Science, performance and transformation: performance for a 'scientific' age?

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Abstract

The 'two cultures' of science and the arts/humanities are often considered at odds, but digital technology, and the broader implications of digital culture, provides a model for more productive forms of exchange and hybridity. This article applies theories of intercultural theatre practice to performance that works across this cultural divide to explore the types of interaction that take place. Following a historical discussion of the science/art divide, a three-fold model is proposed and explored through case studies including Djerassi and Laszlo's *NO* (2003)*,* Eduardo Kac's *Genesis* (1999), Reckless Sleepers' *Schrödinger's Box* (1996/2006) and John Barrow's *Infinities* (2002). It is argued that science operates through the creation of mathematical models of aspects of the physical world, whilst art similarly constructs different kinds of models for understanding the social/cultural and occasionally physical world. Digital technology expands the modelling possibilities both directly, through simulation, virtual reality and integration into 'live' activities in augmented and intermedia performance, and through the transformative nature of digital culture.

Introduction

Digital technology is an essential part of almost all cultural activity; in the Performance Arts this ranges from explicit use in digital performance to the more concealed use in lighting and sound design and operation. Similarly from computational mathematics to data analysis to digital imaging, the practice of science and its application through various tools has been transformed by digital technology. Since C.P. Snow's (in)famous 1959 lecture, the division the 'two cultures' of the arts/humanities and sciences has been challenged through numerous collaborations and experiments, and the use of digital technology in arts/science practices has resulted in a far more complex variety of practices. Intercultural performance theory can be used as a framework for exploring how, through digital media, exchange occurs between these two 'cultures'.

It is worth considering the historical context that has shaped these contemporary practices. Thirty years before Snow's lecture, in 1929, as Brecht was calling for a theatre of the scientific age, the experimental and theoretical developments of quantum mechanics were taking place. These developments underpin most of the digital computing, imaging, communication and storage technology that have shaped science and art into the twenty first century, as well as the performance interactions between them. As Matthew Causey argues, 'the technological advances in the screened technologies of new media and computer environments' has caused profound changes in 'material and metaphysical conditions', which have challenged how theatre and performance operate.(Causey 2006, 2) Johannes Birringer similarly writes about a 'present reality of techno-cultural shifts that have taken place and turned the digital into a mainstream phenomenon.'(Birringer 2008, xii) In recent years the increasing range of academic work exploring the representation of science in and through performance shows how science and technology (often conflated) can influence artistic processes.

This article makes use of theories of intercultural performance theories to explore if and how the 'two cultures' of science and performance interact in practice. I propose three main categories for considering how science performance work operates in relation to developments in digital culture: science in performance; performance through science; science/performance transformation. Although performance working across science and art can often seem to rely on the 'spectacle' of science in either content or form (harking back to the 'scientific experiment as performance' of the nineteenth century, and arguably the representation of programmes such as the Large Hadron Collider at CERN), I argue that there is the potential for a genuine revolution in understanding through what I term

'science/performance transformation'. Examples from a range of recent performance practices that engage with digital performance are used to develop these ideas, engaging with genetics, quantum physics, bio-chemistry and mathematics. How digital media is used in live performance is explored, as well as how live performance is shaped by digital culture.

The Two Cultures

Snow's *Two Cultures* sets the scene for much of the subsequent developments between science and arts, and was part of a developing concern that the scientific exploration of nature could no longer be considered part of 'the all-embracing enterprise of philosophy.' (Snow, 1998, pp. ix-x) Over the twentieth century the ability of people to maintain an understanding of these various domains became increasingly under threat because of increasing specialisation. The use of digital technologies in science, such as large scale computer modelling or statistical analysis, provides a further barrier as there is a tendency for these to be treated as a 'black box', without the possibility of an intelligible demonstration of how results are obtained.

 The key point that Snow makes in *The Two Cultures* is, that 'the great edifice of modern physics goes up, and the majority of the cleverest people in the western world have about as much insight into it as their neolithic ancestors would have had.' (Snow 1998, 15) Snow, who had trained and worked briefly as a scientist, and was a successful novelist, argued that the specialization of education in England in the first half of twentieth century produced incompatible literary and scientific cultures that were unable to communicate with each other, and not even interested in trying to. This separation turning to conflict between the sciences and humanities continues, with a view presented that scholars 'in the Humanities continue to feel the economic and institutional sting of Science [...]. While the sciences and

their technologies, proliferating wildly, seem to assimilate more and more of our social, economic, ecological, and aesthetic reserves, they have also increasingly withdrawn into their own specialized styles of articulation, consorting exclusively with their chosen forms of so-called facts and figures and actively rejecting any 'humanistic' tracking of their ideas as 'uninformed'. (Case 2007, 1) Similar viewpoints have been put forward by scientists involved in theatre, stating that it 'is recognized universally that the gulf between the sciences and the other cultural worlds of the humanities and social sciences is increasingly widening and that any attempt to narrow it should be welcomed' (Djerassi and Laszlo 2003, 63).

Kirsten Shepherd-Barr in, *Science on Stage*, observes that at 'about the same times as Snow, the pioneering British theatre scholar Glynne Wickham delivered his own thoughts on the 'two cultures' noting that 'arts graduates know even less about science than science students do about art' (Shepherd-Barr 2006, 13). Wickham saw drama as having a particular 'integrating power' that can 'provide the arts man (sic) with a lively introduction to scientific thinking and the scientist with as lively a reflection of his own human condition'(Wickham 1962, 56). The use of digital media in performance perhaps offers an equivalent integrating opportunity for the twenty first century as Wickham saw drama as offering in the twentieth, through its ability to supersede 'conventional forms of narrative explanation, visualization, and comprehension.'(Vanden Heuval 2013, 376)

Beginning with Brecht

Brecht is often held in a foundational position in the discussion of science and theatre; Shepherd-Barr argues that any 'discussion of science plays must include quite centrally Brecht's *Life of Galileo*', describing the play as 'a watershed in the development of 'science plays' (Shepherd-Barr 2006, 24). However, whilst *Galileo* raises interesting questions about

the presentation of biography and history in relation to science and scientists, here I will use Brecht's theoretical writing to discuss why the performance arts and science are brought together specifically through digital media. Brecht was explicit in his call for a theatre for the scientific age, and wanted actors to act for 'an audience of the scientific age.' (Brecht 1964, 26) This was not necessarily to 'see science in the theatre', as in representations of science itself, but rather to see 'Theatre.'(Brecht 1964, 27)

Whilst Brecht agreed that 'Art and science work in quite different ways', he felt that without an understanding of science, art was not able to fulfil its functions, whether those functions were political, or more personal. (Brecht 1964, 73) For Brecht, the 'great and complicated things that go on in the world cannot be adequately recognized by people who do not use every possible aid to understanding', and science was one of those aids to understanding.(Brecht 1964, 73) Digital technology can act as an aid to understanding in both arts and sciences, and as social, cultural and scientific life are now so shaped by these technologies, so their use can be used to understand the interactions of these often divided worlds.

What is apparent is that the relationship between science and theatre that Brecht felt was important was not the one that that the naturalists of the nineteenth century had set forth. , In the preface to the second edition of *Thérèse Raquin* (1868), Émile Zola claimed that his 'objective was first and foremost a scientific one', and in the preface to the stage version of the latter he proposed that the 'scientific spirit of the century will win over the theatre' (Zola 1992, 2) (Zola 1994, 70). For Brecht, these were 'scientifically exact representations' of 'so-called naturalism', not the acquisition of scientific knowledge that could be applied to create a better understand the world.(Brecht 1964, 179)

Writing in 1948, the changes in science and technology that had taken place since the late 19th Century were identified by the now 58 year old Brecht:

> I who am writing this write it on a machine which at the time of my birth was unknown. I travel in the new vehicles with a rapidity that my grandfather could not imagine; in those days nothing moved so fast. And I rise in the air: a thing my father was unable to do. With my father I already spoke across the width of a continent, but it was together with my son that I first saw the moving pictures of the explosion at Hiroshima.(Brecht 1964, 184)

Whilst Brecht identifies primarily technological developments, the pace of scientific change across the twentieth century has been equally rapid. As Roger Penrose observes, 'one of the remarkable things about the behaviour of the world is how it seems to be grounded in mathematics to a quite extraordinary degree of accuracy. The more we understand about the physical world...the more it seems as though the physical world almost evaporates and we are left only with mathematics.'(Penrose 1997, 3) Digital technology has often been conceived of in this way, the 'Digital Rain' of code in the *Matrix* films an illustration of this, but there is a significant challenge for art engaging with the underlying mathematical content, rather than just layering another type of representation upon the scientific understanding of reality. Whilst mathematicians have been the subject of a number of theatre works (Auburn's *Proof*, 2000 Complicite's *A Disappearing Number* 2007), employing mathematics in any meaningful way is far more challenging for performance, although works such as *X&Y*, that I discuss in more detail below, have attempted this. What science provides is the means (through the complicated and complex nexus of theories and experiments) for understanding how mathematical models relate to the physical world, and performance provides models (through the complex connections between production and reception) for understanding the world; the cultural and social world. Furthermore, digital media provides the ability to model the physical, cultural and social worlds in new and

profoundly revolutionary ways, and these new ways then impact on all forms of subsequent practice.

Performance and the digital: Performance and science

As Nicola Shaughnessy observes, there are a range of companies producing 'work variously exploring the interface between the live and the virtual, the real and cyber performance whilst also exploring the potential of interactivity as a means of engaging spectators as players in the production of meaning' (Shaughnessy 2012, 160). Whilst digital media is clearly dependent upon scientific advances for its technical development (such as the quantum mechanical properties of semiconductors for integrated circuits or lasers for reading DVDs) there is not a priori reason that digital performance should engage with science any more than any other form of performance. Indeed, there is perhaps a trend in science-theatre that leans towards plays that 'are groundbreaking in their use of science but rather mainstream in their theatricality.'(Shepherd-Barr 2006, 199) However, the permeation of culture by digital media has resulted in the possibility for a transformation of all performance, whether it is mediated through digital media entirely, partially or not at all. For the participatory digital work that Shaughnessy analyses, 'rather than art representing life, young people draw upon mediated versions of the real in their imaginative and creative acts. New technologies are needed to represent new realities.' (Shaughnessy 2012, 163) In addition, the new technologies that exist outside of the theatrical frame condition the expectation of work within the theatrical frame. As Matthew Causey argues, there is a fragmentation of the subject that can occur in videated performance art, and the 'presence of the televisual in contemporary theatre has a similar effect. The televisual in performance, not unlike the Cubist rethinking of representational space on canvas, acts as an agent of

transformation, altering the manner in which we represent and look at narrativity, subjectivity, spatiality and temporal images.'(Causey 2006, 38)

Marcus du Sautoy and Victoria Gould created the mathematical play *X&Y* (2013) which was performed for the Science Museum, London and the Manchester Science Festival. Du Sautoy, a professional mathematician, makes explicit the connection between theatre, mathematics, and digital media, stating that both he and Gould 'have this belief that theatre and mathematics have a lot in common, they are very much about creating abstract worlds ' (M. a. du Sautoy n.d.). These abstract worlds consist of 'setting up some rules which you then follow through the consequences' and for *X&Y* the whole play is almost like 'a mathematical proof' (M. a. du Sautoy n.d.). In the post-show notes from the performance, du Sautoy makes the link between the fictional space created in the play, and 'the computer game Asteroids [where] the universe consists of the finite computer screen. But this finite universe has no walls. If you travel off the top of the screen you reappear at the bottom. Head off at the left and you reappear at the right.' (M. du Sautoy 2013) The 'world building' through models that takes place in theatre and in science also takes place both in and through digital media.

The key thought linking performance, science and digital media is given by Sue-Ellen Case, for whom both 'the laboratory and the stage construct a space that is organized as alternative to the ubiquitous, pedestrian realm [...] both theatre and science have deployed notions of the virtual and its avatar that are as old as *The Upanishads* and as new as cyberspace and online avatars.'(Case 2007, 4)

Intercultural science and art

When discussing performance work that tries to operate at the intersection of the two

cultures of art and science there is an existing body of theoretical work that can help in

understanding these interactions. There is the possibility that a greater understanding of the

interaction between the 'two cultures' can be developed through the application of these

intercultural performance theories, such as those developed by Patrice Pavis, whose object

is 'the crossroads of cultures in contemporary theatre practice.' (Pavis 2004, 1) Whilst Pavis

explores performance work that brings together foreign cultures and varying artistic

practices, the ideas developed can be applied to performance work where the two cultures

of science and arts are brought together.

The key theoretical construction that Pavis develops that will be used here is the hourglass

model of exchange. The hourglass, described as 'reminiscent of a funnel and a mill', where

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> the upper bowl is the foreign culture, the source culture [and] to reach us,
> this culture must pass through a narrow neck. If the grains of culture or
> their conglomerate are sufficiently fine, they will flow through without any
> trouble, however slowly, into the lower bowl, that of the target culture,
> from which point we observe this slow flow; The grains will rearrange
> themselves in a way which appears random, but which is partly regulated
> by their passage through some dozen filters put in place by the target
> culture and the observer (Pavis 2004, 4).

Pavis observes that if the hourglass operates only as a mill the source culture will lose any

specificity, whilst if it is only a funnel, then it will not reshape the initial substance into the

new culture. The types of filter that Pavis discusses are the perspective of the adapters, the

preparatory work of the actors, and the choice of theatrical form and so on, to the particular

reception in the target culture. This final reception is key for Pavis, for after 'the sand has

filtered from one bowl of the hourglass to the other, the spectators are the final and only

guarantors of the culture which reaches them, whether it be foreign or familiar. Once the

performance is complete, all the sand rests on the spectator's frail shoulders.'(Pavis 2004, 18)

Criticisms of this hourglass model have been made with respect to its use in intercultural performance practices, for Lo and Gilbert 'it assumes a one-way cultural flow based on a hierarchy of privilege' which 'ultimately reduces intercultural exchange to an alimentary process'(Lo 2002, 42-43). It may be that the use of the hourglass model is more reasonable in an arts/science context than the use in intercultural work, especially when considering the significant methodological and epistemological differences between the arts and the sciences. It is certainly more difficult to see how the hourglass could be reversed without significantly changing the material that is passed through the hourglass. Simply put, there are numerous examples where an aspect of science is the content of a work of art, but it perhaps less clear what it would mean for a work of art to be the content of science.

Pavis makes a warning which is particularly relevant for work across the two cultures divide, cautioning that

> Choosing a theatrical form involves choosing a type of theatricality, a status of the fiction vis-à-vis reality. Theatricality offers specific means for transferring a source culture to a target audience: only in this context can we speak of a theatrical interculturalism. We may certainly doubt whether culture can really be represented by theatrical means or even performed. Perhaps only the most external and superficial features of culture can be represented; in any case, we must look for specific theatrical means to express or perform this (foreign) culture(Pavis 2004, 194).

Whether the specific theatrical means chosen to represent science can avoid the most external or superficial features being represented is the question that the following case studies will try to address.

Intersections

I suggest that there are three main ways that science and performance intersect: science in performance; performance through science; science/performance transformation. These categories are not new, Carl Djerassi writes of his work as Science-in-Theatre, (Djerassi 2002) but considering them together allows for an understanding of the different ways that the intercultural hourglass processes these interactions between science and performance (in Pavis' terms) and how they can act as possible aids to understanding (in Brecht's terms). I have selected Eduardo Kac's *Genesis* (1999), Reckless Sleepers' *Schrödinger's Box* (1996/2006), John Barrow's *Infinities* (2002) and Djerassi and Laszlo's *NO* (2003) as case studies to illustrate these potential interactions. I have chosen them, because they represent a diversity of performance practices (plays, performances, participatory artworks) and creative partnerships (artists, scientists working with artists, scientists turned artists, 'biological artist') and also because they are in some ways ordinary examples of how science and art interact in performance.

Science in Performance

NO, was written by Carl Djerassi and Pierre Laszlo, both Emeritus Professors of Chemistry, for as a work to be performed in school or university classrooms. As the authors acknowledge, 'people go to the theatre to be entertained and any pedagogic motive must be downplayed, if not totally hidden, to ensure that such plays are accepted on their theatrical merits.'(Djerassi and Laszlo 2003, 63) However *NO* is a deliberately much more didactic presentation of scientific material, in this case the chemical and biological role of Nitric Oxide, told through a research grant discussion between two scientists (Dr. A and Dr. B.) and a venture capitalist (Mr. VC). The authors expressed hope is to 'illuminate, however briefly, the complexity and wonder of much of contemporary research', and it is written

with consideration of the technical limitations of being performed in a classroom, and the performance limitations of untrained and unrehearsed actors. (Djerassi and Laszlo 2003, 65) The published script includes a CD ROM of 24 slides to be projected during the performance, including the chemical structures involved in processes in which nitric oxide plays a key part, such as the effect of Viagra. Whilst this incorporates digital media into the live performance, there is very little interaction between the two; the projected images are static slides which merely illustrate the scientific material being discussed in the play. There is very little opportunity for transformation here, rather the material is presented by experts (Dr. A. and Dr. B.) to the audience, lacking in knowledge, represented by the Mr. VC. Here the mill operates merely as a funnel, and there is no transformation of the material, or, arguably, the understanding of the audience.

In response to arguments put forward by Djerassi, Michael Vanden Heuval observes how in the conventional science play he is often 'struck by the conventional storytelling, the overt literariness of the styles and themes and, consequently, the relationship they establish with the putative spectator.'(Vanden Heuval 2013, 366) Whilst there may be a clear and direct engagement with science in the content of this science-in-theatre, and, as discussed above whilst Djerassi and Laszlo might wish cast light onto the manifold joys of scientific research, without a productive engagement between the content and form, then effectiveness of the performance in reduced when 'the essential mediality of theatre, theatre as a specific mode of communication and expressiveness related to, but also distinct from, other media, [is] repressed'.(Vanden Heuval 2013, 366) Here we see the consequence of when the hourglass operates only as a funnel, the material remains insufficiently transformed and so not shaped into a new culture. For Vanden Heuval, in performance which makes use of enhanced

intermediality 'the multiple levels of creating meaning are not only sustained but interfere and resonate with one another, producing not just complicated but 'complex' and potentially emergent patterns of meaning co-created by the active spectator.'(Vanden Heuval 2013, 375) Without the processing that takes place when the hourglass operates as a mill there is no opportunity for the spectator to develop understanding with a meaningful relationship with the scientific content: instead they can only act as passive recipients.

Performance through Science

The second category is that of Performance through Science. As mentioned earlier, whilst almost all performance depends on or makes use of scientific and technological developments in its realization, for performance through science the work is entirely dependent on a scientific process or procedure for its particular form, and here Brazilian artist Eduardo Kac's works Genesis is most helpful in this respect . Kac's work directly engages with scientific processes, such as genetic modification to create transgenic art. Kac's work is not presented as a collaboration with scientists (though, there are occasional references in the writing of others about Kac's work to 'scientific collaborators') but as art that could *only* be created through these scientific processes; transgenic art is not altered through the application of scientific processes, but exists only through these processes.

 Matthew Causey has analysed Kac's work in some depth, positioning it as 'a performance of the posthuman.' (Causey 2006, 132) Causey argues that the idea of the posthuman fundamentally changes the nature of body and consciousness, as the technological means for viewing, mapping and changing the body has rapidly and radically changed both our understanding of and ability to alter ourselves. (Causey 2006, 52-53)

In *Genesis* (1999) the human body is not the reconfigured, rather, through technology humans are able to rewrite life at a distance. Kac describes the work as exploring 'the intricate relationship between biology, belief systems, information technology, dialogical interaction, ethics, and the Internet.' (Kac n.d.) It has at its conceptual heart what Kac terms the 'artist's gene' 'created by translating a sentence from the biblical book of Genesis into Morse Code, and converting the Morse Code into DNA base pairs'. (Kac n.d.) The sentence reads 'Let man have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moves upon the earth', which Kac asserts was chosen 'for its implications regarding the dubious notion of (divinely sanctioned) humanity's supremacy over nature.' (Kac n.d.) This gene is then inserted into *E. coli* bacteria, which then form the centrepiece of the artwork.

The modified *E. coli*, which are also genetically altered for enhanced cyan fluorescence (that is they glow greenish-blue), are mixed with *E. coli* similarly enhanced for yellow florescence, and both are then subjected to UV light (controlled by spectators over a website) which will not only produce the fluorescence, but also increases the chance of genetic mutations. Real time images of these modified bacteria from a microvideo camera are projected and the 'left and right walls contain large-scale texts applied directly on the wall: the sentence extracted from the book of Genesis (right) and the Genesis gene (left)' (Kac n.d.). Without the scientific processes, such as the cloning of the synthetic gene into plasmids, and the subsequent incorporation of those plasmids into the bacteria, the starting point for the artwork could not exist. Following this, the action of the spectators upon the bacteria, via the internet, then causes not only short term florescence, but also genetic mutation, changing the text inscribed into the DNA of the bacteria. At the 'end of the show the altered

biblical sentence is decoded and read back in plain English[1], offering insights into the process of transgenic interbacterial communication.' (Kac n.d.) The new text is written out, altered, and revisited through scientific processes, and these processes become the artwork.

For Causey, *Genesis* both describes and is shaped by the posthuman. '*Transgenic art* exercises the artist's ability not simply to create the object of art, but to actually create the subject within art. The boundaries of art and science are traversed with unsettling ethical dilemmas. Who has the right to create new life? Who takes responsibility for the results? What are the final results?'(Causey 2006, 130-131)

Whilst *Genesis* clearly brings together art and science, the hourglass here operates as a mill, and the specificity of the source culture is lost. Whilst *Genesis* might be aesthetically effective, and might, as Causey notes, raise some profound questions, it does not provide the audience with any tools for answering them. Furthermore, the specific rewriting of the Genesis text provides no additional aesthetic or scientific meaning other than it having taken place. There is no emergent meaning that can be taken from the exact rewriting, coming as it does from random genetic mutations. Whilst the spectator might be amazed by the ability to code text within bacterial DNA, within the piece itself there does not appear to be a transformation of the spectators understanding of those wonders. In Brecht terms again, it does not aid understanding of science.

Science/performance transformation

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[1] The translation of the mutated gene reads as follows: "LET AAN HAVE DOMINION OVER THE FISH OF THE SEA AND OVER THE FOWL OF THE AIR AND OVER EVERY LIVING THING THAT IOVES UA EON THE EARTH"

Whilst the first two case studies have engaged directly with digital technology with different degrees of integration, the final case studies are instead shaped by the modelling principles of digital media. As discussed above, digital media both shares with and shapes the defining features of performance. This includes the 'transformative nature of performance, the power to reorder all that enters its sphere (whether text, subjectivity or ideology)', which might also seem to be the key feature of digital media.(Causey 2006, 56)

Reckless Sleepers' work *Schrödinger's Box* (re-worked and re-titled *Schrödinger* in 2011) directly refers to the quantum mechanical thought experiment, where a dead/alive cat in a box illustrates a paradox: how the micro (quantum mechanical) and macro worlds can interact in way which is consistent with observations in both realms. Erwin Schrödinger's original 1935 thought experiment consisted of a cat in a box with a radioactive source, a vial of poison, and a device that if it detects radiation will break the vial and release the poison, killing the cat. In the macro world, if looking in the box the radioactive source would either decay and release radiation resulting in the death of the cat, or not. Radioactive decay is a stochastic process that it impossible to predict for individual atoms, but that follows a constant chance over time. Under the Copenhagen interpretation of quantum mechanics, until observed, quantum systems (such as the radioactive particle) exist as a superposition of states, probabilistically combining the decayed and non-decayed states; the act of observation collapses the wave function into either 'decayed radioactive source' or 'non-decayed radioactive source'. Whilst this delayed collapse might be philosophically acceptable for an atom, it is much harder to accept or even understand what it would mean for a cat (or person) to be in a quantum superposition of both alive and dead.

Andrew Brown observes that *Schrödinger's Box* is presented as playful space despite all the struggles that are apparently faced within, where 'Childlike scientists conduct experiments on virtual cats, much as cats play with mice.'(Brown 2007, 44)

The title might produce an expectation of an elucidation of scientific theory, and as Reckless Sleepers' artistic director Mole Wetherell recounts, 'I think in some circles we were criticized for not explaining Quantum Theory. I'd like to say that we tried to make sense of it [...] we do explain these concepts, albeit not in a classical way, such as a lecture demonstration.'(Brown 2007, 7) Shaughnessy, in the introduction to *Affective Performance and Cognitive Science: Body, Brain and Being*, argues that the black box of *Schrödinger* is a metaphor for both cognitive science and performance, and that digital technology, through the cognitive revolution of the 1970s, became a key way of understanding cognition. (Shaughnessy 2013, 5) *Schrödinger* is, Shaughnessy argues, 'a production in which we see, simultaneously, theatre staging science, performance processes exploring scientific concepts and an 'affective' aesthetic.' (Shaughnessy 2013, 13) The combined effect of these three operations is to produce theatre that transforms understanding through 'a different kind of knowledge' that combines 'intellectual understanding and intuition.' (Shaughnessy 2013, 16) If science through mathematical models provides a different way of seeing the world, much as digital media provides different ways for organising and visualising information, then this combined understanding is what is required for a transformed understanding through performance. Here a transformed understanding is achieved through an integration of showing and feeling, but not through a development of technical knowledge of quantum mechanics.

The closing sequence provides an example of this combined understanding. Through the piece, the walls of the box are covered 'in a confusion of text and image, bewildering with potential interpretations'.(Brown 2007, 44) Then, as Brown describes:

> 'In the closing sequence [...] it appears to be raining inside the set. The introduction of cold water delivered from above by means of watering cans creates a genuine shock for the performers. They are affected to the extent that it becomes impossible for them to continue and they literally have to catch their breath. [...] The performance/experiment concludes with the performers emerging, all soaked to the skin. They stand, looking back into the box, as if the original scientists surveying their handiwork as if to say 'What have we done?''(Brown 2007, 83)

Schrödinger provides a series of models, such as the use of contacts between people and objects, or simultaneous actions, which transforms ideas from twentieth century physics into actions through the process of performance making. Whilst it might not be a piece *about* quantum mechanics, watching it gives as good a *feeling* for quantum mechanics as can be achieved without understanding the complex mathematics. The hourglass transforms the material into a new structure, which keeps a vital aspect of its original form.

By way of a conclusion *Infinities*, directed by Luca Ronconi and written by theoretical physicist John D. Barrow. *Infinities* does not try to show scientific processes or portray scientists, nor is the performance mediated by scientific methods. What *Infinites* does is convey to the non-mathematician the beauty of mathematics, and the way in which mathematics can change thought. Shepherd-Barr describes *Infinities* as staging 'some of the great paradoxes or 'thought experiments' about infinity: the Hotel Infinity in all its vastness, the notion of time travel, the idea of living forever, Borges's library of Babel with its endless corridors of books. Watching *Infinities* brings such concepts to life in a stunning combination of mathematics, philosophy, science, and theatricality.'(Shepherd-Barr 2006, 149)

Shepherd-Barr goes on to argue that the 'play demonstrates the very concepts it deals with, and takes the genre of 'science play' to a new level [...] deliberately [rejecting] such mainstays of traditional theater as plot and characterisation.'(Shepherd-Barr 2006, 150) The ideas of infinity are explored in *Infinites* without a particular use of digital technology, instead, for example, Hilbert's Hotel which can always accommodate and number of new guests, took place in the warehouse where the backdrops for operas at La Scala are painted. 'The warehouse has a huge wall with hundreds of doors through which set designers emerge to paint the backdrops hung against the wall. Remove the backdrop and what you have is Hilbert's Hotel: endless doors lining the wall stretching into the rafters of the warehouse.'(M. du Sautoy, To infinity and beyond 2003) As Vanden Heuval argues, whilst performance can allow for multiplicity of perspectives:

> Science-in-theatre renders invisible these multiple acts of representation
> because rather than foregrounding the perception of bodies 'present' — which
> are also being 'presented' as signs even as these are part of a larger
> 'representation' or narrative — didactic realism of the sort Djerassi prefers
> collapses everything into the single layer of narrative representation, of
> mimesis.(Vanden Heuval 2013, 374-75)

Performances such as *Schrödinger* and *Infinities* produce multiple layers of meaning, a multitude of ways of reading, though not through a singular naturalistic dramatic narrative. As mathematics underpins reality, so the science underpins these productions, though not necessarily described or explained through them. The ephemeral qualities of performance allow for a more subtle exploration of a range of ways of experiencing infinity, or the collapse of the quantum mechanical waveform.

Infinities allows for the audience to take the sand that comes through the hourglass upon their shoulders and make meaning from the multiplicities that are presented to them. The audience will not come away from the performance with a single shared understanding of

infinity – this is not the performance equivalent of 'teaching to the test'. Instead, the piece operates as a model of infinity, which aids our understanding of both mathematics, and how mathematics relates to what it means to be human.

The 'two cultures' may still exist; but there are frequent travellers between them. Digital technology has shaped both cultures, and can be used, directly and indirectly, to build models that aid an understanding of both. The work which perhaps most successfully builds bridges between the 'two cultures' create models that can be interacted or experienced in a range of ways. This interactive model clearly reflects aspects of digital culture, and an integration of form and content. Rather than the predetermined and linear experience or exchange when science is communicated through performance, or performance is mediated through science, when performance has a transformative effect on understanding then it can achieve the Brechtian 'aid to understanding' of what it is to be human in a world underpinned by mathematics, understood through science, and visualised through digital technology. Whilst I am not providing a methodology for performance that sits across the two cultures, what seems key to a forming a bridge between the two is for neither to be utilised in the service of the other, but for the multiplicity of reading possible in performance to enable a transformative experience.

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