**Mathematics and Performance Art: first steps on an open road**

**Telma João Santos, Professor, Performer.**

**Department of Mathematics and CHAIA, Universidade de Évora, Rua Romão Ramalho, 59 7000-671 Évora, Portugal. tjfs@uevora.pt , www.telmajoaosantos.net**

**Abstract**

This paper concerns the presentation of some possibilities of connecting mathematical concepts and performance art pieces. These possibilities have their origin on a personal practice in performance art and mathematics, but are presented here as a set of possibilities of connecting both areas, as well as connecting theory and practice, especially in performance art context. Three main possibilities are discussed here: a model to connect with a performance art piece using mathematic tools, turbulence in mathematics and in performance art, and some thoughts of how to understand a performance art piece as a intersubjective matrix. Also, a case study is provided.

**Keywords:** Almost Convergence, Mathematics, Performance Art, Turbulence, Intersubjective Matrix

**Introduction**

Many connections between art and science have been made in the last decades, especially within interdisciplinarity, where art is inspired by new developments in science and where science is inspired by art pieces and art concepts to obtain new ways of developing science and obtaining new scientific results. In particular, considering mathematics and dance, there are many authors searching for inspiration from one discipline to find developments within the other and vice-versa. For instance, Karl Schaffer and Erik Stern, who are scientists and choreographers that create dance pieces inspired in mathematical theories and teach mathematics using dance movements **[1]**. Also, Katarzyna Wasilewska uses mathematical knowledge to approach dance pieces, using several possibilities: probabilities, dynamical systems or geometry **[2]**. In performance art context, Esther Ferrer uses some questions from mathematics as “which is the biggest prime number known?”, or “which is the last known decimal of π?” to create performance or visual art pieces **[3]**.

This paper is devoted to the presentation of three possible connections between mathematics and performance art, with some concrete performance art pieces that showcase them in different ways. The first connection is an individual relational, where some mathematical concepts are involved. Other connection is the concept of turbulence, which is a concept intensely studied in mathematics, and which was already introduced in performative arts context by Eugenio Barba in *The Deep Order Called Turbulence: The Three Faces of Dramaturgy (2000)*.

We will make some considerations on how a performance art piece can be perceived also as an *intersubjective matrix*, a concept introduced by Daniel N. Stern in the context of psychology and finally, we present the performance, or case study, *G.O.D.,* a performance by Flávio Rodrigues, performed by Bruno Cadinha,as an example of all the concepts approached.

**Preliminary Mathematical Concepts**

**On Almost Convergence**

Mathematically, we say that a function *f* (a map that for each element belonging to a subset of the real numbers corresponds only one element of other subset of the real numbers) is convergent if we have the elements of its domain approaching a real number *a*, then the values through the function also converge to some real number *b*. We denote *b* as the limit of the function *f* as the points in the domain *x* converge to a, or *b =* $lim\_{x\rightarrow a} f (x) . $

Connected with the convergence concept is continuity property, when the limit of a convergent function when the domain converges to *a* is the value of the function at that same point *a*: *f(a) =* $lim\_{x\rightarrow a} f(x) $. This concept is also an important and widely used term in daily life. In both directions daily life and mathematics – it concerns a function (that can represent a situation, a path, an action, a movement) that does not jump, or that does not have any disconnections from itself.

We can consider a performance art piece as a set of several convergent functions to several limits, where the image at the end of the performance becomes the set with all those limits. But, taking into account that we have the notion of uniqueness associated to the notion of limit (a limit, when exists, is unique), it is hard to not consider at least some discrete set of numbers with the possibility of not belonging to the uniqueness property to convey the openness of a performance art piece - even if it is a concrete image at the end we should be able to easily construct other possible images.

Meanwhile, we introduce a concept that suits better our purposes: the concept of *almost continuity*. We say that it is almost continuous when it is continuous for almost all points in its domain, i.e., except on a countable set of numbers. This concept allows us to consider sets of discontinuity points. These points are, in the context of this paper and in the context of the concept of almost continuity, called cuts: a cut is a where the almost continuous function is not actually continuous; so, a point of discontinuity, but a point that belongs to the domain.

**On Turbulence**

A *flow* is the continuous movement of a fluid – liquid or gas - from one place to another. There are two types of flows: *laminar flows* and *turbulent flows*. In a *laminar flow* the molecules move smoothly, all in the same direction at a constant speed; in turn, in a *turbulent flow* the molecules move in many different directions at different speeds. There are many examples of turbulent flows in nature and in daily life. One of the simplest examples of the transition from a laminar to a turbulent flow is when we boil water using an electric cooker: after some time the water starts to move constantly and it forms a laminar flow, but if we wait longer, then bubbles start to appear coming from the bottom to the surface and the movement of the water inside the electric cooker becomes very complicated and not predictable, generating then a turbulent flow.

A turbulent flow can also be seen as the solution of a Navier-Stokes equation. In fact, a precise definition of turbulence that settles the “sensitivity to initial data” as an essential requirement is: “Turbulence is any chaotic solution to the 3-D Navier-Stokes equations that is sensitive to initial data and which occurs as a result of successive instabilities of laminar flows as a bifurcation parameter is increased through a succession of values” (Chapman & Tobak, 1985). Navier-Stokes equations were introduced by Claude-Louis Navier and George Gabriel Stokes by the mid-19th century **[4].**

**Performance Art: definitions and connections**

A performance art piece is, in many cases, body-based, in the sense that it uses the body to convey representations of stereotypes associated to gender, race, social and cultural behavior, and/or rituals that question identity and self-determination. It can be related with body limits (the case of performers as Ron Athey **[5]**, Marina Abramovich **[6]** and Angelica Liddell **[7]**, for instance), or changing ways in which we perceive gender or race (the case of performers as Coco Fusco **[8]**, Guillermo Gomez-Pena **[9]** or Esther Ferrer, for instance), or also forms of political and social intervention and action (as Guerrilla Girls **[10]**, Pussy Riot **[11]**, among many others).

The mathematical concepts introduced in the previous section are also concepts that can be reformulated within performance art context. We are not interested, within this paper, in this direction. Nevertheless, we will present a quick review on some examples in how these concepts can be approached in performance art. The concept of an almost continuous function is considered also in this context since performance art pieces that don’t have to be exactly continuous; or in which we can exclude some discrete points – moments, actions, and so on – and to treat them within a continuity approach, considering limits of defined functions between those discrete points. Also, in Performance Art, if we consider an action as running around the stage, each time we hesitate can be considered a cut of that function. So, it is a point where we are still running but where we can stop, analyze our perception skills at that moment and to change – or not – the effective action of running around the stage.

In the context of performance art, considered an experimental-based field and practical field regarding concepts, I believe that turbulence has always been implicitly embedded in creative processes, but only some decades ago have we witnessed the emergence of theoretical texts around concepts such as turbulence and methodologies, taking into account emotions and “feelings” as part of its random in appearance, yet deterministic nature, as well as efforts to search for theorization and for some mapping and understanding around each of the practical experiments and possible connections and interferences among them. In 2000, Eugenio and Judy Barba introduced, in *The deep order called turbulence: the three faces of dramaturgy,* the concept of turbulence to describe, regarding their experiments and practice methods, what “appears to be a violation of order; in fact, it is order in motion”. In the same paper, the authors enunciate and argument turbulence as a state that may be seen as a succession generated by “the vortexes that upset the current of narrative action”. We can, then, observe that, moving back and forth from comfortable constant states into turbulent states, turbulence is, then, a possibility to characterize a performance art piece.

**Mathematics and Performance Art: possibilities to create intersujectivities**

The connection presented here can be seen as the first steps on an open road, where its global mapping remains to be done. In this paper we want to step into new universes, where we search for particularities and common points between mathematics concepts (theory) and performance art (practice). We present new ways of relating different concepts under different fields of study. Like this, we need to be careful and maintain a general element that depends on specific situations, since we cannot close ideas on a model or paradigm.

**A relational model**

We present now a relational model as a first sketch of a possible structure to look at artistic processes as an observer and, in particular, within performance art pieces. This model was presented in *On a Multiplicity: deconstructing Cartesian dualism using mathematical tools in Performance (2014)* and it approaches the construction of concrete performance art pieces, using some mathematical notions. This model can be used also within creation processes, in rehearsals, or just as a tool that helps an observer to create a paradigm of understanding a performance art piece.

The model concerns three new notions: *Axiomatic Image*, *Sub-Images* and *Dynamics*. These notions are presented by the order they were written above, but in fact they can overlap each other and they may not be chronological. The *Axiomatic Image* is connected with the informal idea of what is the main concept of a specific performance art piece. It is not exactly the concrete departure point from which we work on different directions. It has an axiomatic, abstract and conscious (process-wise consciousness) nature. It needs to be part of a conscious and creative process of research. The *Sub-Images*, which are concrete three-dimensional, and dynamical images are part of the construction of a paradigm where mathematical notions, together with improvisation techniques are involved. The *Dynamics* is associated to the effective narrative and final form of a performance art piece. It is then possible to construct a model with three different but overlapping parts, where the idea of an axiomatic origin is present, as several mathematical definitions, and where it is possible to understand an artistic process along the three parts, converging to the performance.

The *Axiomatic Image* can be understood as a *cut* in the creation process of the performer: it is a point where the continuous flow of the performer’s life is stopped to change its nature and direction. The *Sub-Images* are also *cuts* in the process of constructing concrete dynamical three-dimensional images, as the *Dynamics* is the process resulting of filling several *cuts* within physical, body related images.

The model referred above is a possibility within my artistic creation, and also a possibility in discussing and characterizing a performance art piece. In fact, it characterizes three phases in any artistic process that are not chronological, but in the end map the process as well as characterize the concrete artistic final object.

In *On a Multiplicity: deconstructing Cartesian dualism using mathematical tools in Performance (2014)* is presented an application of this model on the construction of the performance art piece *On a Multiplicity* **[12]**.

**Turbulence**

We may perceive a performance piece as a set of Navier-Stokes equations, which describe the several flows within the performance that have turbulent solutions. These turbulent solutions start, obviously, as laminar flows but become turbulent ones, and then they become laminar again until some new laminar flow appears and the process re-starts.

Even if we consider, for instance, the performance *The Artist is Present*, by Marina Abramovich, we can perceive that, with each spectator it is created a set of turbulent flows along the performance, as well as if the public outside that moment who is observing it can perceive the several states of Marina along the performance. So, it can be seen as a set of Navier-Stokes equations, some of them having as a solution a turbulent flow, starting as a laminar one.

**A performance art piece as an intersubjective matrix**

Finally we present the last possibility of interconnection between mathematics and performance art. Daniel N. Stern was the first author to coin, in *The Present Moment in Psychotherapy and Everyday Life* (2004), the concept of *intersubjective matrix*: “our mental lide is cocreated. This continuous cocreative dialogue with other minds is what I am calling the intersubjective matrix” (p. 77). In the same book, the author also observes that this cocreation can be within just one mind. This concept is introduced in the context of the way children connect or interrelate with others. It is not a black or white way of performing or understanding, but instead is a cocreation between minds, taking into account the intersubjectivity present in the process.

The concept of *matrix* is also familiar in mathematics to define a rectangular array composed by a finite number of elements disposed in rows and columns. These elements are part of the same structure – the *matrix* – and, even if they are related, they are not interconnected and they are not subjective. So, what Daniel N. Stern recovers is this structure, where the elements are well disposed, but adds to it the possibility of intersubjectivity and interconnectedness. This structure is somehow similar to the one of *rhizome*, a concept introduced by by Gilles Deleuze and Felix Guattari in *Mil Planaltos – Capitalismo e Esquizofrenia 2* (2008), as a set of interconnections with no center, no logical development, which generate multiplicities. But the *intersubjective matrix* has an organized structure instead.

I propose here that a performance art piece can be seen as an *intersubjective matrix* composed by the *almost convergent* functions involved, their *cuts*, as well as the *turbulent* flows, where the *Axiomatic Images*, *Sub-Images* and *Dynamics* are also included. In the creation process, we come from a *rhizomatic* universe and we create a set of almost convergent functions, where their cuts are analyzed, and where the turbulent flows are identified, creating the *intersubjective matrix*, or the concrete performance art piece.

It is important to note that we are not referring to a performance art piece as an *almost convergent* or *almost continuous* function, which has a limit – unique – except for a set of measure zero. No. We are dealing with many *almost convergent* functions and we also consider neighborhoods of several *cuts* within them, also taking into account their metamorphosis of behavior – laminar to turbulent – along the way. So, there is no uniqueness associated, which, in fact, conveys our desire of maintaining the openness that characterizes performance art.

***G.O.D.*: a case study**

In this last section we will present a case study: *G.O.D: (Goddess of Desire),* a performance by Flávio Rodrigues **[13]**, performed by Bruno Cadinha **[14]**.

Since the beginning of his career as a performer that I virtually follow the work of Flávio Rodrigues. However, for me it was not enough to see his performances. I needed to understand his body of work from a personal , biographical and creative point of view . So I support the need to integrate and analyze the several instruments that make up the same body of work: text, video, music, debates, interviews , intentions, actions , among others. In 2014 , I proposed him to work together at a distance, and we ended up establishing a partnership in a project his performance G.O.D. ( Goddess of Desire ) , which premiered at Theatre of Campo Alegre - Porto, March 7, 2015 , with co -production of Porto’s Municipal Theatre. I participated in this project documenting and researching along the creation process.

**Manifest of Intentions for *G.O.D.*, from some initial texts and ideas by Flávio Rodrigues**

*Till the World Ends* is the title of a song performed by Britney Spears, which is the second single from her seventh studio album , Femme Fatale , 2011. The song was written by Kesha , Alexander Kronlund , Dr. Luke and Max Martin and the video that promotes it was launched on 6 April 2011, under the direction of Ray Kay . The scenes of this video show B. Spears in an underground party with allusions to an apocalyptic environment, where it is referred the 21st of December , 2012 . This is the day on which the Mayan calendar ends the cycle of 5125 years .

It is with this event that Flávio Rodrigues starts a new project , where a number of branches from the idea of building a family tree emerges ( wrong - or very particular), to which he decided to call *G.O.D. (Goddess of Desire)*. This tree is the symbolism found to create a new choreographic and sound score, where are represent *Thriller,* by Michael Jackson , *Wall –E*, by Andrew Stanton , the Bible , the last desert Coke , *Anaconda*, the movie, the hyper consumption, the so-called *gender paintings*, by JH Fragonard, Andy Warhol and the supermarket , the hole in the ozone layer, and the brilliant dancing. These are some of the connections projecting a place for the creation of a soundscape (remix) , which in turn will be the basis for a body that moves and metamorphoses .

*G.O.D.* is the construction of a soundscape – made in Homestudio – like a house where the body dwells and from which territory mapping possibilities are generated: he sound of whales, the music of Britney Spears and the sounds of nature together in transport for both urban and primitive universe, where the demarcation of territory , the search for an identity, while the use of makeup , current pop music are factors which are also present.

In this project , the body is not the first time , the body of Flávio Rodrigues. The possibilities that allow mappings are clearly manipulated , thus resulting in the interpreter as a metaphor / projection / narrative of paradoxes, a recall and transformation of desire , in continuous dialogue. There is also another body of writing, a documental one, as another generator of possibilities, which analyzes throughout the process further layers of directions. This body is another external view which notes, adds, cuts, contextualizes and decontextualizes. It is descriptive, argumentative and a generator of interpretation possibilities.

**Excerpts of G.O.D.’s written documentation**

The written documentation of *G.O.D.* was built over six months in the course of several meetings , virtual conversations, and video recordings. Along the process , I built, in addition to the official documentation (description, synopsis), a personal connection, which allowed me to develop writing possibilities and approaches between the official documentation and the creation of the piece.

**# 1**

*G.O.D.* is a piece where life is exploitation, desire, ritual, animal, Britney Spears, territory, Mardi Gras, intimate, global, referential, ethereal, and yet real.

It is a universe of conquest, based on the emotional complexity of an individual path, where an individual language is present as one of the young voices within performance art and dance context in Portugal.

*G.O.D.* is me, is you, is the way of looking for leads in a globalized world, where the references are edited, metamorphosed where you and I have become a constant search of possible identities. To delimitate nobody’s territories, turn this one into our own party.

**# 2**

We do not know his origin, we just realize that he is in this place. We call it place because it is yet to be named . He was lost and was left alone.

Loneliness does not kill, but gradually turns concrete actions into concepts and reflections on them.

 He is lost, know exactly how to react, but not knowing where to arrive.

He is blue. Or he bring the blue with him. Blue. Sad, From another place, from another absent state, which becomes present along the performance. A fish, a bird, the fragility within the conviction of action. He is an hybrid, he shines, he is the ritual metamorphosing his guts, he is Britney wanting more, languid and sexy with a weapon on his hands. He is the non-gender, where sexuality is put into constant tension over his concrete actions. The poetic lyricism as a place of refuge and statement.

Fig. 1 Caption (with permission), by José Caldeira

Fig. 2 Caption (with permission), by José Caldeira

**# 3**

The universe stopped when the end happened to him. A lapse in space- place made time to collapse and he found himself there, with us. He presents himself safely and looks us in the eyes. He defies our view, waiting for something to happen. No one predicted the end. The end was blue. A blue party, a mardi gras of ecstasy. He is blue. He is sea. He is fragility. He is safety. He is saying hi. He wants to settle down. He doesn’t want explanations.

He wants to research, to look for, to loose himself, to mark and remark concrete territories. In here, with us. He wants to affirm his existence within lost, in a redefinition of materials that allow himself to multiply ways of being, to establish new ways of connecting with place and space. He is an installation of himself, not a proof or a characterization of something that doesn’t belong to him. It is him. In here, with us. Hybrid, sensual, strong, ideal, open and concise

Fig. 3 Caption (with permission), by José Caldeira

Fig. 4 Caption (with permission), by José Caldeira

***G.O.D.* and the relational model**

In *G.O.D.*, the *axiomatic image* is to exist, above all. That is, an *Ode to Existence*, where a body defines a space, a territory, mapping it, with a purpose of affirmation and self-presentation, instead of a mission. This IA arises from a personal perspective of Flávio Rodrigues, to reflect on the end of a love relationship that lasted nine years and on the times of economic crisis that some countries, such as Portugal, go through. So, an ode to restarts, to life reformulations. From this initial image, several sub- images of much more concrete form, and thus three-dimensional images, were generated, which are part of a set of ideas and experiments that Flávio Rodrigues was exploring with Bruno Cadinha. I consider in this project three *Sub-Images*:  *Presentation*, *Conquest* e *Nest*.

There is, in this performance, a desire to present the individual as a metaphor of individual search of meaning within the world around: it is depersonalized and is not intended to be interpreted or even be represented. It is presented as an example of himself, who can also be other, or as an individual contextualized in a landscape that is not only his landscape, with which the public can establish affinities. This performance is an identity search in world without definitive references. This individual wants to affirm himself. Not in his specific individuality, but in his possibility of existence and in his desire for territory where he will construct his nest, his comfort space.

In each of the *sub-images* a *dynamics* was established, where the rules of movement, the music and the sub-images become concrete, effective and shared. In *Presentation*, are used images immobility interleaved with quick actions and soft metamorphosis. In *Conquest*, the movement is accelerated, the performer runs around the stage, delimiting a specific territory, installing it. Finally, in *Nest*, the performer searches for comfort within the conquered territory.

***G.O.D.* as a turbulent flow and as an intersubjective matrix**

Considering the performance *G.O.D.* a turbulent flow, or an example of the existence of turbulence within performance art pieces seems to be a difficult task, at least at first sight, since it isn’t a violent performance, nor has quick movement, nor it is based on anger. In fact, we need to take into account an essential aspect of turbulence within performance art context: it doesn’t have to be obvious, it doesn’t need to be like boiling water in front of our eyes as spectators. In this performance, turbulence is within the performer, within the metamorphoses of his perception states, from presence to absence, to a state of conquering, to a state of almost giving up, to organizing material, space. He is constantly rebounding between fluid and turbulent flows within perception.

The performance G.O.D. can also be seen as an intersubjective matrix between movement technique, autobiography and performance. These can be seen as almost continuous functions, where some cuts are analyzed and worked on – the cuts being the moments of change: of direction, of perception state, of type of movement. The movement technique used in this performance belongs to the work that Flávio Rodrigues has been developing along the years through his solos and also through his work performing for others: the use of immobility, or almost inexistent mobility interconnected with quick movements or actions, the use of specific positions as the head and the cervical slightly curved, with the feet *en dehors*, or positions where the body is on one leg only, among many others.

On of the main features of Flávio Rodrigues work is autobiography. This *performer* develops his artistic creation as an extension of the way he relates with his own life, his daily routines, his experiences, mainly through movement and music creation. Performance art is, in the work of this performer, the place of questioning, reformulating, exploring materials, movement, images, meanings.

**Acknowledgements**

I do acknowledge support from FCT through FCT PEst-OE/EAT/UI0112/2014.

I do thank the anonymous referes for the helpful comments.

**References and Notes**

**[1**] See their website: http://www.mathdance.org/

**[2]** See the author’s paper “Mathematics in the world of dance: http://archive.bridgesmathart.org/2012/bridges2012-453.pdf .

**[3]** See her website: http://estherferrer.fr/fr/

**[4]** See the works by Terence Tao around regularity, compactness and on three-dimensional Navier Equations: https://terrytao.wordpress.com/

**[5]** See http://www.ronathey.com/

**[6]** See http://www.mai-hudson.org/

**[7]** See https://eu.wordpress.com/tag/angelica-liddell/

**[8]** See http://cocofusco.com/

**[9]** See http://www.pochanostra.com/

**[10]** See http://www.guerrillagirls.com/

**[11]** See http://pussyriotthemovement.com/

**[12]** See www.telmajoaosantos.net

**[13]** Flávio Rodrigues is a dancer , choreographer and performer , resident in Porto, Portugal . Formed by Balleteatro (2003 ) , Dance Works Rotterdam (2005 ) and the Choreographic Experimentation Center (2008) , has collaborated on projects with several artists such as Isabel Barros , Né Barros , Vitor Hugo Pontes, Tania Carvalho, Joana Castro , Bruno Senune. Since 2006, he develops his own projects :performances, films, installations , soundscapes . He is also a DJ since 2015, finishing his a DJ professional course at Bimotor. More about him at www.flaviorodrigues.info

**[14]** Bruno Cadinha did his basic training in contemporary dance at Balleteatro, Porto, having Flavio Rodrigues as one of his teachers. He did a modular course in Olga Roriz dance company, Lisboa, and he is now a student of PEPCC in Fórum Dança, Lisboa. He has been developing multidisciplinary work around queer and gender issues.

**General Source Bibliography**

Barrett, E.; Bolt, B., Practice as Research: Approaches to Creative Arts Inquiry.(New York: St Martin’s Press, 2007).

Carlson, M., What is performance)? In A. G. Rayner, *Género, Culutra Visual e Performance - Antologia Crítica* (Braga: Edições Húmus, J. P. Ana Maria Chaves Trad., 2011), pp. 23--31.

Damásio, A., The Feeling of What Happens: Body, Emotion and the Making of Consciousness (London: Heinemann, 1999).

Deleuze, G.; Guattari, F., Mil Planaltos - Capitalismo e Esquizofrenia 2. (Lisboa: Assírio & Alvim, 2008)

Goldberg, R., Performance Art: From Futurism to the Present(London: Thames & Hudson, 2011).

Kirshenblatt-Gimblett, B., Performance Studies, in The Performance Studies Reader, ed. by Henry Bial. (London and New York: Routledge, 2004).

Laws, K.; Sugano, A., Physiscs and the art of Dance – Understanding Movement Oxford:  Oxford University Press, 2008)

Lebl, J. (2013). Basic Analysis: Introduction to Real Analysis. Madison, Wisconsin, USA.

Noë, A., Varieties of Presence (Cambridge: Harvard University Press, 2012).

Santos, Telma João, “Local estimates for functionals depending on the gradient with a perturbation”, Journal of Mathematical Analysis and Applications, Vol. 434, No.1, 858-871 (2016).

Santos, Telma João, “On a Multiplicity: deconstructing Cartesian dualism using mathematical tools in Performance”, Liminalities: A Journal of Performance Studies, Vol.10, No. 3, 1-28 (2014).

Stern, D. N., The Present Moment in Psychotherapy and Everyday Life(New York: W. W. Norton & Company, Inc., 2004)

Zakon, E., Basic concepts of Mathematics (West Lafayette: The Trillia Group, 2001).

**Biographical Information**

Telma João Santos is a PhD in –Mathematics and waiting for the public defense of her second PhD in Performance Art. She is a Professor at the University, where she teaches at the Department of Mathematics and Department of Scenic Arts. The author i salso a performer, presenting her works in galleries, bars, theatre foyers, university conference.

**Figure Captions**

Figure Captions are supplied in separate files, accordingly with their names inside of the paper : Fig.1, Fig.2, Fig.3 and Fig.4.