are defined at the level of their mechanics) or operations performed by the work as observable activities, as the works "dynamics", i.e. "the runtime behavior of the mechanics" (Hunicke et al. 2004).

24. This invokes the procedurality that characterizes the "principal value" of the computer in relation to other media, or its "defining ability" to execute rules that model the way things behave (Murray 1997, 71).

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