

Patient Zer0: Creating Online Generative Art During the COVID-19 Pandemic

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ABSTRACT

Patient Zer0 is an interactive generative artwork, designed around the poem “In Memory of Anyone Unknown to Me” by Elizabeth Jennings and created during the first confinements imposed by the COVID-19 pandemic in 2020. While it has been showcased in several online exhibitions, this article details and analyses, for the first time, the artwork’s algorithmic approach, as well as its aesthetics, the different media components, and the artist’s intentions behind their inclusion and combination. In line with Springgay’s, Irwin’s, and Kind’s a/r/tography, a recent creative research method is presented here, a/r/cography, which is complemented by a phenomenological dimension, as the author experienced the events from a physical, intellectual, and emotional perspective, in isolation, while at home in Portugal. The whole process was documented in a digital journal, which not only supported the underlying research but also documented the artwork variants and evolution. Patient Zer0 was entirely coded in Processing.js.

INTRODUCTION

Patient Zer0 (Veiga, 2020a, 2020b) is an online interactive generative artwork. It was designed around particle systems—an appropriate metaphor for an airborne virus—and the poem “In Memory of Anyone Unknown to Me” by Elizabeth Jennings (2012, p. 287). It was inspired by, conceived, and designed during the first confinements imposed by the COVID-19 pandemic in 2020, when little or no information was available, and a feeling of helplessness invaded people’s homes. This artwork has been—and still is—showcased in several online exhibitions, but this article contextualises, describes, and analyses, for the first time, the artwork’s algorithmic approach, as well as its aesthetics, the different media components, and the artist’s intentions behind their inclusion and combination.

In line with Sawyer’s (2012) eight-stage model of creativity, design thinking, and Springgay’s, Irwin’s, and Kind’s a/r/tography (2005), a recent creative research method is also presented here: a/r/cography (Veiga, 2019, 2020c, 2021). It identifies seven distinct iterative and generative stages in the creative investigation process, applied in the creation of *Patient Zer0*: inspiration, trigger, intention, conceptualisation, prototyping, testing, and intervention. This analysis was complemented by a phenomenological dimension, as the author (and creator of *Patient Zer0*) experienced the events from a physical, intellectual, and emotional perspective, in isolation, while at home in Portugal. The whole process was documented in a digital journal, which not only supported the underlying research but also documented the artwork variants and evolution.

BACKGROUND: COVID-19, GENERATIVE INTERACTIVE ART, CREATIVE RESEARCH

The COVID-19 Pandemic in Portugal

For most people, the early months of the COVID-19 pandemic in Portugal, in 2020, were spent indoors, due to the compulsory confinements, during which little was known of the disease, other than

its extreme contagiousness and lethality. Medical and health staff, including nurses, firemen, and policemen, as well as essential services staff (electricity, water, fuel, and food), were among the few who had to continue working during those confinements. However, even though both the government and major international health organisations recommended physical isolation and the wearing of masks, many more chose not to abide, potentially putting themselves and others at risk.

While some were busy protecting lives, others were disputing those measures, claiming they were ruining the economy. Perhaps understandably so, as their businesses were shut down, their employees were laid off, and the future felt uncertain and dark. During those days, the world learnt of the Italian people applauding their doctors and nurses from windows and balconies each evening, of neighbourhood concerts from private terraces and also of ambulances carrying COVID-19 patients being stoned (Rodríguez, 2020) and of elderly people being abandoned in homes where they died of starvation (Muñoz, 2020). There were even rushed funerals and mass burials (Hennigan, 2020), without the presence of loved ones. To sum up: 2020 marked one of the darker, sadder pages in our recent global history.

Figure 1. Patient Zero Title Screen



Note. From Veiga (2020a).

It is not the main purpose of this article to engage in a discussion of health and economic issues and the impacts that the measures adopted to mitigate the spread of the pandemic had on global society. However, this was indeed the actual context in which the author's creative process took place and is therefore relevant for the analysis of the resulting artwork, hence this brief recall of those dark days. Under those circumstances, creating an interactive online artwork felt like a fruitful direction to pursue,

as although most people were locked inside their homes, it could be exhibited in one of the few global spaces where communication was thriving: the Internet. These were, thus, the starting conditions for the interactive online artwork: *Patient Zer0*.

On Generative Interactive Art

The term *generative* implies an iterative algorithmic framework within which the artwork is manifested. Generative algorithms, in general, are responsible for combining order with chaos, bringing structure to controlled randomness. Controlled randomness can be achieved through computation, as most programming languages include pseudo-random number generation, but also by considering the human factor—or human interaction—as a source of randomness, as each visitor's free will determines potentially different interactions in time, scope and span. Each iteration of the algorithm—or each new generation—can also become the seed for the next iteration, thus resulting in a seemingly infinite, non-repetitive number of states within a pre-determined aesthetic boundary as defined or pre-determined by the artist-programmer (Galanter, 2014).

The designation *generative* applied to *art* was first introduced by Georg Nees in 1965, with his Stuttgart exhibition “Generative Computergraphik,” following the work he developed under the supervision and inspiration of philosopher Max Bense. There are various definitions and classifications of *generative art* (Galanter, 2014, 2016; McCormack et al., 2014) as well as alternative designations for variations and subtypes, such as systems art, interactive art, algorithmic art, OpArt, BioArt, and evolutionary art, among others.

However, the term *generative* always implies the existence of an autonomous algorithmic structure that leads to the creation of a particular type of output—and the artwork consists in the ensuing runtime process and its output, rather than merely just in its encoding alone. The algorithmic structure is used to combine order (specific rules and structure) with chaos (controlled randomness, interaction, and agency), each iteration becoming the seed for the next one, thus resulting in a seemingly infinite sequence of states—a flow—but all within a certain aesthetic boundary defined by the artist-programmer.

These systems also may vary in terms of their sensitivity to initial and external conditions and can be defined as non-sensitive (closed) or sensitive (open). Non-sensitive systems produce a finite number of states, even if in a very large number, that will probably prevent repetition from occurring during the audience's experience of the artwork. In such systems, the result is defined by the algorithmic structure alone and has no significant dependency on the initial generation or on external factors. Thus, closed systems are usually non-interactive or have limited interactivity. Sensitive systems, on the other hand, will eventually generate a potentially infinite number of states, not only because each state strongly influences its own evolution but also because external interference and interactivity are allowed (and indeed welcome), and they contribute to further modulate the result (Veiga, 2017).

Creative Research

Arts-based practices have posed serious challenges to methods conventions, thus unsettling many assumptions about what constitutes research and knowledge. Inkeri Sava and Kari Nuutinen refer

to these methods as presenting a “troubling model of qualitative inquiry into self, art, and method.” These disruptions to traditional research practices, much like early responses to the qualitative challenge to positivism, have caused concerns and inspired debates. As our methods history shows, such debates are critical to scientific progress, as they create a space for a professional public renegotiation of disciplinary practices and standards. (Leavy, 2020, p. 11)

Creative research fundamentally differs from the positivist approach used in sciences to address epistemological questions that fail to be addressed by quantitative methods. Creative research also differs from creativity research: while the latter seeks to assess, understand and explore creativity, the former uses creativity in applied research (e.g., the flexibility of stored cognitive structures, the capacity of memory and attention systems, their interconnections, and the mental processes that transform them (Sawyer, 2012), to achieve new knowledge, supported by qualitative (e.g., phenomenological, hermeneutical, or self-ethnographic) approaches. The difference between them could be paralleled to that between (arts-)practice-based research and arts-based research. In the former, the researcher is actively involved in the creation and creativity processes, and the ensuing artefact is the basis of the contribution to knowledge—therefore engaging in creative research. In the latter, the researcher is focused on the artwork through its agency as a finished object of research, rather than the evolutionary creation or creative processes.

Among the many different approaches to creative research, already amply accepted in the Academic community, this article focuses on three: Sawyer’s eight-stage model, design thinking, and Irwin’s a/r/tography. Because there are common traits among them, their use in the field of digital media arts can be combined and optimised. For Sawyer (2012), the consensus resulting from cognitive psychology determines that creativity isn’t a single, unitary mental process. Instead, he proposes that creativity results from many different mental processes, and he proceeded to identify eight stages (Sawyer, 2012, p. 88):

1. Find and formulate the problem;
2. Acquire knowledge relevant to the problem;
3. Gather a broad range of potentially related information;
4. Take time off for incubation;
5. Generate a large variety of ideas;
6. Combine ideas in unexpected ways;
7. Select the best ideas, applying relevant criteria; and
8. Externalise the idea using materials and representations.

The umbrella expression *design thinking*, which finds multiple instances and variations in literature, as summarised by Micheli et al. (2019), commonly designates an approach to applied creativity (mostly in the areas of education, product design and management) and delivers a significant contribution to the analysis of the creative process. The authors identify the three most influential applied models of design thinking and their respective stages: (1) IDEO: inspiration, ideation, and implementation; (2) Stanford Design School: empathy, definition, ideation, prototyping, and testing; and (3) IBM: understanding, exploration, prototyping, and evaluation (Micheli et al., p. 8). These models usually start from an initial exploration, then evolve into an ideation stage, followed by an implementation and testing

phase based on prototyping and iteration. Both Sawyer's model and design thinking thus clearly identify different stages, which can then more broadly be classified as:

1. Contextual
2. Conceptual
3. Actual
4. Evaluative

A/r/tography (Springgay et al., 2005; Irwin et al., 2017) is a research paradigm firmly rooted in the arts-based research paradigm, where knowledge emerges from the engagement of artmaking (a), researching (r) and teaching (t), through living inquiry and reflective writing. *A/r/tography* systematically questions ongoing creative and artistic practices in order to create knowledge, rather than to discover or structure pre-existing realities. New understandings—not findings—are shared upon reflection, and for the authors, these forms of arts-based research need to be considered not as extensions of qualitative research but rather as methodological approaches in their own right. *A/r/tography's* relevance can be ascertained by its worldwide dissemination (Irwin et al., 2017).

A/r/tography deals with the potential of using three different roles to iteratively achieve doing, thinking, exploring, and sharing. Doing and thinking are the artist's business, in the same way that thinking and exploring are the researcher's tasks and sharing is the teacher's duty. But sharing, which is essentially the process involved in teaching, can more broadly be posited as a communication process, not exclusive to teachers, and therefore be more encompassing. And communication is also one key factor in art and creativity.

Csikszentmihalyi (2014) posited a "systems view" in which "creativity is defined with respect to a system that includes individual, social, and cultural factors that influence the creative process and help to constitute a creative outcome" (p. 68). These influences are separated into the *field* (the group of individuals that contribute to innovation) and the *domain* (the accepted body of practice and knowledge). For him "a field—or the society that harbors it—may stimulate directly the emergence of new ideas in people who otherwise would never have taken up work in a particular domain" (p. 55). "Thus, the field of art, like any other field, is made up of a network of interlocking roles" (p. 52).

One would then posit that in the domain of digital media art practice, and its inherent academic research processes, the artist, the researcher, and the communicator are clearly among those interlocking roles; they "have a better chance than others of incorporating a selected variation into the domain. The people who fill these privileged roles act as 'gatekeepers' to the domain" (p. 56).

For Csikszentmihalyi and Gruner (2018), "demonstrating one's understanding of knowledge by crafting new combinations of existing equations or solving problems by refashioning previously mastered behaviors and ideas can be creative" (p. 450). He proceeded by stating that "understanding learned material requires application of knowledge to uncharted territories," leading to the externalisation of creativity.

To capture creativity in action, ideas and patterns must somehow be recorded, so that they can be made conscious to the researcher and visible to the public.

The key is to identify the right way to represent the problem; with most creative problems, there are many different possible ways to externalise it, and the most effective way to represent a problem, changes with the nature of the problem. (Sawyer, 2012, p. 136)

To achieve this effective representation in the domain of digital media art, a methodological approach was developed, using the above theoretical principles as cornerstones, steering toward an understanding of interdisciplinarity, multidisciplinary, and transdisciplinarity.

This should not be regarded as a collage of different disciplines and approaches but rather as a disruptive paradigm where, in absence, new courses of action—and knowledge—unfold, driven by the cumulative roles of the artist, the researcher, and the communicator. A/r/cography (Veiga, 2019), the practice-based research methodology used in this project, has been published by the ACM-DL (Association for Computing Machinery Digital Library; Veiga, 2019), and The Association of Computational Creativity (International Conference on Computational Creativity; Veiga, 2020c), among others, and is further demonstrated below.

ART-PRACTICE BASED RESEARCH METHODOLOGY: A/R/COGRAPHY

This project, consisting of both the artwork development and the related research, was brought about using *a/r/cography*, which frames the work of creative research along three vectors: art (a), research (r) and communication (c). At the core of the creative research process lies artistic experimentation: its intended and perceived meaning and aesthetics, the research it implies, which is documented in a digital journal (Veiga, 2021), and the outcomes it generates, materialised in the public presentation of both the artwork and research.

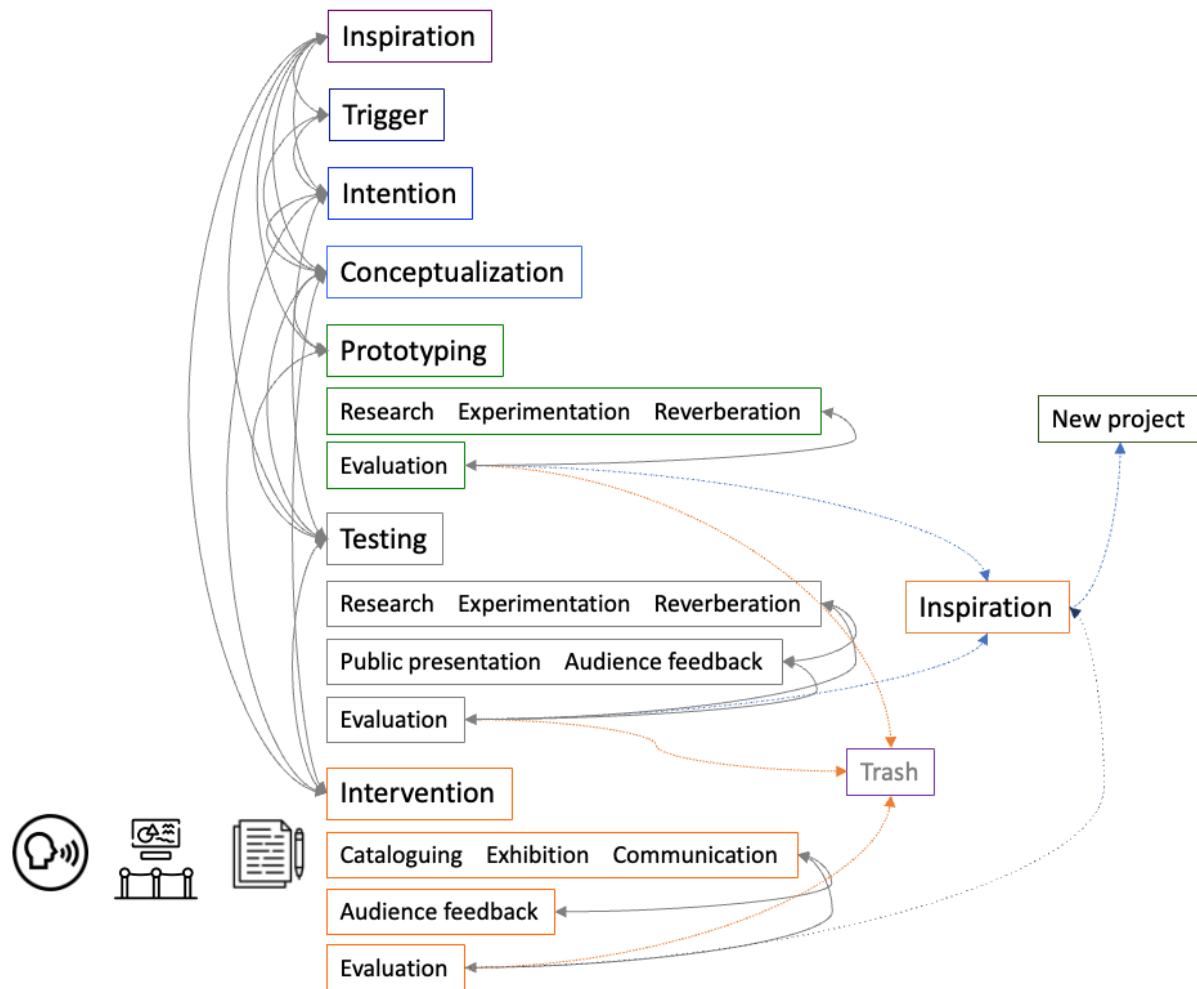
The happy abbreviation of a/r/tography (a/r/t) echoes through the metaphor of the arc (a/r/c) as a creative and exploratory path, disregarding the efficiency of the straight linear connector while embracing the eccentric exploration of the periphery, seeking paths that will surely not be the shortest and fastest but will potentially be richer and more fruitful. The arc differs from the wanderings of *flâneurs*, as it implies a well-defined starting point and destination, allowing—and even fostering—a determined and deliberate eccentricity in this route.

Creative processes are thus sets of moments with generative potential, paths and versions of the development of creative thinking, and open interactive communication systems that include diverse elements with dynamic characteristics articulated through relationships (with academic, historical, social, cultural, political, and economic contexts), such as media, technique, values, narratives, memories, dialogues, encounters, individualism, collaboration, geography, temporality, among many others.

Producing and keeping records of these iterative processes, which lead to the creation of artworks, is a way of materialising and communicating creativity in its defining vectors: originality, usefulness, and surprise (Simonton, 2022). The study of creative processes assumes that the system is not

the simple sum of its elements, as they establish a complex interplay of mutual implications, in which actions and reactions feed into one another. This web of relationships resembles a network or rhizome in permanent transformation, which implies renouncing concepts such as origin, conclusion, hierarchy, and methods of linear organisation. However, there is a progression in stages or phases, but even they can, at any time, be revisited, questioned, and reoriented.

Figure 2. The Seven Stages of A/r/cography



A/r/cography allows—and incentives—the creative individual to simultaneously explore different directions, potentially facilitating new evolutions, derivatives, or even new projects. If a/r/cography was already considered a methodology of situations by its creators, then clearly a/r/cography embraces generativity, potentially leading to unforeseen lines of evolution, brought about by broad and varied audiences, influencing each stage through which the artists themselves evolve, and through three different types of communication: (1) reflexively, through writing and self-analysis; (2) with the public, by

engaging in conversations, interviews or questionnaires; (3) and with other artists or academic peers, through shared analysis and critical thinking. Thus, the a/r/cographers refine and evolve their artworks as a result of those processes, which then become a part of the project itself.

This methodology is particularly suitable for digital media art, since different stages of evolution of the same artwork (and research) can coexist in a non-destructive way, unlike with painting or sculpture, in which a new iteration implies the obliteration or concealment of the previous one. A/r/cography identifies seven distinct, iterative, and generative phases or stages in the creative investigation process, in line with what Sawyer (2012) also posited with the eight-stage model of the creative process (p. 89) that “lead up to the generation of a creative work: a product that can be shared, discussed, and communicated” (p. 141). Thus, the seven stages outlined in a/r/cography can also be mapped onto the previous four posited categories of (a) contextual, (b) conceptual, (c) actual, and (d) evaluative:

1. Inspiration (a)
2. Triggering (a)
3. Intention (b)
4. Conceptualisation (b)
5. Prototyping (c and d)
6. Testing (c and d)
7. Intervention (d)

Each of these stages may influence the next one and potentially influence itself and the previous stages (see Figure 2), as the artist reverberates within the creative process. At the intervention stage, an output is expected, according to the artist, researcher, and communicator profiles: an artwork, a written body of research, or a communication.

The a/r/cographical stages of the online interactive artwork, *Patient Zer0*, are presented in the next sections. Each stage (and each sub-stage) begins with a general contextualisation and is then instantiated with the observations concerning *Patient Zer0*. The present tense is used in the contextualisation, as well as artwork definitions and characteristics, while the past tense is used to describe the events and specific decision-making processes as they occurred. The term *a/r/cographer* is also used to describe an indeterminate agent, whereas *author* is used to specifically refer to the authorship of *Patient Zer0*.

Inspiration

Inspiration is a diffuse concept, often alluded to as a form of enlightenment, artistic discernment, or intuition, potentially characterised by evocation and motivation. In a/r/cography, inspiration appears as the first stage, which may seem paradoxical in a non-linear model. However, inspiration may also be the potential outcome of other stages' iterations, and often, only in retrospect will the artist-researcher fully identify—or acknowledge—all its elements.

Facing mortality—especially that of others—is a process that all humans will have to experience at some point in life. But a global pandemic is truly an exceptional event, and one cannot but feel deeply

impacted by it, especially when seeking solace among friends and family is no longer physically possible. During the pandemic, the continuing stream of international news media reporting the collapse of the health system due to an unforeseen number of cases, insufficient staff, and the fatality toll, all contributed to a widespread feeling of being surrounded by death and loneliness. The relentless and merciless statistics reduced individuals to numbers and percentages, stripping them of their uniqueness and individuality, as if prematurely turning them to dust and ash.

This relationship between life and death through ashes and dust is—at least—as old as the biblical book of Genesis and as modern as quantum physics, depicting the decomposition of the body into its tiniest particles after death. Very early work conducted by the author using cellular automata (Veiga, 1991) and contact with newer agent-based models, such as the ones available in NetLogo (<https://www.netlogoweb.org/>), specifically dealing with virology and immunology (Beauchemin et al., 2018) also influenced the (graphical) nature of the artwork. All these factors contributed to the use of different particle systems (and their behaviour) in the artwork.

Trigger

Creative processes, when creating art or conducting research, are set in motion by what can be termed a *trigger*: an impetus, a motivating element or factor. This trigger can be either internal (from a neuropsychological perspective), external (induced by external stimuli), or a combination of both (Schwartz, 2006). The trigger is an event (or a series of events) that creates or manifests connections between inspiration and reason, channels them, and leads the artist into creation and the researcher into the investigation.

A trigger can, thus, be potentiated by the artist's general motivations and lived experiences and contexts, its impact being a direct function of those factors. It can be translated as the instant in which latent inspiration was manifested, energised, and potentiated, a starting point to the conscious creative process, defining its intention. As with inspiration, the trigger may sometimes only be identified as such in retrospect, when analysing the creative process.

The author identified two separate triggers in *Patient Zer0*: the first was Elizabeth Jennings's (2012, p. 287) poem, "In Memory of Anyone Unknown to Me," which found its way into the author's reading list when news services and broadcasts grew too unbearable to watch or read. This poem appeared to perfectly portray the author's experienced emotions, traversed by respect and sympathy toward "Anyone Unknown to Me," even though it had been written decades ago, in a different context from the global COVID pandemic. The second trigger was a call for participation in the collective exhibition *Art In Quarantine*, an initiative of Portuguese artists and academics wr3ad1ng d1g1t5 (Diogo Marques and Ana Gago; wr3ad1ng d1g1t5, 2020). During the forty days of the open call for participation, this exhibition registered 911 participations from various countries (shown on the website), in different genres, including poetry, illustration, sound design, and generative art.

Intention

An artwork creation process relies on the artists' intentions, which will lead them through a chain of subjective (re)actions, populated by effort, dismay, satisfaction, refusal, and decision-making. Several among these are not fully within the creators' conscious awareness at the time of their occurrence, at least on the aesthetic plane. As a result of this struggle, there will always be an objective difference between the artists' intentions and their achievement in the artworks, even if this difference will remain mostly invisible from the artists' subjective perspective.

The a/r/cographer's intentions are thus often multi-layered and complex and will act as a guide through questions, systematic processes of gathering, comparing, experimenting, contrasting, and interpreting information, leading into deeper analysis, conceptualisation, and consequent execution, through iterative refinements, culminating in public exhibition or communication—and, eventually, in the revisitation and alteration of several stages of the process.

There is an implicit injunction in the art room to take responsibility for the experiments the individual makes because she has chosen to make them; and when that focusing on response is sharpened by the sharing of the intentions of the maker and the perceptions of peer perceivers, the individual can both give form to and gain an appreciation of the value of her unique contribution to the world, allowing her to become an active maker of a living culture, rather than a passive consumer. (Gormley, 2005, p. 10)

Patient Zero's trigger acted as a bootstrap mechanism, promoting the connection between the different sources of inspiration, channelling them into the will to create an artwork depicting the extreme contagiousness of the virus and the connected nature of humanity. Visualising this interconnectedness also evoked the *small-world phenomenon*, the principle that we are all linked by short chains of acquaintances, also known as the *six degrees of separation*, first addressed in social sciences by Milgram (1967; and, on a lighter note, available to be tested in *The Oracle of Bacon* at <https://oracleofbacon.org/>).

During the early days of the pandemic, the public perception of contamination somehow equalled a death sentence, since the mortality rates were very high, leading to mass burials and graves in several countries. It was the artist's intention to bring each of those deaths into the spotlight, not treating them as an anonymous part of the masses but as individuals, identifiable by first name, age, and country. Finally, it was also the artist's intention to depict the role of the economy as the force compelling people to break quarantine and isolation protocols, acting like a contamination accelerant.

Conceptualisation

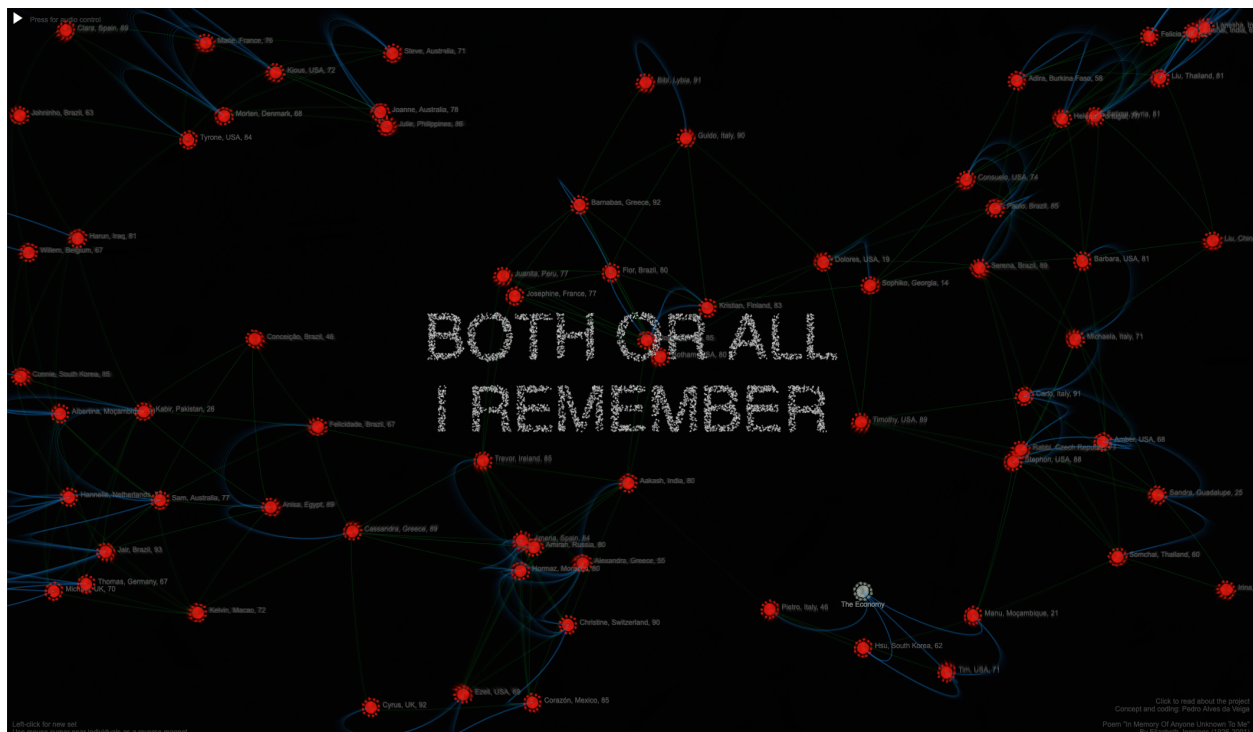
After having a clear understanding of the project's intention, the a/r/cographer has all the elements to define a concept, which is a vision of where the intention will lead, a conceptual prototype of the artwork. To help manifest the concept, the a/r/cographer brings together the sources of inspiration and attempts to creatively correlate them through research, experimentation, and evaluation—a filtering process during which the a/r/cographer discards some results, while validating the feasibility of the

project, thus leading to an initial written formulation of the concept: the research hypothesis or artistic hypothesis.

The concept of *Patient Zero* is thus an interactive generative online installation, claiming a rehumanization of the pandemic victims, while depicting the contamination process and its potential accelerants, namely individual mobility and the economy. It ought to be regarded as an educational tool, albeit with artistic liberties, in the depiction of the contagion phenomenon. The starting premise of *Patient Zero* is a population of individuals where only one of them is infected (the literal *patient zero*, in epidemiological terms).

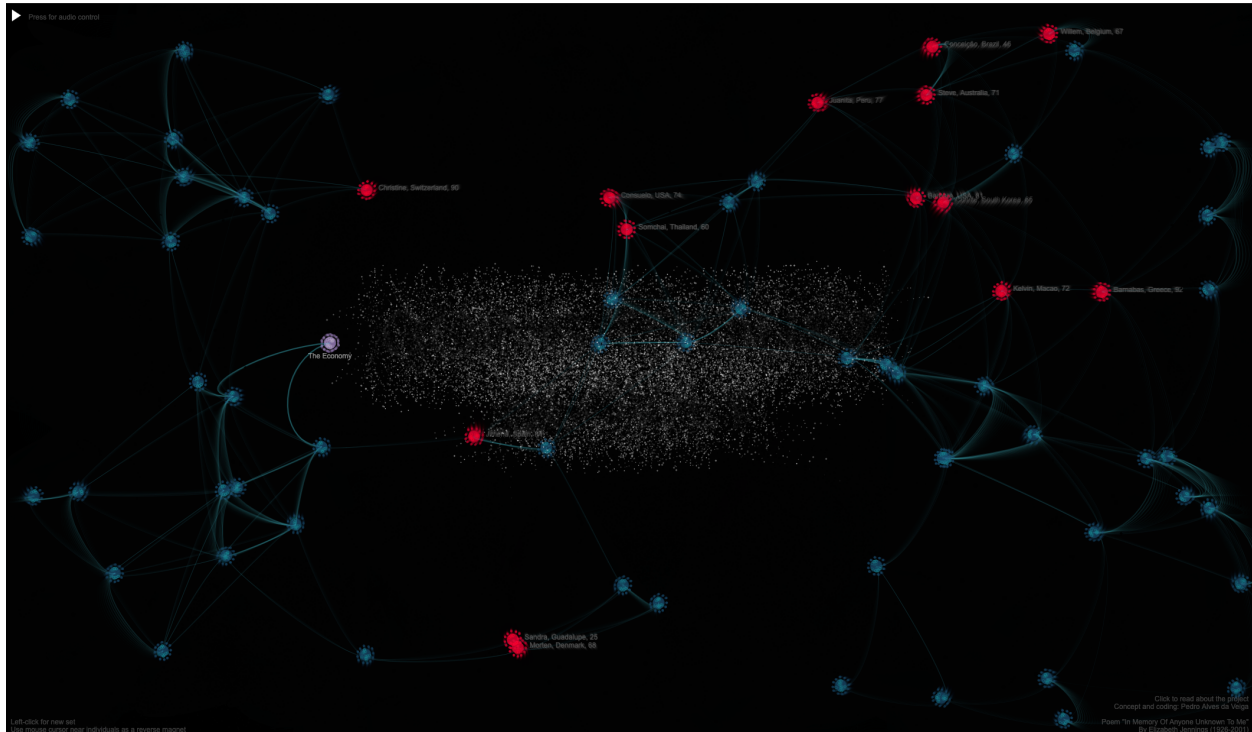
The mouse cursor, represented as the economy, is designed to act as a sling, increasing nearby individuals' velocity, making them move faster, enabling them to reach other individuals more easily and, in the process, also contaminate or be contaminated more easily. All individuals remain anonymous until they are infected. Once they are infected, their names, countries and age are displayed, like a simplified obituary (at a time when a COVID-19 infection was generally perceived to imply the death of the infected patient). Figure 1 illustrates the starting conditions, with only one infection, whereas Figure 3 illustrates the point where all individuals have become infected.

Figure 3. Screenshot From the Live Website: All Individuals Have Been Contaminated



Note. From Veiga (2020a).

Figure 4. Screenshot of a Line of Text “Dissolving to Dust” in Real Time, From the Live Website



Note. From Veiga (2020a).

Prototyping

After delivering the first full concept of the artwork, the a/r/cographer initiates a first cycle of interconnected and mutually influenced processes, consisting of design, execution, and evaluation—henceforth called prototyping (also common to the grounding theories of design thinking and Sawyer’s eight-stage model of creativity). This stage is developed mainly through research, experimentation, and hermeneutical phenomenological interpretation, resulting in filtering out unwanted results and fine-tuning the desired ones. This allows the a/r/cographer’s concept to be confirmed or adjusted through the incorporation of newly acquired knowledge and by direct testing and analysis of experimental versions (through experimentation and reverberation). The research goal at this stage aims mainly at determining if similar projects were developed by other authors and artists (as in a “state of the art” study), thus verifying its originality or newness, but also to explore variations, alternatives, and detours that might contribute to refine, enrich, and improve the concept itself.

The a/r/cographer then reverberates over the results, generating feedback processes that will lead to further research and experimentation, potentially implying adjustments to the previous stages, including new sources of inspiration, new triggers, and new insights on the concept—as was the case with the audio in *Patient Zer0*, which was only integrated into the project after the first prototype was evaluated. During this stage, the following sub-processes occur:

1. Research
2. Experimentation
3. Reverberation
4. Evaluation

These sub-processes are also in line with Sawyer's (2012) stages 4, 5, 6 and 7:

1. Research → incubation
2. Experimentation → generation
3. Reverberation → combination
4. Evaluation → selection

At the prototype stage, when designing a generative art project, the a/r/cographer is faced with various decisions, from aesthetic to technical. Because generative processes are intimately tied to representations of natural phenomena, including evolutionary organisms and artificial life models, the use of biological metaphors is only natural (Dorin & McCormack, 2001; McCormack & Lomas, 2021). The terms genotype and phenotype are thus used to represent two distinct stages of the generative system development. In biology, a *genotype* is a collection of markers, or characteristics, such as DNA (and epigenetic markers), whereas the *phenotype* is the collection of the resulting features and characteristics those markers may determine on the ensuing organisms or individuals.

Similarly, in digital systems, the genotype may be regarded as the data used as input into an algorithm, which then produces the phenotype as its outcomes (Zhang & Hu, 2022). This is particularly relevant for generative art, since the outcomes are seldom totally defined, leaving room for the autonomous system to evolve within the boundaries defined by the artist-programmer. The genetic or generative system evolves through the introduction of stochastic variations to the genotype selection, discarding those combinations that do not fit within the artist's aesthetic vision and further breeding phenotypes that do. A finite genotype can thus originate an exponentially larger number of phenotypes, as is also the case with generative artworks, not only because of the stochastic combinations of genotypes but also because the introduction of controlled randomness and interactivity during runtime affects those combinations.

While developing *Patient Zero's* prototype, four characteristic stages of generative art systems could be identified, and within each of them, the previously mentioned sub-processes (research, experimentation, reverberation, and evaluation) may also take place:

1. Genotype selection,
2. Structuring device,
3. Recomposition and amplification, and
4. Phenotype selection.

Genotype Selection

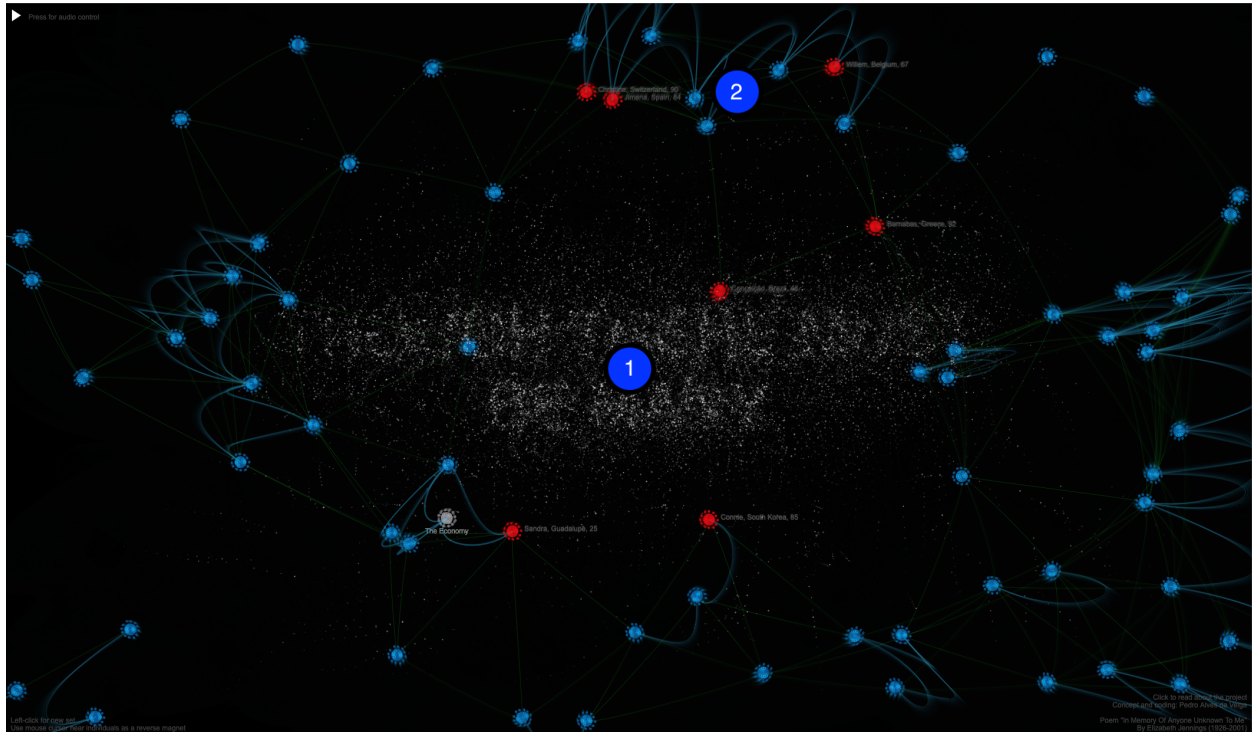
At the genotype selection stage, the artist usually determines which symbols—or vocabulary—will be involved in the artistic creation. *L-systems*, which can be found at the core of most generative art systems (Galanter, 2016), are designed using grammars, comprising (a) a vocabulary—a genotype, consisting of units and symbols, (b) axioms—combinations of genotype units, and (c) rules—which determine the evolution of each vocabulary unit or their combinations. Each abstract symbol can then be mapped into spatial positioning, choice of geometric shape, translation, rotation, scale, or even musical note pitch or duration. The list of possible mappings is as extensive as the chosen programming language allows, including all primitives that can be used from within the code for image and sound synthesis and also to process external files containing any type of relevant data.

Let us then use the term genotype to designate the set of all initial elements to be considered as a starting point, which is also a part of the aesthetic options definition in the creative process of a specific generative artwork. *Patient Zer0's* genotype consists of text units, graphic units, and audio units. The chosen text units are (slightly) remixed phrases from Elizabeth Jennings's poem, as the original verse layout is slightly adjusted for onscreen presentation. The choice was made to present key sentences and expressions at a time, rather than full verses, yet completely safeguarding the original flow of the poem. Other text units are strings of information containing the name, country, and age of the victims. The list was compiled and updated over the course of several months by analysing public obituaries from different countries. However, only the first name was used, for privacy reasons. The selected graphic units are the stylised visual renditions of the COVID-19 virus and the connecting arcs between them.

Technically, *Patient Zer0* uses two particle sets. The first set is reserved for assembling and dismantling the solemn utterances of Jennings's poem, in a visual evocation of Genesis 3:19 "for dust you are and to dust you will return," as *dust-to-text-to-dust*, illustrated in Figures 4 and 5. The second particle set is the societal backdrop, where each larger cell (in shades of cyan-blue or red) represents an individual. The relationships among these individuals are illustrated by connecting arcs, and both individuals and arcs are animated with the natural living rhythm of breathing, using cycling colours for both and movement just for the arcs. This movement mimics breathing, as COVID-19 signature symptoms mostly affect the respiratory system. The two particle sets (text-dust and individuals; see Figure 5) are connected since each dust particle that forms the poetic/text verses has its origins in one of the individuals.

There is also an ominous audio backdrop, evocative of horror movies, derived from a sample of Brazilian President Bolsonaro's televised speech in March 2020, during which he acknowledged the arrival of the virus, criticising lockdown mechanisms and defending the economy over personal safety, while claiming that COVID-19 would cause no harm, as it was comparable to a "little flu" (*gripezinha*; BBC News Brasil, 2020). The left and right audio channels were separated using Adobe Audition, and one of them was reversed. The whole sound file was slowed down by a factor of eight, and the pitch was dropped by two octaves. Both channels were then recombined in a resulting track, reminiscent of a horror film sound effect, and therefore deemed appropriate for this piece.

Figure 5. Showing Examples of (1) Text-Dust and (2) Individuals Particle Sets



Structuring Device

The essence of a *structuring device* is a set of rules and procedures—an algorithm. It will define strategies for combining the previously selected genotype into more complex structures: the actual language of the artwork. *Patient Zero*'s structuring device handles two separate processes. The first one is a state machine, T , responsible for steadily and consistently delivering the poem rendition, one phrase at a time, using a separate particle set. The number of particles is defined by the size of the canvas: a larger canvas will use more particles; a smaller canvas, fewer particles. There are lower and upper limits to the number of particles, which were determined by process of trial and error to neither compromise the animation speed or smoothness nor the legibility of the poem text. T evolves continuously in a semi-determined way, as far as knowing the sequence in which text units will be used, but the initial and final particles' positions for each state are only determined during run time and are subject to controlled randomness.

The second process is a cellular automaton, A , responsible for handling the attraction and repulsion mechanisms between neighbouring individuals (including the cursor), handling canvas limits, and also the contamination process, using a second particle set. At launch, all individuals in this set are initialised as *not contaminated*, except for one (the patient zero), which is *contaminated*. Whenever the distance between two particles falls below a predefined threshold, and one of them is contaminated, the second particle also becomes contaminated, and its state is changed to *contaminated*.

This particle set is subject to similar rules as the first one, namely in the number of elements being a function of the canvas size, also with lower and upper limits. The balance is delicate because a high density of individuals would determine a quick spread of the infection, and a low density would slow the contamination process considerably. Therefore, a suitable mid-term needed to be attained. Both sets communicate during run time, since the initial and final positions of all particles in each state of T are defined by the current positions of particles in A .

Recomposition and Amplification

Once the structuring device is defined, cognitive extensions are developed through correlations between different media types, involving recursive structures and patterns. This is the stage in which the recomposition and amplification of the genotype elements take place. Generative aesthetics are developed from numerical, operational, and structural characteristics, which will, as abstract schemes, fall into the formation principle, distribution principle and set principle. These can be manipulated and applied to any unordered set of elements, in order to deliver what is perceived macro aesthetically as complex and orderly arrangements and micro-aesthetically as redundancies and information (Bense, 1971, p. 207). Due to the introduction of controlled randomness, as well as user interaction via the cursor, at each execution of the generative system, the outcome is potentially distinct, maintaining, however, the aesthetic characteristics that allow for the identification of the artwork. The goal of this stage is thus to create interdependencies between the different elements of the genotype in order to achieve a greater variation in the phenotype. The term *amplification* may also be used, as the amount of generated information will largely exceed the initial vocabulary, due to their various unique combinations.

Another common feature of generative systems: the emergence of new properties that result from local interactions between individual components. These new properties are not specified in the genotype—they emerge via the generative process. (McCormack, 2003, p. 6)

During this stage, the a/r/cographer iteratively identifies the most aesthetically pleasing or meaningful combinations and variations of the genotype and detects opportunities to explore new complex vocabulary elements through repeated execution and observation. Adjustments are then—also iteratively—introduced into the structuring device to reflect these choices and observe the new outcomes they imply and to define the aesthetic boundaries of the artwork.

[Concerning generative art] process (or structuring) and change (or transformation) are among its most definitive features, and that these features and the very term ‘generative’ imply dynamic development and motion. (Clauser, 1988, p. 117)

For *Patient Zero*, this stage consisted mostly of adjusting the shapes, namely the symbolic representation of individuals, but also the connections between them. The first choices were to connect individuals based on different criteria, such as age groups, and even country, but the final option of connecting them based on proximity made the most sense, and also from an aesthetic perspective. Replacing straight-line connectors by arcs was another decision that took place at this stage, so that the arcs could be animated as if they were breathing. Finally, it was also at this stage that the author decided to entangle both particle sets, forcing all the particles used to render the verses, T , to have both starting

and finishing positions extracted from the social backdrop particle set, A. The trajectories of those particles were also adjusted to a swarm-like movement, rather than a linear movement, as a reference to both the airborne state of the virus and the transience and ephemerality of our nature as fluttering dust. Once the author was pleased with the recomposition and amplification mechanisms, it was time to move on to the fourth stage.

Phenotype Selection

Upon reaching this stage, the a/r/cographer has already introduced adjustments to the system, both in terms of structuring device and amplification mechanisms, and is now concerned with identifying the more (aesthetically, meaningfully, or otherwise) relevant occurrences as the system runs. Drawing on the previously presented genotype–phenotype metaphor, they identify which family of elements of the phenotype will be selected for exhibition or communication. At each execution, the a/r/cographer is usually faced with elements of the phenotype that are in line with what was expected, along with others that are undesirable. Further refinement then takes place, extending through the next two stages of the a/r/cographical process. It was during this stage of development of *Patient Zer0* that the author first introduced audio, which was later refined, along with the dependencies between canvas size, web browser performance, animation smoothness, and the number of particles.

Testing

After developing the prototype privately, the a/r/cographer reaches a point at which they feel ready to share their work with an intimate audience in order to collect feedback: friends, family members, and close academic and artistic peers. This stage shares sub-processes with the prototyping stage, the difference being the project’s maturity and the a/r/cographer’s preparedness. This allows for external feedback to be collected and used to enrich and strengthen the project, as well as the a/r/cographer’s confidence in their work. This stage consists of the same sub-processes that were mentioned in the prototyping stage, complemented by a public presentation and audience feedback, wherein the most relevant new information is collected.

1. Research
2. Experimentation
3. Reverberation
4. Public presentation
5. Audience feedback
6. Evaluation

Feedback on the artwork can usually be collected by three methods (or their combinations):

1. Built-in mechanisms (programmed or incorporated into the artwork itself, aimed at registering attention-grabbing factors, number of interactions, and time spent engaging with the artefact, per-user and per-session);
2. Polling and statistical analysis;
3. Semi-structured interviews (with audience members).

In the case of *Patient Zer0*, website statistics were used as a means to ascertain the number of unique visitors and the amount of time spent on the URL. Online chats and video calls were also used to gather further feedback from a small number of people ($n = 8$), as posited by the a/r/cographical method (Veiga, 2019).

Intermediate Results and Audience Feedback

One of the visitors reported difficulty in reading the onscreen poetry, since the text appeared and disappeared too fast, and so by way of refinement, the display duration for each text phrase was adjusted with a timer, rather than a particular number of generations. Other users reported issues with the animation speed (either being excessively fast or too slow). These issues were closely related to the web browser type and version and their integration with the graphics card acceleration. Since those issues were too varied and could not be handled by the code, the decision was made to introduce constraints regarding canvas size, with capped minimum and maximum numbers of particles per set. This way, reducing the canvas size would determine a smaller number of particles, therefore a faster animation (but with less graphic resolution), and inversely, a larger canvas size would deliver a potentially slower animation in older browsers, whereas modern up-to-date web browsers would handle large canvas sizes (and larger particle sets) with no apparent problems whatsoever. From a more conceptual stance, one visitor questioned the role of the “Economy” icon, claiming that it was not obvious, so the author decided to make the connecting arcs react to the onscreen Economy icon location, to visually underline its influence and importance in the lives of individuals and their connections.

Intervention

By methodological definition, this stage constitutes the thesis, as it validates the hypothesis, i.e., the artist’s intention. It embodies at least one of the goals in an a/r/cography project, as its conclusion marks either a public exhibition, a publication, or other communication. An a/r/cography project may foster several interventions, through revisitation (just like all the previous stages may also be revisited), originating other exhibitions, publications, or communications, through the implementation of adjustments, and modifications, once again highlighting the generative nature of the present methodology. In this stage, there are usually five sub-processes to be considered, three of which are related to the different roles of the a/r/cographer (artist, researcher, and communicator), followed by two sub-processes resulting from these previous stages:

1. Exhibition
2. Cataloguing
3. Communication
4. Audience feedback
5. Evaluation

Patient Zer0’s first intervention was as a web-art installation, in the “Art in Quarantine” exhibition, in March–April 2020 (wr3ad1ng d1g1t5, 2020). The goal of its curators was to trigger a different type of transmission chain, aimed at the exchange, reflection, and artistic creation, during such a critical moment of public health on a global scale, with visible cultural, social, and economic impact for all. For them,

stopping physical contact and social activities did not imply ceasing to create, and they welcomed all potential bridges between art and health.

That same year, in June, *Patient Zero* was selected to be a part of the “Pandemic Art” exhibition in Timișoara, Romania (Tehnoarte, 2020). This online exhibition invited artists from all countries to express their artistic position by creating hotspots on a global map. The parallel between a health pandemic and an art pandemic was further enhanced by using the same platform, ArcGIS, which was used for mapping the global evolution of the COVID-19 virus. This platform was thus adapted into a database for the creation of a digital art exhibition that allowed the public real-time access to a reality beyond the limits of traditional art galleries, especially beyond geographical boundaries, where artists expressed their fragments of truth.

On July 14, 2020, *Patient Zero* had its first public presentation as a creative research project in the “Artivism, Public Health and Environment” webinar organised by Fernando Pessoa University in Porto, Portugal. And on the 27th of the same month, it was presented again during the “Creative Articulations, Resistance and (re)Existence” webinar, organised by UNICAMP, the State University of Campinas, in Brazil. This was a particularly difficult moment for the author, as the artwork evoked some of the still fresh and painful feelings and memories that triggered its creation, and its discussion proved rather more difficult than expected, as emotions overtook speech.

The following year, having revised and optimised the code, the project was submitted to Homeostasis Lab, a digital art platform in Brazil, where it was accepted in May 2021 (<https://homeostasislab.org/visualizar/obra/2118>). Homeostasis Lab maps, catalogues, and exhibits digital art on the Internet. It also fosters research, critical discussion and reflection on behaviours and concepts arising from the relationship between humans and technology and their impacts on aesthetics, culture, and society. The Lab is a live collection that is constantly growing through regular open calls and has collaborated with more than 580 artists, programmers, curators and thinkers from different countries and generations. The present article is the first written text on the project, as the author deemed that the necessary distancing had already occurred, in order to provide an objective rendition of the creative process, notwithstanding the power of the deeply subjective emotions that steered it to its conclusion.

CONCLUSION

Digital media art projects often involve many different interdisciplinary, transdisciplinary, or even systemic roles. A/r/cography brings together the most significant of those roles—the artist, the researcher, and the communicator—to foster arts research and arts practice. These roles, as well as many others—such as curators, engineers, critics, and illustrators, to name only a few—establish a network of connections whose hierarchy, linear organisation and beginning and end points can all be changed by interdependencies within the network itself.

Evolution from stage to stage, in a/r/cography, is potentially bidirectional. Even the origin point, or inspiration, can be derived from another a/r/cographical project. Consequently, multiple unrelated projects with shared authors will be influenced by each other due to mutual interconnections. Recording and cataloguing the processes and flows of research, creation and communication is just as important as

recording artworks, oral and written communication. All these processes are regarded as parts of the project, and recording their contextual information is also crucial. The author, thus, posits a/r/cography, as demonstrated with *Patient Zer0*, an appropriate method for the development of digital art practice, the preservation of its associated research and documentation, and the progressive (iterative) enrichment of its written documentation, as well as the possibility of preservation of different versions of the artefacts, thus playing an important role in its curation.

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