A Disappearing Number

Conceived and Directed by Simon McBurney

Devised by	the Company
Original Music	Nitin Sawhney
Design	Michael Levine
Lighting	Paul Anderson
Sound	Christopher Shutt
Projection	Sven Ortel for mesmer
Costume	Christina Cunningham
Associate Director	Catherine Alexander

A Complicite co-production with Barbican bite07, Ruhrfestspiele, Wiener Festwochen, Holland Festival, in association with Theatre Royal Plymouth

Full production details **www.complicite.org**

This information pack accompanies the online video clips which explore some of the ideas behind the production and offer a glimpse of how Complicite works in rehearsal. Dive into the production polaroid on www.complicite.org and play.

Workpack written by Catherine Alexander (Associate Director)
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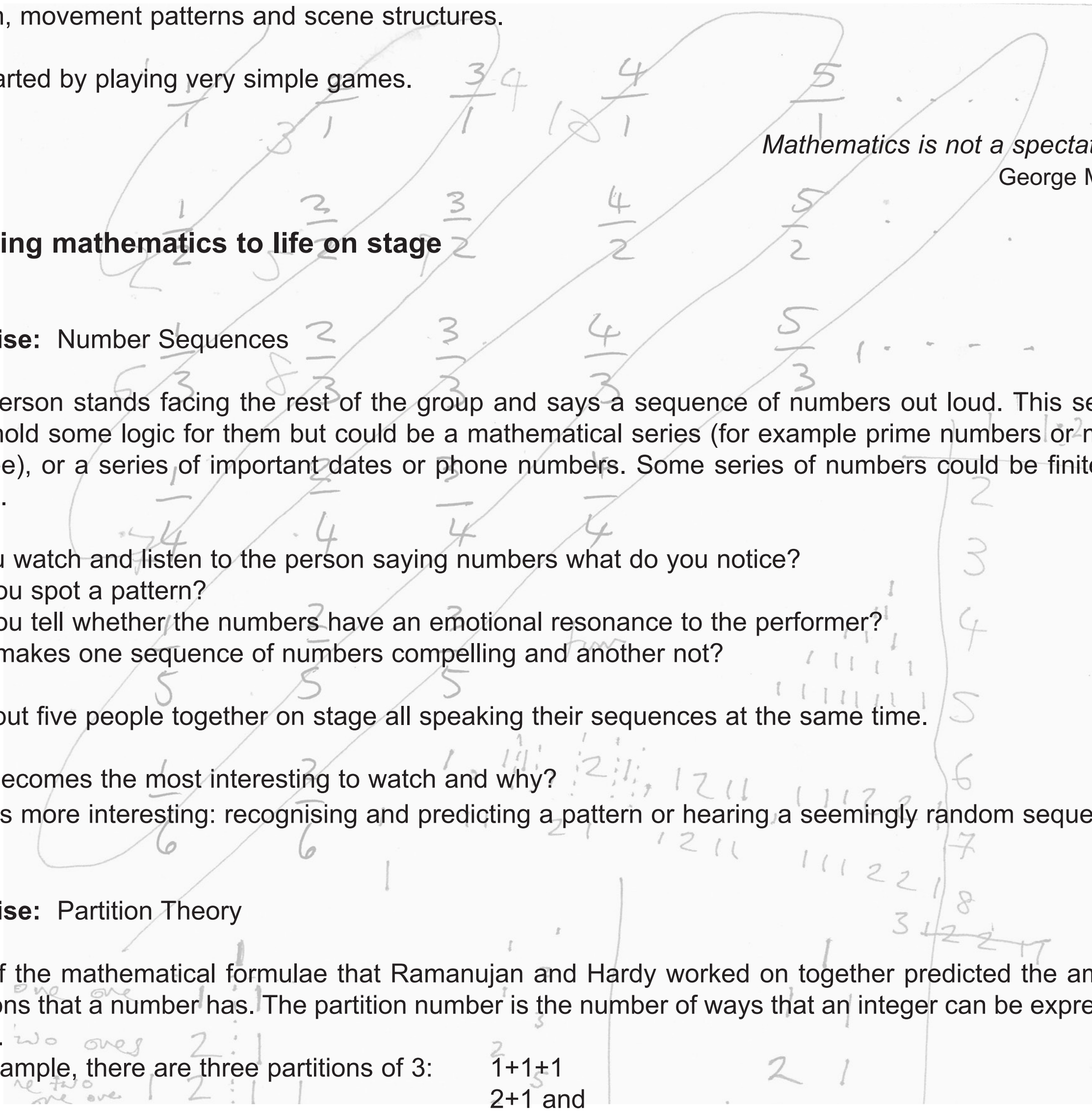
Introduction

Mathematics is at the heart of Ramanujan and Hardy's story. Many of the collaborators on *A Disappearing Number* had an initial fear of mathematics, but as a company we played with numbers and formulae in order to become comfortable with mathematical ideas and enhance our understanding of the subject. This process of playful exploration brought mathematics to life but the question remained as to how to convey these mathematical ideas on stage. Though the production doesn't endeavour to understand or explain the mathematics, story telling and theatrical metaphors are used in an attempt to express mathematics through rhythm, movement patterns and scene structures.



We started by playing very simple games.

Mathematics is not a spectator sport
George M Phillips

Bringing mathematics to life on stage

Exercise: Number Sequences

One person stands facing the rest of the group and says a sequence of numbers out loud. This sequence must hold some logic for them but could be a mathematical series (for example prime numbers or multiples of three), or a series of important dates or phone numbers. Some series of numbers could be finite others infinite.

As you watch and listen to the person saying numbers what do you notice?
Can you spot a pattern?
Can you tell whether the numbers have an emotional resonance to the performer?
What makes one sequence of numbers compelling and another not?

Then put five people together on stage all speaking their sequences at the same time.

Who becomes the most interesting to watch and why?
What is more interesting: recognising and predicting a pattern or hearing a seemingly random sequence?

Exercise: Partition Theory

One of the mathematical formulae that Ramanujan and Hardy worked on together predicted the amount of partitions that a number has. The partition number is the number of ways that an integer can be expressed as a sum.
For example, there are three partitions of 3: 1+1+1
2+1 and
3

There are five partitions of 4: 1+1+1+1
2+1+1
2+2
3+1 and
4

As the number gets even slightly bigger the number of possible partitions quickly becomes very large.

In groups of five, six or seven arrange yourselves spatially into the all of the possible configurations for your group number. Pay particular attention to the order you choose to do the partitions in and how you move between the various arrangements.

How do you remember the moves?
Does the number of people in your group lead to a particular set of shapes, spaces and movements?
Does the final sequence of movements suggest a dramatic narrative or dance?

Exercise: Articulating Actions

Choose a simple action: for example reading a newspaper or drinking from a bottle. Deconstruct the action into a repeatable phrase with a set number of movements punctuated by distinctive articulation points (i.e. where each sub movement begins and ends). Practice your phrase so that you can move on each articulation point as if to the regular beat of a metronome. One person can count or beat time to make this clear. The movement should appear quite mechanical. Then choose a number between 1 and 7 and only move on multiples of this number, or choose a sequence of numbers like square numbers or primes and only move on these.

What happens to the action?
Observe when this makes the action organic, comic or when it reads as a specific attitude to the action.

By simply focusing on making numerical / timing decisions we can sometimes communicate a character or narrative without trying. The idea of making clear timing decisions based on numbers can be explored further in the following exercise.

Exercise: Time to think

One person – A, gives their partner – B a simple task or action to do. For example 'scratch your nose' or 'cough'. Person B has to do what person A says within a 15 second period, but can choose when to do the task by picking a number from 2 – 15 and timing their action according to the number they have chosen. Person B returns to neutral after they have completed the task.

What meanings do different timings give?
What can you read from a quick or slow response?

As the exercise develops, the instructions can involve the voice and become more provocative in order to stimulate an emotional response. For example A could ask B 'Why don't you love me?'

Often when we improvise we respond too quickly. This exercise slows us down and makes us consider how the rhythm of a response can affect meaning.

Exercise: The dynamic of numbers

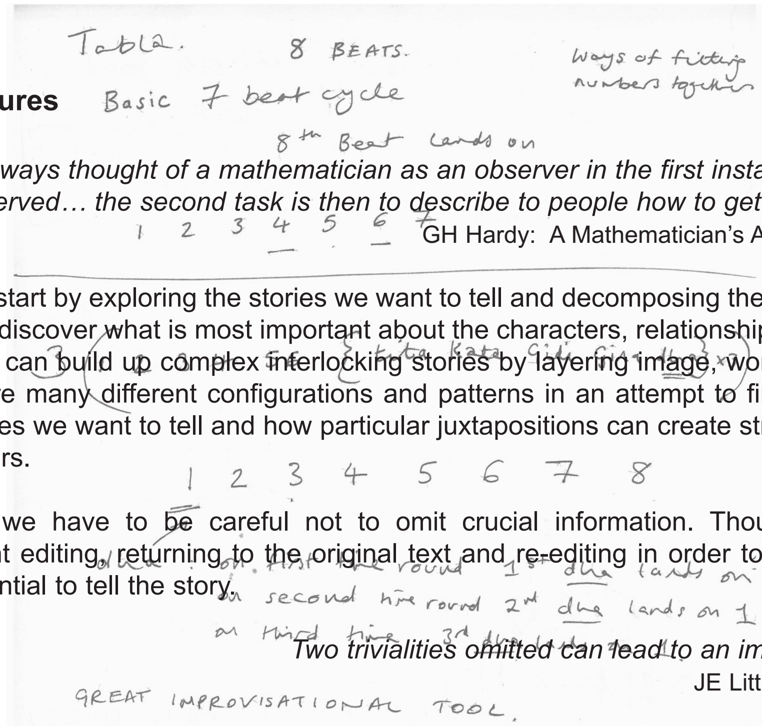
When we think about numbers we each get instant mental images: 3 might conjure the figure 3, three objects, a triangle, or three dimensions. Numbers are all unique and have distinctive qualities. As theatre makers we explored how each number might be expressed as sound, rhythm or movement. We started by exploring the positive whole numbers, then we explored negative numbers, rational and irrational, and imaginary numbers,

Try to express different numbers in sound, rhythm or movement.
How does 1 move and relate to space? What is its rhythm and tension?
Is there an intrinsic physical dynamic to a number?

Later in the rehearsal process we explored formulae and tried to express more complex mathematical expressions as movement phrases. For example the irrationality of the square root of 2 was expressed by two people clinging desperately to each other then being forced apart into crazy unresolved movement. This improvisation later grew into a proposition for a scene. (see also online video Patterns for an example of an improvisation born out of the rhythmic pattern of the mathematical identity 'the difference of two squares')

So our explorations of abstract ideas gave us propositions of form and structure that were developed into scenes and movement sequences.

Stories and mathematical structures



I have always thought of a mathematician as an observer in the first instance…
Once the mathematician has observed… the second task is then to describe to people how to get there.
GH Hardy: A Mathematician's Apology

When we make a piece of theatre we start by exploring the stories we want to tell and decomposing them into their essential fragments. We need to discover what is most important about the characters, relationships and themes we want to develop. Then we can build up complex interlocking stories by layering image, word and movement. Along the way we explore many different configurations and patterns in an attempt to find the connections between the various stories we want to tell and how particular juxtapositions can create stronger resonances for an audience than others.

When we decompose the material we have to be careful not to omit crucial information. Thoughout the devising process there is constant editing, returning to the original text and re-editing in order to avoid leaving something behind that is essential to tell the story.

Two trivialities omitted can lead to an impasse
JE Littlewood

Exercise: Stories in images

In groups choose a real story (from a newspaper for example) and attempt to tell it in a series of static images (tableaux). Ask the audience to close their eyes whilst you move between the images so they simply see a series of freeze frames. (see online video clip Patterns for an example of this exercise)

Does the number of images you use to tell your story matter? Are two images too few and ten too many?
Is an even or an odd number of images more effective?
Do you feel the need to use an uneven rhythm between the images?
Is there a clear beginning, middle and end?
Is the story clear?
If this essential visual story is clear then you can proceed to more detailed and sustained versions.

Mathematical proofs are similarly essentialised but need to express just enough information to communicate the mathematical idea clearly. Constructed from the smallest possible series of crucial steps assembled in the uniquely "right" order, proofs start with an axiom (theme) then develop much like a theatrical or musical composition. One example is proof by *reductio ad absurdum* which works by constructing a proposition and then systematically reducing it to absurdity, thus proving that the counter to the proposition must be true. Pythagoras' proof of the irrationality of the square root of 2 begins by assuming that the square root of 2 is rational and ends by revealing that this rational number cannot exist, resulting in a dramatic denouement.

A mathematical equation should be surprising
GH Hardy: A Mathematician's Apology

Exercise: Layering stories

Choose three sources that have only oblique connections: perhaps a newspaper story, a photo and a poem. In groups find a way to integrate or layer all three sources and find one moment where the three sources come together or converge in some way.

This is a very open ended task which is often used in our devising process, demanding a high level of inventiveness and experimentation. The results are unpredictable and generally chaotic but from these improvisations we can start to see what is alive and resonant.

It seems that mathematical ideas are arranged somehow in strata,
the ideas in each stratum being linked by a complex of relations
both among themselves and with those above and below.
GH Hardy: A Mathematician's Apology

The process of devising involves experimenting and discarding numerous ideas, throwing ideas together and allowing the possibility of the unexpected. Simon McBurney frequently describes his process as chaotic but the exploration throws up often collective 'ah ha!' moments of revelation. Mathematics works in the same exploratory way.

A mathematician is a pattern searcher.
Maths is about finding patterns in the chaos of numbers that surround us
Marcus du Sautoy

Patterns in mathematics can be elusive and intangible, requiring a huge amount of creativity to unlock. Ramanujan's ability to make imaginative mathematical leaps without proving each step by rigorous methodology both baffled and inspired Hardy.

It came into my mind
Ramanujan

How does the mind imagine?

Where does creativity come from? Is imagination affected or determined by culture? Does someone with Hindu beliefs have greater access to the idea of possibility and belief in the infinite? Why and how did Ramanujan think differently about mathematics? Does the language of mathematics transcend cultural differences or is cultural difference still evident in the mathematics between Ramanujan and Hardy?

Exercise: Word association

Stand in a circle with as many people as you have in the group. The first person says a word and the next person says a word with some association to the first word. As the chain of words grows, so does a fairly logical narrative. Almost everyone can follow the train of thought. Then do the opposite and try to say words that have no connection to each other.

There is certain pleasure, and humour, associated with the disconnected list of words: the absurd links are appealing. However, even when we are trying to stop any association, our brains work hard to put images together in a logical way and often succeed. So we can observe first hand that we all constantly search for patterns. We are surrounded by patterns in the world around us and have an innate ability to recognise patterns.

Exercise: Coordination exercise

One person stands facing the rest of the group and performs a series of simple actions with a short pause between each movement. The group copies the movements (as in Simon Says…), then performs the same movements as the leader but one movement behind, then two movements behind. (see online video Patterns)

Though a simple copying exercise, this exercise shows us how hard it is to break patterns.

Social groups of animals including humans work naturally well as an ensemble. Try to think of moments in life when you feel an inner impulse to do something: this could be the moment you speak in a conversation, a first kiss or when to cross the road. Actors often have to re-activate these impulses individually when they work in the rehearsal room and on stage. An acting ensemble that has found shared impulses is able to breathe, react and move as one.

Exercise: Clapping together

Stand in a circle with your hands in front of you ready to clap, then without any one person leading attempt to clap at the same time. Extend this exercise by performing a whole sequence of claps one after the other. Let the series of claps continue for some time.

What happens to the rhythm? Does anybody in the group try to resist the organic changes in rhythm?

Exercise: Moving on impulse

For this exercise have a group of 7 -10 people participating and an equal number watching. The participants travel about the space and then all stop at the same moment. Then one person starts moving by themselves and stops. Then two people start and stop moving together, then three, then four and finally five. When the group has reached five count back down to one person moving alone. The moments of starting and stopping the movement must be spontaneous, crisp and absolutely together. If there is a mistake on any of the numbers (ie three people move when there should be four, or the start isn't really together) an observer says 'no' and the group must keep trying to achieve the number they are on.

This game is about acting on an impulse and not deciding who will go. It requires intense concentration but there are wonderful 'ah ha!' moments when a group seems to be umbilically linked.

Exercise: Counting game

One person counts from one upwards rhythmically and clearly so everybody can hear. Each other participant chooses individually which number series to move on (again: primes, squares, multiples, odd numbers etc). The movements are really simple: walking, sitting, rolling. The exercise reveals the rhythms, patterns and spaces between different number series. Narratives emerge as observers instinctively search for or try to predict patterns and are surprised when something happens that doesn't match their expectations.

SFX. + music

moving to counting – walking, moving objects, doing up shirt buttons,

when I was small I used to count everything...

It's getting bigger...

numbers + bigger numbers

people in room, building, holloway rd

London, England

→ gradually fading...

Europe ... 460 million

shut your eyes

" Try to conceive of the number 64,000,000,000

490m

Jan 2007.

→ 64 billion in world

difficult

try to conceive of 11.

try to conceive of 1 – you...

then person next to you.

" now in time ...... conceive of having 2 children.

11 x 2 + 11 = 33

11

Each of those children – another 2

55

"

77

77
88
165

"

99

wrong: if the maths is wrong then you lose the narrative immediately.

11 (1 + 2 + 4 + 8 + 16)

11 33 77 165

11 (1 + 2 + 2^2 + 2^3 + 2^4

Space and time

Mathematicians often describe themselves as explorers discovering a mathematical landscape.

A proof is a journey from somewhere familiar to somewhere unknown
Marcus du Sautoy

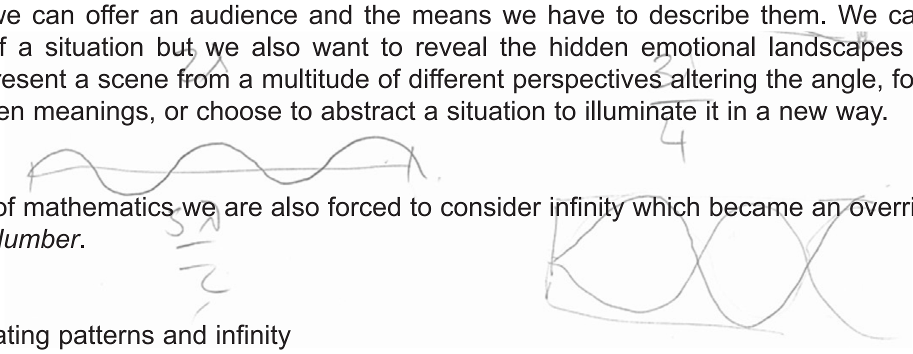
Exercise: The triangle game

This can be played with any number of people in a fairly large space. Each person secretly chooses two other people in the room then everybody moves to create an equilateral triangle with their two chosen people. The triangles have to be very precise.

The ensuing movement appears chaotic but the rhythms and patterns suggest some kind of order (perhaps a movement version of a fractal where a simple set of rules creates complex and seemingly random patterns). If we were to write the mathematical equation for the combinations of groups of three it would be:
(n) (n-1) (n-2) / 6 where n equals the number of participants.

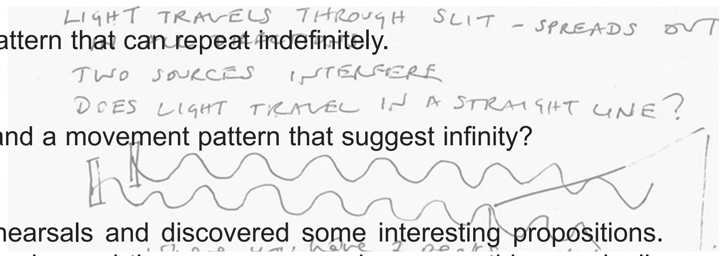
Sometimes the game concludes in a fixed point.
Will it always come to a full stop?
Does the size of the space make any difference to the movement choices, rhythms or patterns?
Is there a repeating pattern?

Mathematics enables us to describe the physical reality in which we exist and also to understand the possibility of further dimensions. Cartesian geometry allows us to notate these complex and hidden dimensions (see online video Permanence and Ideas). In theatre we must also consider the variety of perspectives we can offer an audience and the means we have to describe them. We can present the external reality of a situation but we also want to reveal the hidden emotional landscapes and subtexts. Sometimes we present a scene from a multitude of different perspectives altering the angle, focus and scale to illuminate hidden meanings, or choose to abstract a situation to illuminate it in a new way.



Within the study of mathematics we are also forced to consider infinity which became an overriding theme of *A Disappearing Number*.

Exercise: Repeating patterns and infinity



In groups of three, four or five create a movement pattern that can repeat indefinitely.
Do these movements suggest infinity?
Then try to express infinity using movement.
What is the difference between a repeating pattern and a movement pattern that suggest infinity?
What do we really believe will go on forever?

We repeated this exercise several times during rehearsals and discovered some interesting propositions. Often the unseen, the sense of something continuing beyond the room we were in or something gradually disappearing, created a strong sense of the vastness or minuteness of infinity.

In mathematics there is not one infinity but an infinity of infinities. An infinity can be bound at one end by any number or be unbound and include all numbers negative and positive from the infinitely small to the infinitely large. Not all infinities are the same size, for example the infinity of rational numbers is smaller than the infinity of irrational numbers.

We can go beyond mathematical infinities and explore the infinity of space and time, of possibility and imagination. Mathematics is timeless and permanent. What fascinated us in considering mathematics, was how we marry our own impermanence with mathematical permanence, how we situate ourselves along the continuous line of humanity and time and how we might find ways to express permanence and infinity in another form. By juxtaposing these different ideas on stage through storytelling and metaphor, we hoped to reveal something of the ubiquity, mystery and beauty of mathematics.