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Visualising the invisible: performing chaos theory

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Abstract: Edward Lorenz, the pioneering figure in the field of chaos theory coined the phrase "butterfly effect" and posed the famous question "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" In posing the question, Lorenz sought to highlight the intrinsic difficulty of predicting the long term behavior of complex systems that are sensitive to initial conditions, like, for example, the weather and climate; these systems are often referred to as chaotic. Taking Lorenz' butterfly as a starting point, *Chaos Cabaret* sought to explore the nuances of chaos theory through performance and music.

<1> Context of science theatre

Science theatre [1] has begun to attract interest from academics representing a range of disciplinary perspectives, including literary, performance and science communication and education perspectives, though the bulk of published work focuses on text based analysis [2] or educational settings [3,4]. This has resulted in two dominant strands of literature, one focused on more traditional, playwright driven theatrical approaches, which because they focus on the text tend to explore the scientific content or position of science within the text. The other strand of science theatre has focused on learning and the potential of theatre to provide alternative science learning experiences. This literature necessarily focuses primarily on science theatre performed in institutions (schools, museums) with explicit pedagogical intent and aimed primarily at younger audiences. While there is much of interest in the educational literature, this paper explores the somewhat overlooked area of theatre aimed at largely adult audiences. There has been relatively less focus on theatrical performances developed through approaches such as devised theatre [5] or dramaturgical approaches [6] and few studies that have explored adult audiences for science theatre [7 – 9].

From a science communication perspective, there is as Philip Ball [10] notes, a divide between 'theatre writers looking to science, and scientists looking to theatre'. Playwrights may find inspiration, metaphors and stories in science, but as Ball points out it is not easy to portray science well on stage, as you cannot assume the audience is familiar with the subject matter or metaphor you are borrowing. For many playwrights the intent is usually not explicitly to educate, but rather to explore ideas or the lives of their characters as a means of engaging with ideas. Scientists, however, may turn to theatre with more explicit pedagogical or communicative intent, seeking what Carl Djerassi has termed 'science-in-theatre' [11]. This genre is one which makes more than passing reference to science and scientists, though science may still act primarily as a backdrop to the

narrative. Postdramatic performances, where scientific concepts come to be embodied in theatrical productions, are also beginning to emerge. *Infinities* by John Barrow and Luca Ronconi [12] perhaps epitomises this shift toward theatre that weaves scientific concepts into the fabric of performance, rather than drawing on them for other purposes, such as Michael Frayn [13] borrows Heisenberg's Uncertainty Principle to use as a metaphor for human psychology in *Copenhagen*.

Unlike the majority of science plays which see 'science as a supporting actor' [14], the slippery mathematical concept of infinity is brought to life by Barrow and Ronconi in five scenes that are linked but can be experienced in any order [15]. Hilberts Hotel, for example, explores the outer edges of infinity. In this scene, a hotel whose rooms are all occupied, accommodates another guest by simply moving each gest along one room (guest in room 1 moves to room 2 etc). In another scene, the paradoxes of eternal life are explored in a nursing home for those who never die. This scenario explores the human implications of infinity. A further scene explores originality (or lack of it) is used to consider the implications of a universe where everything will happen, repeatedly. Two additional scenes further complicate our understanding of infinity [16, 17]. Barrow and Ronconi sought to place the mathematical concept of infinity and challenges in conceptualising it at the heart of the performance, giving infinity a central role in the structure as well as performance of the play .

Infinity is a concept we first encounter in school, and many of us will have an intuitive grasp of its mathematical meaning: a number greater than any assignable quantity or countable number, though we may also attach colloquial meanings to the term, such as limitless or boundless. These are subtly different meanings and a mathematician will have a different understanding of the term infinity than will a layperson. The same applies to the term chaos. In popular culture, chaos is usually linked to randomness, while as a scientific term it more closely maps to unpredictability. This is a subtle difference, but an important one when it comes to explaining chaotic systems. I refer to this this as a 'language challenge' in an attempt not to be normative about word meanings and it was the stimulus for the development of *Chaos Cabaret*, a theatre performance that used chaos theory as inspiration. *Chaos Cabaret* was an exploratory piece in which I was involved along with author Frank Burnet, Angel Theatre Company and composer Jo Ives and which was funded by the Science and Technology Facilities Council.

<1> Origins of Chaos Cabaret

Edward Lorenz [18, 19], who pioneered the field of chaos theory, was a mathematician. As he probed the unpredictability of weather systems mathematically, he discovered that while they are deterministic, they are non-linear and not predicted by linear models. Originally, called the 'seagull effect' Lorenz apparently listened to colleagues who suggested that 'butterfly effect' was rather more poetic. In any case, many of us will make some link between chaos theory and butterflies, perhaps recalling the question posed in the title of Lorenz's 1972 presentation to the AAAS: "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" Interestingly, Lorenz points to Philip Merilees as concocting this title (apparently Lorenz failed to provide a title at all).

In developing chaos cabaret, we took this famous question as a jumping off point, as I explain below. However, before diving into the performance itself, it is worth exploring chaos theory in a bit more depth. Lorenz used the question "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" as a way of highlighting the intrinsic difficulty of predicting the long term behaviour of complex systems that are sensitive to initial conditions, like for example the weather and climate; these systems are often referred to as chaotic. As Lorenz puts it:

> ‘Our results … indicate that prediction of the sufficiently distant future [weather] is impossible by any method, unless the present conditions are known exactly’ [20].

In essence, what Lorenz is arguing is that even a very slight change in starting conditions can lead to widely divergent outcomes. Thus, the flap of the butterfly’s wings here represents this very tiny change which could (in theory) result in some apparently unpredictable weather event (the tornado) in a distant and seemingly unconnected place (in this case Texas). Or, as Lorenz supposedly puts it:

> ‘Chaos: When the present determines the future, but the approximate present does not approximately determine the future’ [21].

Chaos Cabaret, then, set out to explore how small unknowns might lead to different outcomes. The performance is based on a hypothetical conversation between Edward Lorenz and a young journalist who has trouble grasping the notion that tiny differences could produce widely divergent results and that we may not be able to describe a system fully, even though we appear to have accounted for all the important conditions. This conversation is interspersed with vignettes that seek to visualise chaos theory for the audience and which are performed through dance, movement, sound and words by three actors and three musicians. For most of the performance, at any one time attention is directed toward either Lorenz and the journalist or the actors and musicians creating a separation between a largely expository and a largely narrative exploration of chaos theory. These two frames come together in a final whirlwind (tornado) in which the two worlds collide and merge.

If we take the different elements of the performance we can uncover the ways in which by drawing on both expository and narrative devices, the performance seeks to visualise the story of unpredictability that is chaos theory. Thus we have didactic explanations from Lorenz, such as this excerpt where Lorenz explains a ‘key dropping’ experiment he performs for the journalist (two keys are held together and dropped, but naturally do not land in the same place):

> ‘From the moment I released the keys the laws of physics took over subtly altering the way each key fell, that’s why one ended up over here and the other over there. So they started together in exactly the same place and ended up in different ones and that is because they were our very own chaotic system one in which there was no way we could have predicted where these keys would end up, and that would be true however often I dropped them.’

To counterpoise this didactic explanation we have a narrative ostensibly conceived by the journalist as he seeks to articulate his growing understanding of chaos theory. This narrative story is performed as a series of vignettes, whereby an initial set of conditions lead to a range of possible outcomes. For example in this excerpt at the beginning of the performance a butterfly, being chased by a bee attracts the attention of a little girl called Emily:

> The movement outside her window was noticed by Emily, a six year old girl who had been sent to her room for conducting an experiment that involved discovering what happened when you mix everything you can reach in the kitchen and put it in the oven for an hour.
>
> Emily opened the window very carefully and a puff of wind may have:
>
> *Music in background while performers act out the different options*
>
> Blown the butterfly in
>
> Made the curtain knock over a vase
>
> Turned the page in a diary

Smashed the window

With the music ending, we move back to the expository sphere, where the journalist confirms their understanding of chaos theory:

> So the idea is that the direction of the journey will depend on what the puff of wind changes in the room. Is that OK?

This dialectic between the expository and the narrative is used throughout the performance to build a deeper understanding of the nuanced meaning of chaos in relation to chaotic systems.

<1> Audience reactions

Brief interviews with audience members both before and after the performance sought to explore ways in which audiences might engage with science theatre. It was evident that many in the audience were attracted to the performance either because they knew the performers or had previously attended work by the Angel Theatre Company, while others were attracted by the topic (chaos theory) which was perceived to be an unusual topic for a performance, as explained by this interviewee:

"I thought it was a really unusual idea. How do you bring something like chaos theory which is so dull, to life." (Int3)

Entwined in this response is a perception that science and mathematics are in some way uninteresting and irrelevant, which was not a view shared by all interviewees, many of whom 'have always been interested in science' (Int 1). Thus the audience seemed to be composed of two quite different groups, on the one hand those looking to feed an existing interest in science, and saw theatre as just another venue in which to encounter science, and those primarily interested in theatre, who saw science as an interesting challenge. This audience was culturally active, and many held existing interests in science; just over half had previously attended science-themed theatre (56%, n=30). Interviewees also felt that the performance "was really good fun and it explained a lot of questions. Really in layman's terms." (Int 2). The majority of respondents felt that the science content of the performance added to the overall experience (87% agreed or strongly agreed, n=30) and 80% (n=30) felt that the performance had encouraged them to think about chaos theory.

There was one, rather interesting, exception amongst the interviewees. Int 8 had evidently attended the performance by accident, assuming it would 'be more of a lecture' and that 'all this acting and poncing about is a load of rubbish' [22]. This audience member's experience highlights the importance of expectations when attending live events; theatre is not enjoyed or seen as relevant by everyone. As a genre that blurs boundaries and might be sited in unexpected venues (where either science is expected and theatre is not, or vice versa) it has the potential to attract diverse audiences, but these audiences may be ill prepared for their experience.

<1> Discussion

Like the plays of Djerassi, *Chaos Cabaret* does have didactic content and, unlike Barrow and Ronconi's *Infinities*, the vignettes do have a direction of travel (which ultimately leads to the tornado). Audience responses suggested that the combination of narrative and expository elements was effective at engaging the audience with a topic that might otherwise have been seen as 'dull'; audience responses also suggest that the concept of chaos theory was translated effectively into layman's language. For the majority of audience members who were aware that they were attending

theatrical event, theatre was viewed as an interesting way to encounter science, feeding their curiosity. However, the rather angry dissenting voice highlights the importance of audience expectations. While it may be hard to understand how an event advertised as a performance could be mistaken for a lecture, there are many ways in which an audience can be unprepared for science communication leading to dissonant experiences. (These dissonant experiences are not necessarily without value.)

Chaos Cabaret sought to visualise chaos theory through the performance of potential futures, in doing so it seeks to enact and embody unpredictability. Performers' bodies become our way to see the unseen and music a means of signalling change. Through movement, music, narrative and expository dialogue, *Chaos Cabaret* engaged the audience with a topic perceived by some in the audience as challenging. The performances was designed as a cultural collision – between performance, science and people. Such collisions offer challenges, but also opportunities for new meaning to be created.

<1> References and notes

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22. It should be noted that this performance was scheduled during a science festival in which much of the programme was lecture or discussion based, but information on the programme clearly stated that Chaos Cabaret was a theatre performance.