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Performance / Mathematics: a Dramatisation of Mathematical Methods

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ABSTRACT

This essay conceptualises the notion of performance mathematics in terms of a paradoxical relationship with the constructed notion of truth, which is shared by theatrical and mathematical performance. Specifically, I argue that these two disciplines can and cannot be reconciled with truthfulness. Grounding my comparison on the notion of an axiomatic method common to both disciplines, I argue that theatrical and mathematical performance can speak of truths only when these truths are properly staged or methodologically grounded according to the internal rules and conditions laid out by each discipline. But in the same way that these truths can be constructed, or they can be done, so they can be undone. Arguing that mathematics can be described as a performance of specific outcomes involving abstract objects and functions, I trace a cross-disciplinary comparative analysis of performance elements (especially axioms and functions), drawing on a number of theatre and mathematical theories. Some suggestions are also put forward in terms of the connection between the performance of mathematized texts and computational mathematics, particularly in terms of an inherent poetics and theatricality inside the performance-oriented, mathematized languages of digital computing.

Key terms: performance mathematics, axiomatics, function, theatricality, real, binary digit, digital

Bio: Salazar Sutil is a Chilean cultural theorist and performance practitioner. His work focuses on cultural theory of human movement, and digital movement, as well as the intersection of formal languages and performance. He is the artistic direction of C8, an artistic collaborative that works in the integration of stage performance, language formalisms, and technology. He currently works as Lecturer in Dance and Digital Arts at the University of Surrey. Upcoming books include *Digital Movement: Essays in Motion Technology and Performance* (Palgrave, co-edited with Sita Popat).

What is Performance Mathematics?

My challenge is to study the possible relationship between theatrical and mathematical performance in relation to their shared capacity to perform truths. Does this relationship highlight what is NOT common to each discipline? Are theatrical and mathematical performance two entirely differentiated expressions of human creativity? This essay answers these questions in two ways. I argue that there IS commonality and that there is NO commonality. And so my thesis is a paradox. And this is fitting, seeing as this essay is about truth (or the lack of it), both in a mathematical and theatrical sense. Paradox, as I understand the term, is the position of being caught between truth and falsehood. This is a place where both theatrical and mathematical performance can find a common creative ground. To begin with, I propose a concept. Performance mathematics is the conceptualisation of an interdisciplinary relation that highlights the following historical condition of possibility: Mathematical constructions are true only insofar as they are performed. In other words, theorems and equations are true only insofar as they are staged according to rules of mathematical engagement and delivery. The same applies to the scripted truths of the theatre. And this is key: both theatrical performance and mathematics rely on a construction of the real (the mathematical real and the theatrical real). It is within arbitrary inventions of the real that truths can be variously dramatised and performed. What is common to both creative practices is that they give a *temporary* existence to those realities (or if you like 'temporealities'), which they perform.

Assuming the understanding of theatrical performance is clear, then it is perhaps worth looking closer at what I mean by mathematical performance. To perform a mathematical operation typically requires proving a theorem, answering a mathematical problem, delivering a mathematical result. All of this indicates that an output or outcome has been met, that a performance has been carried out in one way or another. Brian Rotman writes that 'numbers and their passage to the limit exist only through the *performance*- that is to say, what constitutes their form as abstract objects follows from this determination' (2000, 148). According to this author (2011), mathematical practitioners refer constantly to performing: 'performing a calculation, a construction, a computation, an operation, and numerous other series of moves, performed – carried out – according to some design.' Rotman adds that the key activity of proof is likewise described by mathematicians as a performance— proving being completely synonymous with showing and demonstrating. In what follows, I argue that what connects these two disciplines is the historical transit from a belief in a priori truth, to a belief in the performance of truths via specific functions (theatrical and mathematical). What is emphasised in this argument is that rather than being truth-laden entities that exist prior to any creative human intervention, and outside any constructed sense of temporality, the works of mathematical and theatrical performance are part of the larger and open-ended human initiative of constant invention and the temporary making up of performed or staged truths. In other words, mathematics, like the theatre, can be the temporary staging of a reality, or temporeality.

Although it is well known that mathematics is intended to be rigorous, it is not rigorous to the point of risking *rigor mortis.* On the contrary, mathematics is no less creative than an artistic pursuit like theatre. To be clear, mathematics is a creative language. In fact, it is a family of languages. There is no single, upper-cased Mathematic but only mathematics. And whilst historical metaphors depict maths as a formidable tree with a single oak-like trunk branching out into robust offshoots, today mathematics boasts no single foundation, no single trunk. For this reason, it does not necessarily resemble a tree but a complex network or rhizome of languages. We must not forget that aspects of digital computation are also inherently mathematical. If we were to visualise the rhizomatic representation of maths it would appear highly complex not only given the widespread mathematization of computerised communication, but also because mathematics itself has become highly synthetic (e.g. algebraic geometry, arithmetic topology, analytic geometry, and so on). In other words, the branches of the network also mix to create new language fusions and hybrid concepts.

So instead of asking the simplistic question: what is the relationship between theatrical and mathematical performance?— one could ask: which branch of mathematics are we talking about, and in relation to which discipline of theatrical performance, according to which technique or which technology? Because mathematics is a language liable to cultural dynamics, it is also liable to technologically and materially defined conditions of possibility. The difficulty of the problem is compounded by the fact that there are myriad languages (and even metalanguages) inside mathematics, and anyone of them could be made to connect with a problem arising within the orbit of the performing arts. To simplify the problem, I will not locate this discussion in the orbit of computational formalisms. For the time being, I am not concerned with the realisation of a theatrical mathematical performance in a digital-era context. Although this is an inviting question given the inherently mathematical and performative nature of digital communication, here I will focus on something perhaps less current, something more historical. I will speak of the dramatisation of mathematics in text-based theatrical performance and theatre theory.

Polygamy

One way in which a synthesis might begin to make sense is by way of a connection between a mathematics of space and formalised space in the performing arts. In this context, one could mention the use of solid geometry and topology in the work of Rudolf Laban (Salazar-Sutil 2013), or the stereometric pre-robotic performance pioneered by Oskar Schlemmer (Salazar Sutil, 2014). In both these cases, the manner of the interaction is by way of an *application* of a mathematical language to stage performance. In addition to *applying* mathematics, one could *conceptualise* mathematics within a theatre performance practice. One example of this might be the use of the mathematical concept of 'partition' in Theatre du Complicite's production of *A Disappearing Number*

(2007). Mathematics can be mined within the theatre as a rich area for ideas, concepts and mathematical philosophy. This is the case, for example, of Witkacy's *Tumor Brainowicz*, which draws heavily on ideas derived from Cantorean set theory. Theatre might even be a rich place to mine mathematical *themes*, in the sense that a play might be *about* mathematics or mathematicians, or mathematical texts. Thus, scholars speak of the 'maths play' or maths-in-theatre'[1] This category refers to plays that use maths as subject matter, as in the case of Tom Stoppard's *Arcadia* (1993). Yet another modality of engagement might inflect mathematical sensibilities in theatre and performance design at the level of a mathematical aesthetics, in the way Italian Futurist performance was intended to support a geometric and numerical sensibility. And finally, theatres vaguely embrace mathematics by misusing or creatively deforming mathematical terms or operations. Thus, Polish playwright Witkacy abused the term 'non-Euclidean' in order to refer to an irrational modern character. Soviet theatre pioneer Vsevolod Meyerhold referred to his actor training technique as 'algebra'. So to make the argument worthwhile, I will speak of a more straightforward interaction between theatrical and mathematical performance. Not by way of application, conceptualisation, ideation, thematization, or deformation. In this instance I will focus on the use of mathematical methods within theatre and performance. The trajectory of this work will take the reader across two very different notions of a mathematical method: an axiomatic approach and a non-axiomatic approach.

Axiomatics

For thousands of years mathematical creativity was firmly grounded on notions of proof, of soundness, and ultimately — and here is one of the factors

[1] For considerations on the rubric of the 'maths play' see Kirsten Shepherd Barr, 'Hilbert's Hotel, Other Paradoxes, Come to Life in New 'Math Play', *SIAM News* 2003. 36: 7. http://www.siam.org/news/news.php?id=347, accessed September 2013. See also: Stephen Abbott 'Turning Theorems into Plays' in *The Edge of the Universe*, ed. Deanna Haunsperger and Stephen Kennedy (Washington DC: The Mathematical Association of America, 2007), 113-119; and Robert Osserman, 'Mathematics takes centre stage', in *Mathematics and Culture II: Visual Perfection: Mathematics and Creativity,* ed. Michele Emmer (Berlin: Springer, 2005).

that supported all branches under a common trunk — mathematics was based on its methodological incontestability. Mathematical methods have served as guide for the construction of methods in other disciplines of knowledge, especially science. Even within the visual arts, music, architecture and indeed the theatre, one can detect a reliance on mathematics to provide a sense of methodological rigour. This sense of foundation could be said to stem from a historical sense of Greek mathematics, which is in fact limited to two principal branches: geometry and number theory. Methodologically, this so-called classical mathematics was based on the grounding notion of an axiomatic method. Whether in art or science, Euclidean axiomatics is often looked up to as the mother of all methods.

Written in Alexandria around the year 300 BC Euclid's *Elements* represents the culmination of various philosophical schools devoted to the study of geometry (including the Pythagorean school and Plato's Academy). Euclid's contribution was to simplify this body of work into the smallest possible collection of definitions, postulates, propositions and mathematical proofs. To guarantee the self-consistency of its method Euclid's treatise describes the elementary unit of a self-affirming truth or axiom upon which a sound, consistent, and complete system may be constructed. Before I can explain why Euclidean thinking had to be surpassed, and how a post-axiomatic approach may be dramatised, it is first necessary to explain why this method remained unsurpassed for almost two thousand years, and how it came to play an important role in the theatre.

The claim made by the inductive-axiomatic method is this: things that are equal to the same thing are also equal to one another. No further proof is needed to support this proposition. By settling on five axioms that provide the starting point for any theorem in geometry, Euclid's *Elements* replaces an unspecified body of propositions with five claims that, when used in conjunction, are a guarantee of proof. According to Karl Popper, for a theoretical system such as Euclidean geometry to be axiomatised, a set of statements has to be formulated which satisfies four fundamental requirements: (1) the axiomatic system must be free from contradiction (2) the system must be *independent* (i.e. it must not contain any axiom deducible from the remaining axioms) (3) it must be *sufficient* for the deductions of all the statements belonging to the theory and (4) it must be *necessary*, which means they should contain no superfluous assumptions (2002, 50-1).Yet, what is crucial about Euclid's axiomatisation of geometry is not what axiomatisation allows us to see, but what it hides or occludes. Foucault tells us that, as opposed to systems that may be invented or applied in a considerable number of ways, what axiomatic methods allow us to see is that 'there can be only one method' (2002, 156). Euclidean axiomatics remained for millennia the only possible way of thinking (conceptualising) mathematical space. In fact, it only allowed us to see space in terms of arbitrary assumptions and in terms of a limited range of geometric transformations, which these assumptions permit. Likewise, the spatial arts (including theatre), were conceived methodologically under a series of axioms, which, if I may extend Foucault's argument further, not only allowed for a certain type of theatrical construction, but also, disallowed alternative ways of realising the theatre.

One might conclude that the non-contradictory properties of the system make axiomatisation a basis for any process that shows a certain degree of reflective abstraction, even within the theatre. Thus, according to American theatre theorist Clayton Hamilton (1910) theatre axiomatics may be expressed more fully in terms of 'a representation, by actors, on a stage, before an audience, of a struggle between individual human wills, motivated by emotion rather than intellect, and expressed in terms of objective action.' French mathematician Henri Poincaré pointed out that the essential thing in theatre, as in mathematics, is to learn to reason exactly with the axioms once admitted. Poincaré muses on the idea that 'the audience at a theatre willingly accept all the postulates imposed at the start, but that once the curtain has gone up it becomes inexorable on the score of logic' (2003, 136). Likewise, according to French philosopher Alain Badiou theatre exists as soon as it can be axiomatised. Badiou's theatre axiomatic begins with three elementary conditions: 'first, a public gathered with the intent of a spectacle; second, actors who are physically present, with their voices and bodies, in a space reserved for them with the express purpose of the gathered public's consideration; and, third, a referent, textual or traditional, of which the spectacle can be said to be the representation' (2008, 190). According to Badiou, public, actors, and textual referent provide the threefold basis upon which every theatrical scenario may be constructed.

Like Euclidean geometry, Badiou's system produces a number of secondary propositions or corollaries. For instance, from the fact that there is at least one actor we infer that there must be at least one costume (191). In addition, Badiou points out that the existence of a referent, textual or other, constrains the stage director to the position of director of a company or 'self-governed' collective. In a conceptual move reminiscent of Aristotle's categorisation of tragedy, Badiou speaks of place, text or its placeholder, stage director, actors, decors, costumes, and public as the 'seven required elements of theatre' (191). According to the author, these axioms do not realise themselves in an effective way except in their fidelity to an event. The axiomatic of theatre is not true because of any universally prescribed order. It is true because all things come together in the event: the performance. From the fact that a theatre production requires the simultaneous and ordered presence of the seven elements, Badiou surmises that theatrical representation *takes place* as a 'circumscribed event' (192). Permanent theatre is, like infinite lines in Euclidean geometry, a scandal. The fact that immediately the spectacle is played a second time changes nothing in this regard. It is two times One (192).

By inventing a sense of theatrical reality that fulfilled none of the axiomatic premises mentioned above, an iconoclastic playwright like Stanislav Witkiewicz (Witkacy) could speak of non-Euclidean theatre to express the sense that theatres invent truths, rather than build up a truth that is faithful to lived-in actuality. Theatres can deform existing realities and invent new domains of the real that are not subservient to a singular or universalising understanding of true representation. Witkacy claimed a re-axiomatisation of modern theatre, which stretches Badiou's theorisation to its natural conclusion: why should theatre be realised according to one way of thinking its self-affirming true method? In other words, why can't theatre assume its undecided relationship with truth and reality, by accepting that these constructs are temporary and makeshift, and that they are endlessly contestable and transformable? Is reality not always a temporeality, i.e. a temporary and impermanent realisation subject to subjective change? As such, neither theatre nor mathematics have to copy any pre-existing sense of the real— there is no grounding in a universally lived-in or physical real but only the performance of realisations and the performance of truths according to the discipline's own internal rules of staging—whether in the abstract sense, in the sense of staging a mathematical performance— a theorem— or in the concrete theatrical sense.

This discussion on the contestation of an axiomatic method pries open a more general debate on what truth is. The argument is not only directed against a mathematical sense of axiomatic thinking (Euclidean geometry), but also against theatrical axiomatic thinking. For instance Konstantin Stanislavski's sense of truth is clearly defined as something internal to the theatre, as something quite different to truth in a lived-in sense. Having said this, Stanislavski's search for truth in the theatre laid the foundations for a methodological approach that was based on what is quite clearly an axiomatic way of thinking. To find this theatrical truth, Stanislavski set out basic rules and techniques. These supposedly enable an actor to extract a sense of realism, of veracity, from basic foundations found in lived-in experience. Because the truth of these experiences is self-determining, so the entire character is constructed on the basis of such techniques (for instance, magic if, emotional memory, observation, and so on), leading to a sound and incontestable acting method. Perhaps one of the best known axioms associated with Stanislavski's work is this: from an actor's perspective, the audience is not meant to be present in a live performance given the audience is separated from the action by an imaginary fourth wall. Once fulfilled, the fourth wall protects the actor from the artificiality of the theatrical event so that he or she may retain the authenticity of what is being portrayed on stage.

The process of constructing a character, and the manner in which such a process is to be carried out, according to Stanislavski, cannot be left to chance. This process relies on an analytical breakdown and calculation of the elements that make up a character. As such, the Stanislavski system encourages the actor to prepare by dividing a character's journey through a play into super-objectives, objectives, units and activities, a technique of segmentation and quantification that led some critics to refer to Stanislavski's actor training methods as 'mere mathematics' (Toporkov 1998, 217). Stanislavski himself claimed that his interest in psychology was a key aspect of his science of acting. Clearly, from what I have intimated above, Stanislavski's method is neither mathematical nor scientific, but axiomatic, given its belief in a universally agreed truth, and a true method based on finite rules intended to provide a method for the construction of realism and truth. Insofar as the Stanislavski method is grounded in a direct relationship between the real 'I' (actor), and a Dramatic 'I' (character), Jonathan Pitches argues in his book *Science and the Stanislavski Tradition of Acting* that Stanislavski's system led to the development of a linear, rational and empirical approach to theatre making, particularly in the work of Lee Strasberg, who coined the term Method Acting. The scientific rationality Pitches traces in these theatre laboratories exemplify a theatre-making tradition dictated by an axiomatic methodology. Yet, the somewhat truth-oriented aspirations of this theatre came under some scrutiny by subsequent generations of theatre practitioners and experimental artists. Witkacy's theatre is one good example of this, especially since his reaction is articulated explicitly in terms of deformable theatrical truths and what the Polish iconoclast referred to as non-Euclidean drama, by which he meant a theatre that is not liable to any lived-in or assumed sense of truth or realism. In sum, by formalising an axiomatic method within theatre pedagogy Stanislavski not only created a tradition to follow, but also, perhaps unwittingly, a tradition to react against.

Truth is what is actually happening

In a prefatory note to the novel *One, No One, and One Hundred Thousand*, Luigi Pirandello wrote that ‘this book not only demonstrates dramatically, but at the same time demonstrates by what might be termed a mathematical method, the impossibility of any creature’s being to others what he is to himself’ (2005, *v*). Pirandello insists on focusing on the precariousness of human reasoning when trying to extract a single understanding of reality and Truth. The truth of whether actors are more believable than the parts they play, or whether the parts they play are more believable than the actors, is ultimately unresolvable. Thus, Pirandello’s fictional characters in *Six Characters in Search of an Author* exist beyond their own play- they exist as meta-characters that reflect back onto the stage a new reality of ‘character’. These are characters without a play, and without an author- like quantities without a number, which is also a paradox of set theory.

One way in which Pirandello's theatre might be said to resemble non-Euclidean thinking is by virtue of the fact that for Pirandello axioms are not incontestable, and truth is not a universal given. A good example of Pirandello’s treatment of the dramatisable nature of mathematical truth can be found in the play *So It Is (If you Think So)*. Here the author concludes that it is impossible for human beings to reach truthfulness or even to determine if Truth exists. Like Badiou, Pirandello ushers a modern philosophical discussion of the chanceful nature of Truth by suggesting that Truth may exist, but that it is not for human beings to find it in singular terms or according to mathematical methods. Instead, truth can be realised in terms of whatever is needed at a particular point in time to convince a particular audience. Badiou makes a similar point when claiming that truth is an appearance of a supplement that breaks with repetition. It is chance, which bring about a sense of newness in the form of the event. Or as the character of Laudisi puts it toward the end of Pirandello's play:

> … Don’t you see what they are after? They all want the truth— a truth that is: Something specific; something concrete! They don’t care what it is. All

they want is something categorical, something that speaks plainly! Then they'll quiet down. (1995, 187)

From the perspective of non-Euclidean theatre proposed by Witkacy—and this is also applicable to Pirandello—: 'Truth is what is actually happening' (Witkacy 1989, 73). Truth is a happening, a performance. From this realisation, a concept springs up: Mathematics can be a theatre of performed truths, whilst theatre can be a mathematics of truths performed. Jon Erickson poses a neat question to follow this conceptualisation through: 'What drives the truth of illusion in the theatre in order to produce the illusion of truth?' (2003, 163) and can theatre produce not merely the illusion of a truth, but Truth itself, as Stanislavski claimed the theatre could? Or put otherwise, does the illusion of truth not negate the truth that the theatre seeks in representation? Or is theatre precisely a paradox that would have us believe that illusion is truer than the so-called real or lived-in world, as Pirandello argued it could? The logic becomes more and more vicious. If the question of truth is to be addressed in terms of true/false categorisations, then the decidable meaning of theatre cannot be settled upon. Nor can modern mathematical truths be completely agreed on, incidentally.[2]

A mathematical approach to theatre theory

Theatre theorists speak of a 'mathematical approach' within the sub-discipline of theatre semiotics. In what follows, I will take a slight detour into the field of theatre theory in order to back up my argument, and in order to show how

[2] Austrian mathematician and logician Kurt Gödel showed that one cannot prove completeness in any approach to mathematics by safe logical principles. His so-called incompleteness theorems told mathematicians that a set of axioms is not adequate to prove all the theorems belonging to the branch of mathematics that the axioms are intended to cover. In other words, the epoch-making implication of Gödel's idea was that mathematical reality could not be unambiguously incorporated into axiomatic systems. The moment a statement is axiomatised, it becomes incomplete given the finite nature of the axiom itself. Mathematics, and the axiomatic method that had reigned seigniorial for thousands of years, would inevitably give rise to statements, which could neither be proved nor disproved. For a study of relations between Pirandello's work and Gödelian logic see Matteo Bonsante, 'Luigi Pirandello Precursore del Grande Matematico Kurt Gödel?' In *Transfinito International Webzine*, accessed September 2013, http://www.transfinito.eu/spip.php?article971

theoretical thinking can realise theatre mathematically, or at least in terms of a methodological analysis of objective data. No doubt the notion that dramatic situations can be pinned down to a limited number of quintessential types is a method that works very much in the spirit of Euclidean axiomatics. The historical emergence of this so-called mathematical approach dates back to the work of 18th century Italian dramatist Carlo Gozzi, and the 19th century French theorist Georges Polti. According to Patrice Pavis' definition, mathematical approaches to drama consist of a process of reflection on the various combinations of dramatic situations based on the possible relations among the characters (1998, 204). This theoretical project is possible, according to Pavis, only on the basis of objectively observable data of the dramatic structure, namely, the number of people, scenes, entrances and exits, the length of various speeches, and the existence of recurring themes or images.

According to Italian playwright Carlo Gozzi there is a finite number of dramatic situations in world theatre. Thirty-six, to be precise. Gozzi's idea is prompted by a rationalistic and quantitative, rather than mathematical interest, which is more akin to the Aristotelian tradition of typology and categorisation in drama theory, particularly as found in the work of Aristotle's student Theophrastus. Theophrastus proposed an exact number of character types: thirty. This typological tradition may not be mathematical, but it is nonetheless axiomatic. What these authors proposed was a way of thinking theatrical methods that is analogous to Euclid's axiomatics. One can construct every dramatic character and every possible dramatic situation based on a limited number of types and situations, and their subsequent combination. Throughout the late 18th century and early 19th century, Schiller, Goethe, and Gérard de Nerval made serious attempts to calculate the exact number of dramatic situations. However, it was the French writer Georges Polti who first approached the problem systematically. That is, whilst the number 36 was not justified either by Gozzi, Schiller or Goethe, Polti dedicated an entire book, suitably entitled *Thirty Six Dramatic Situations*. Polti's work, published in 1895, explores the so called 'synthetic law' of dramatic situations. Polti himself acknowledged his method was not exactly mathematical when he wrote: ‘it might be possible to choose one trifle higher or lower, but this one I consider the most accurate’ (2007, 9). In other words, the procedure is by no means exact. It is not a mathematical procedure, insofar as no formal process was used to obtain such a numerical result. However, the spirit of an axiomatic method is palpable, in the sense that, methodologically speaking, the logic of Polti’s system is that the whole of drama can be built on a finite number of basic building blocks.

The structuralist and formalist approaches to theatre semiotics would become hugely popular among theatre scholars in the fifties and sixties. Within this tradition, it is worth mentioning the school of literary criticism known as Russian Formalism, in whose ranks, one finds the influential work of literary critic Vladimir Propp. His work *Morphology of the Folktale* introduced key ideas in structural analysis of theatre and drama such as the delineation of the formal structure of a text (i.e. its understanding in terms of a sequential line of actions), or its patterning and organisation in nonsequential orders and the subsequent regrouping of the structure in one or more analytic schemas. Propp can also be credited for offering the notion of *dramatic function.* In his distinctly axiomatic approach, all characters in the 100 tales he analysed could be resolved into seven character functions.

Although the term function is not, strictly speaking, to be used in the same sense as the mathematical use of the word, it nonetheless carries with it a mathematical resonance. In mathematics, a function is a relation between an input and a permissible output, such that each input is related to one and only one output. Thus, insofar as Propp’s dramatic sequence or line is one and only one, these dramatic functions enable a one-to-one link, or chain-like sequence, which makes up a storyline. This guarantees a logical progression, and the creation of a unity, which Propp calls the ‘sphere of action’ (1968, 79). Propp identified thirty-one functions of the fairy-tale, a number that is close to Polti’s number of dramatic situations. Although Propp was concerned with character, plot and action as it pertains narrative and literature, more specifically folk-tales, his work had a direct influence on the ways in which character was approached in dramatic studies during the structuralist wave of the late fifties and sixties.

A typology of dramatic situations is also developed to a more fully blown semiological approach in the work of Etienne Souriau in the 1950s. Souriau's somewhat alarmingly titled book *200,000 Situations Dramatiques* (1950) dealt with a systematic theory of dramatic plot analysis based, once again, on functional arrangements. According to Souriau, it was possible to speak of six functions, which by different combinations create a 'morphology' or 'calculus' of all possible dramatic situations. Drawing on Propp's work, Souriau applied the functional view of actions to Western dramaturgy in defining 'mathematically' the number of dramatic situations generated by the six, core dramatic functions. This supposedly mathematical operation, which according to Pavis is mathematical in 'spirit if not reality' (1998, 156), yielded an exact result: there are 210,141 dramatic situations, covering every possible arrangement found in the whole of world drama.

Among the structuralists who have built on Propp's morphology and Souriau's 'calculus', was the prominent Lithuanian semiotician A.J. Greimas. The so-called 'actantial model' developed by Greimas is commonly used in semiological and dramaturgical research to reduce the structure of narrated events to an underlying 'grammar', comprising certain binary oppositional categories and the modes of their combination. The actantial model provides a perspective on character that is not likened to a psychological drive, but rather to an overall system of actions, varying from the amorphous form of the actant to the specific form of the actor. Greimas' 'actantial role' commonly refers to universal oppositional functions analogous to the syntactic functions of language. The axiomatic idea of the model is based on division of characters into a minimum number of categories to embrace all the combinations actually present in the play. Like Souriau's 'calculus', Greimas' model proposed six functions (Sender, Object, Receiver, Helper, Subject and Opponent), which are in turn subdivided into three oppositions, each of which forms an axis; namely, the axis of desire (subject – object), the axis of power (helper- opponent) and the axis of transmission or knowledge (sender to receiver). If we apply the formalism to a play like Shakespeare's *Hamlet*, the Ghost is the Sender who gives a mission (Object of revenge) to Hamlet (Receiver). The Subjects (Ophelia and Gertrude) are caught up between the Opponents (King Claudius/ Polonius) and the Helpers (the Players / Horatio) in their desire to understand Hamlet's mission.

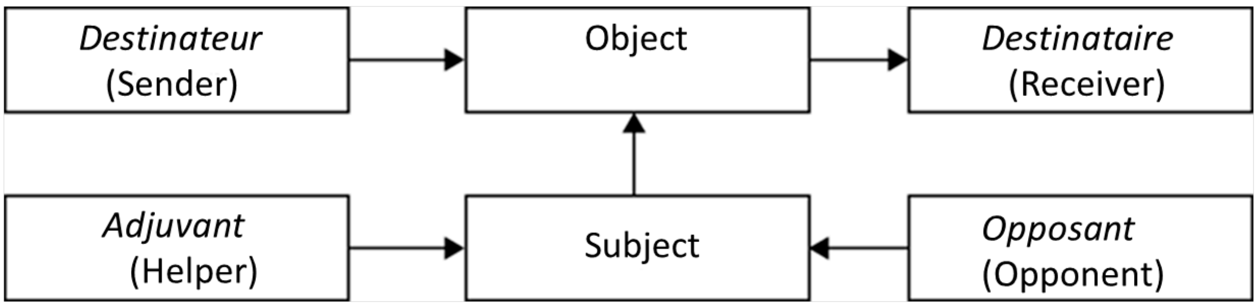

Fig 1. Diagrammatic representation of A.J. Greimas' actantial model

Perhaps one of the most relevant contributions of this model is its attempt to visualise the forces at work in the drama and their role in the action. The actantial model is instrumental in the development of structuralist analyses and the establishment of theatre semiotics as a diagrammatic approach to the study of dramatic structures. Thus, following an application of the model to the structure of Shakespeare's *Hamlet*, we are able to visualise the play's structure as an inherent shape. In addition, the model visualises the set of relations between the various functions in terms of spatial tensions, produced by the structural arrangement of the character's relations.

Likewise Paul Ginestier spoke in *Le théâtre contemporain dans le monde* (1961) of a geometric typology or 'dramatic geometry' based on the idea of parallel scenes, triangular arrangements, and other balanced patterns in character relationship. Ginestier's dialectic approach combined theatre analysis with a psychological approach to character theory, culminating in a supposedly Hegelian synthesis that argued for 'physical simplification and spiritual triumph'

(1993, 438). According to Ginestier's theory, situations occurring in a drama can be represented in three different ways. A simple situation can be represented as a directional line, or what the author calls open geometry (*geometrie ouvert*), as in the case of Antigone's fixed and unchangeable destiny, which she has inherited from Oedipus' curse. Ginestier then identified situations that are semi-closed or semi-open (*geometrie semi-ouvert* or *semi-fermée*), and dramatic situations, on the other hand, which create closed geometries (*geometrie fermée*). The most well-known example of the third category of dramatic situations is the love triangle, that is, the arrangement of character relations in terms of a closed, dramatic triad. Indeed, the triangle becomes for Ginestier a key shape in the understanding of a number of dramatic situations, and not only in terms of amorous relationships. The Classic existentialist drama *Huis Cos*, by Jean-Paul Sartre, comes to mind as a good example of the triadic arrangement of Ginestier's closed geometry model, insofar as the play depicts a notion of hell where damnation is realised as an amorous triangle unfolding between the cowardly Garcin, who desires the lesbian postal clerk Ines, who in turn desires the high-flyer Estelle, who in turn desires Garcin.

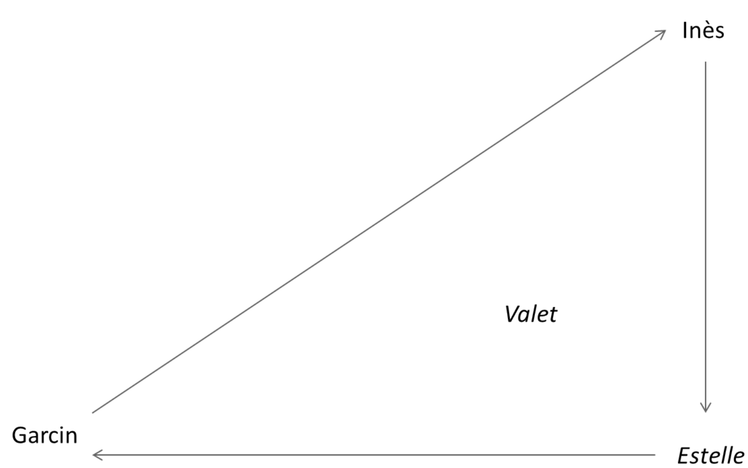

Fig 2. Diagrammatic representation of Ginestier's closed geometry analysis of Sartre's *Huis Clos*

Ginestier argued that dramatic geometry is helpful to analyse the 'architectonic cohesis' (438) of a play, but that this only provides a partial analysis. Thus, to obtain a more synthetic result Ginestier proposes two further layers of analysis. Further to a dramatic geometry it is necessary to conduct a psychological analysis, which should begin with the central character, and then proceed to an understanding of a surrounding architecture of psychological structures. The third step, philosophical analysis, combines the previous two to show how the theatre works dialectically and how it can provoke a philosophical transcendence. The binary logic of mathematical performance analysis is here given a philosophical dimension, leading through the process of dialectical antithesis to a spiritualising higher ground.

Mathematical poetics

Despite the decline of structuralism and formalism a number of mathematical analyses within a semiotic approach to the theatre were advanced following Souriau's symbolic-logical approach in the seventies and eighties. Perhaps the most important of these methods was espoused by the highly prolific Rumanian mathematician and theatre semiotician Solomon Marcus, who in the late sixties and seventies developed a school of semiological study known as mathematical poetics. The approach spearheaded by Marcus led to formal strategies of drama and theatre analysis derived from system theory, cybernetics, and computer science, as well as from the mathematical fields of algebra, graph theory, combinatorics, logic, code theory, probability, and game theory.

First published in 1970, *Mathematical Poetics* is an important historical attempt to construct a poetical language making use of determinist mathematical methods, in order to model the differences between poetical and scientific languages. The model relies both on figurative propensities of poetic language and the global mathematical model of the dramatic work. Marcus suggested that there was a conflict between the continuous nature of a language's semantics and the discrete nature of its syntax, but that no such conflict exists in mathematical language. Solomon's analysis also highlights the contrast between the discrete, algebraic structure of scientific signification, and the continuous, topological structure of lyrical signification. Hence Marcus tried to show that a deep-set understanding of the differences between the poetic and the scientific could be overcome by a framework of similarities found in the formal languages and logic common to both. Marcus was willing to accept that if there are differences between poetic and scientific semantics, these are cultural and arbitrary, and that there are also notable similarities that call for a mathematical poetics.

Marcus stripped the contents of a theatrical play to units, thus providing the 'primitive and objective data' (1993, 493). Accordingly, every play or dramatic structure could be analysed using a number of other mathematical methods, not just axiomatisation. One of Marcus' main contributions to a mathematical theorisation of the theatre is his model of human conflict, understood via the different configurations of characters in the successive scenes of a play. According to Marcus, to each theatrical play one can assign a Boolean matrix where each column corresponds to a scene and each row. At the intersection of row and column Marcus inserted the digit 1 or 0, which indicated the presence or absence of that particular character in that scene.

$$
\begin{matrix}
1 & 0 & 1 & 1 & 0 \\
1 & 1 & 1 & 1 & 1 \\
0 & 0 & 1 & 1 & 1 \\
0 & 0 & 0 & 1 & 1
\end{matrix}
$$

The matrix above is a representation of Sartre's play *Huis Clos*, using Marcus' method in the following character order: Valet, Garcin, Ines, Estelle. By processing the structure of this play through this operation, one can arrive at a series of structural clarifications. For instance, each scene has a different number of characters (except the final scene, where the triad is repeated), thus producing a sense of numerical rhythm within structure of the piece. Secondly, whereas the male characters are constant, the female characters enter progressively into the play's line of action. Finally, seeing as Scene 5 (fifth column in the matrix) makes up for around two thirds of the entire play, we may again conclude that the triad Ines-Garcin-Estelle is the main character-relational arrangement of the play, and that other possible triads or relational structures involving Valet are of no significance. Marcus suggests that this 'mathematical and computational processing of primitive information leads to… results with high theatrical relevance' (1999, 294). In the strictest sense of the word, Marcus could be said to have pioneered the concept of a binary digital theatre, in the sense that Boolean logic could be said to lie at the heart of digital computation. In computer science, Boolean or logical data type has two values (denoted as true and false), which can be scripted in terms of binary digits 1 and 0. Boolean data type is used in binary digital computing to perform results derived from conditional statements, which in turn allow different actions and control flow changes according to true-false programme evaluation. Marcus' application of Boolean logic to the performance of true or false (0 and 1) configurations in the structure of a play thus treats the dramatic structure as though it were a logical architecture of a formal type, to be read and performed by a computer actor as much as a theatre actor. Thus, although as I noted in my introduction, my investigation does not touch on the technologization of performance mathematics, Marcus' contributions suggest that not only mathematical languages, but also computational languages, can be considered to be poetical, and indeed performable.

In their book *Semiotics of Drama and Theatre: New Perspectives in the Theory of Drama and Theatre,* Aloysius van Kesteren and Herta Schmid tried to condense what they describe as hundreds of new titles in the field of mathematical drama theory, in order to speak of a clearer body of work and a distinct genealogy in the analytical approach to drama and theatre studies guided by Marcus. According to these authors (1984), theatre research can develop into a scientific research that might enable the theatre scholar to formulate correct aims and goals, to build consistent theories, to build hypotheses, to systematise them and to test them.

The pursuit for a so-called scientific method grounded on mathematical principles finally came under scrutiny by one of the school's main followers: Mihai Dinu. Dinu pointed out in his essay 'How to estimate the weight of stage relations' (1977), that the aesthetic value of theatre and performance in fact eludes any mathematical definition. This, according to Dinu, elicits a series of questions that are of interest both to mathematics and the dramatic text. Why, if mathematics turns out to offer amazing possibilities of adjustment to the study of the most difficult aspects of reality, should it fail when it comes to understanding the theatre aesthetically? What particular features of mathematics makes it unsuitable for axiological considerations?

Conclusion

This essay has shown how, at least conceptually, the marriage of mathematical and theatrical performance is paradoxical. Although Dinu's argument is acceptable in many ways, we have also seen that the theatre operates according to a number of key elements that can be compared to operative mathematical elements. These common features, as I have discussed them in this essay, contradict Dinu's argument, and thus leave us in state of undecidability. So, whilst completely different, mathematics and theatre can also be conceptually related: maths is a kind of theatre of abstractions, whilst theatre is a concrete mathematics of staged operations. Badiou has argued that theatre is akin to mathematics, insofar as both count as an intellectual art devoted to the simplification of a problem or a demonstration (2005, 73). Badiou's 'theatre of operations'—I call it performance mathematics—does not supersede representation, but it supersedes the idea that these problems, these demonstrations, and the place where they are staged, have to be real in a universal sense. If it is true that the instructions of the theatre will become more and more abstract, and not corporeal and collective as Badiou claims, then mathematisation and computerization provide suitable opportunities to create new syntheses that realise a crossover between the mathematical and the theatrical real. The technologization of mathematics in a digital-era context is an opportunity to mix realities within a theatre of operations; partly dramatic and theatrical, partly numerical and mathematical. Badiou presciently stated: ‘we are headed, and this is my prophecy, towards an austere theatrical mathematics' (2007, 23). Perhaps we are headed toward a computerized theatrical mathematics.

What this model of performance mathematics focuses on is not an a priori truth, but the event or the performance of truth, and more specifically, the functions used to carry out a series of moves according to some designed sense of the real. So, can this event be at once theatrical and mathematical? Digital computation is a good example of how machines perform according to scripted instructions, and thus act out operations within algorithmic designs based on basic binary functions like input-output, or truth-false evaluatives (Boolean logic). There is a theatricality set deep within this logic, which is why this logic can be theatricalised (as Marcus proposed, if only from a theoretical standpoint).

Performance mathematics is conceptualised as a possibility of staging ideas mathematically, theatrically, or in a synthetic way. What this historical overview shows is that this effort is not an academic one, but that the connection (and disconnection) between theatrical and mathematical performance has existed since these two disciplines first shared their concern with the staging of truth, and the construction of realities in their own terms, axiomatically or otherwise. A crossover— if at all possible— is indeed part of a theatre practice and theory tradition involved in this creative and critical enquiry. The concept of performance/mathematics finally reveals itself as the means to create a stage wherein a mathematical language, or indeed a language of mathematized theatricality, can be acted out; realised; performed. The reason why this concept might be appealing, is because it unleashes a sense of mathematics freed from the clutches of the abstract, and it unleashes a sense of theatrics freed from the clutches of physicality, in order to locate both in the domain of the virtual.

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