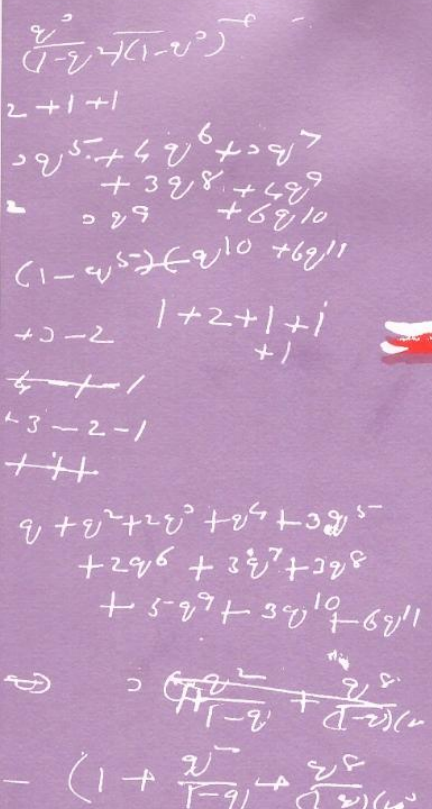

A Bharatha Natyam
dance opera by
Shobana Jeyasingh Dance Company

Correspondences:

The work and imagination of mathematician S. Ramanujan (1887-1920)

And so $f(q)$ is a Mock ϑ function.
When $q = -e^{-t}$ and $t \to 0$

$$f(q) + \sqrt{\tfrac{\pi}{t}}\, e^{\frac{\pi^2}{24t} - \frac{t}{24}} \to 4.$$

The coeff^t of q^n in $f(q)$ is

$$(-1)^{n-1} \frac{e^{\pi\sqrt{\frac{n}{6} - \frac{1}{144}}}}{2\sqrt{n - \frac{1}{24}}} + O\left(\frac{e^{\frac{\pi}{2}\sqrt{\frac{n}{6} - \frac{1}{144}}}}{\sqrt{n - \frac{1}{24}}}\right)$$

It is unconceivable that a single ϑ function could be found to cut out the singularities of $f(q)$

Mock ϑ-functions

$$\phi(q) = 1 + \frac{q}{1+q^2} + \frac{q^4}{(1+q^2)(1+q^4)} + \cdots$$

$$\psi(q) = \frac{q}{1-q} + \frac{q^4}{(1-q)(1-q^3)} + \frac{q^9}{(1-q)(1-q^3)(1-q^5)} + \cdots$$

~~These are~~

$$\chi(q) = 1 + \frac{q}{1-q+q^2} + \frac{q^4}{(1-q+q^2)(1-q^2+q^4)}$$

These are ~~substanti~~ related to $f(q)$ as shown below.

$$2\phi(-q) - f(q) = f(q) + 4\psi(-q)$$

$$= \frac{1 - 2q + 2q^4 - 2q^9 + \cdots}{(1+q)(1+q^2)(1+q^3)\cdots}$$

These are of ~~the~~ 3rd order

Mock ϑ-functions (of 5th order)

$$f(q) = 1 + \frac{q}{1+q} + \frac{q^4}{(1+q)(1+q^2)} + \frac{q^9}{(1+q)(1+q^2)(1+q^3)} + \cdots$$

$$\phi(q) = 1 + q(1+q) + q^4(1+q)(1+q^3) + q^9(1+q)(1+q^3)(1+q^5) + \cdots$$

$$\psi(q) = q + q^3(1+q) + q^6(1+q)(1+q^2) + q^{10}(1+q)(1+q^2)(1+q^3)$$

$$\chi(q) = 1 + \frac{q}{1-q^2} + \frac{q^2}{(1-q^3)(1-q^4)} + \frac{q^3}{(1-q^4)(1-q^5)(1-q^6)} + \cdots$$

$$= 1 + \left\{ \frac{q}{1-q} + \frac{q^3}{(1-q^2)(1-q^3)} + \frac{q^5}{(1-q^3)(1-q^4)(1-q^5)} + \cdots \right\}$$

Ramanujan's Mock Theta-functions

S. Ramanujan

S. RAMANUJAN

1877 – Dec	Born in Erode, Tamil Nadu to Komalattamal and her husband Kuppuswamy, a cloth merchant's clerk. In appearance he resembled his mother and grandmother.
1888 – 1909	Childhood and school years in temple town of Kumbakonam. Prizes for mathematical distinction at school include a book of Wordsworth's poems and 'The Heroes of Scotland'. Fails to get into University because of poor English and lack of interest in other subjects combined with ill health.
1909	His marraige is arranged in the conventional manner to Janaki.
1910 – 12	Lives in Madras. Shows his mathematical work to V.R. Ayyar and R. Rao, the founder and president of the Indian Mathematical Society repectively and asks for a clerical post in order to support his family.
1912 – 13	Works as a clerk in the accounts department of The Madras Port Trust.
1913	Awarded a research scholarship at the University of Madras through the offices of the President of the Madras Port Trust. First letter written to G.H. Hardy, professor at Trinity College, Cambridge. The letter was composed by Ramanujan's friends and signed by him.
1914	Receives an overseas scholarship from the University of Madras and sails for London.
1917	First signs of illness in England and the beginning of his stay in various sanatoria. Doctors suspect TB.
1918	Elected fellow of The Royal Society of Scientists and awarded Fellowship of Trinity College Cambridge.
1919	Due to continuing illness, sails for Bombay, India.
1920	Last letter to G.H. Hardy.
1920 April 26	Dies in Madras.

$$\frac{a^x}{\Gamma(1+x)}\,dx$$

Ramanujan

by George Joseph

Srinivasa Ramanujan was born in 1887 in Erode, a small town near Madras in southern India. The eldest of three sons, he came from a family of Ayyengar Brahmins, a group noted for their traditional learning and strict religious observances. His mother, the dominant figure in the family and who was to have a decisive influence on Ramanujan throughout his life, was well-known locally for her interest in astrology and numerology. Traditional astrologers in South India are known for their agility in mental arithmetic. It is possible that Ramanujan's extraordinary intuition for, and ability to manipulate numbers, owed a lot to his mother. After a distinguished school career, he failed at college as a result of his neglecting to study any other subject apart from mathematics. Between ages twenty and twenty five, he was unemployed and impoverished, devoting all his time to mathematics and scribbling the results that he established in a series of tatty notebooks. Once his mathematical gifts were recognised, it was only a matter of time before he was invited to Cambridge University as occurred in 1914. In the next five years, he produced about twenty research papers of the highest quality, in many cases in collaboration with one of the most prominent mathematicians of his time, G. H. Hardy. He was awarded the B.A. degree by research in 1916, elected a Fellow of the Royal Society in February 1918 and a Fellow Trinity College in October 1918. This is what a historian of mathematics (J. R. Newman) has to say of Ramanujan's achievement. [With hardly any training in pure mathematics, Ramanujan] *"arrived in England abreast, and often ahead of contemporary mathematical knowledge. Thus, in a lone mightly sweep, he succeeded in recreating his field, through his own unaided powers, a rich half century of European mathematics. One may doubt whether so prodigious a feat had ever before been accomplished in the history of thought."*

In 1919, Ramanujan returned to India after having contracted tuberculosis. He died a year later at the age of 32, working at a furious pace up to the last. The results of that year's labour, contained in what is often referred to as the *"Lost Notebook"*, are being mined with increasing success and excitement by mathematicians even today. A result from that source has contributed to one of the most revolutionary concepts of recent theoretical physics – superstring theory in cosmology. And a formula from the Notebook was used to program a computer a few years ago to evaluate = (perhaps the most widely known mathematical symbol indicating the ratio of the circumference of a circle to its diameter) to a level of accuracy (to millions of digits) never attained previously. Most of his work is in a highly abstract area of mathematics, known as the theory of numbers.

How did Ramanujan produce such remarkable mathematics with his limited formal education? I think that part of the explanation may lie in his culture and upbringing. A source of embarrassment to many of his admirers both in India and in the West was his tendency to credit his discoveries to the intervention of the family goddess, Namagiri. Mathematics and numbers have always had a special significance within the Brahmanical tradition as extra-rational instruments for controlling fate and nature. And an enduring aspect of Indian mathematics over a long time: a fascination with numbers and a positive delight in calculations.

In Ramayana, the great Hindu epic about two thousand five hundred years old, there is a description of two armies arraigned against one another. The one led by Ravanna, the chief villain of the story, contained:
$10^{12} + 10^{4} + 36(10^{4})$ men.

Facing them was the rival army of Rama, the hero of the epic, who commanded:
$10^{10} + 10^{14} + 10^{20} + 10^{30} + 10^{34} + 10^{40} + 10^{44} + 10^{52} + 10^{57} + 10^{62} + 5$ men!

An uneven and fantastic contest you would say! But what is interesting is that as early as that time, there were names for powers of ten up to 62. And this practice of reckoning with 10's and the growing facility with large numbers eventually led to one of India's greatest gifts to the world: our number system (easily recognisable as having evolved from Indian digits from about two thousand years ago).

Fascination with numbers can take another form – an instant recall of the peculiarities of different numbers almost in the same way as you would remember the idiosyncrasies of your friends and relations. According to Littlewood, one of his colleagues in Cambridge, every positive integer was one of Ramanujan's personal friends. Hardy recalls going to visit Ramanujan lying in his sickbed in London. Wishing to divert the patient, Hardy remarked that he has just driven up in a taxi whose number was 1729 and that the number seemed to be a dull one. *"Oh no,"* replied Ramanujan in a flash. *"It is a very interesting number. It is the smallest number expressible as a sum of two cubes in two different ways."* To relieve any anxieties, the Ramanujan solution is: $9^3 + 10^3 = 1729 = 1^3 + 12^3$

(For more information on the background and personalities of Indian mathematics, see G.G. Joseph, The Crest of the Peacock: Non-European Roots of Mathematics, I.B. Taurus Ltd, London, forthcoming March 1991.)
Dr George Gheverghese Joseph is Senior Lecturer in the Department of Econometrics and Social Statistics, The University of Manchester.

The company

Ramanujan: Master Mathematician

by Ian Stewart

Srinivasa Ramanujan occupies a very special place in mathematics. Until he came to Cambridge he was almost entirely self-taught, and his ideas about mathematics were derived from a small and rather ramshackle collection of library books. This lent much of his mathematics an oddly old-fashioned flavour. However, such was his innate talent that in its most important feature, the underlying mathematical insight, Ramanujan's work is increasingly recognised as having been well ahead of its time. In short, while the style of his work may seem old-fashioned, its content is so original that only now are mathematicians beginning fully to understand the deep ideas at which it hints.

Mathematicians live in a strange world, a world of the mind. They deal in abstractions, intangibles, a universe of ideas. However, it does not seem this way to mathematicians: to them their world appears real, filled with objects of great beauty that can be touched, picked up, and looked at from different angles. It is as if there is some different kind of mathematical reality which mathematicians can enter by the excercise of will. Although mathematics is invented, its practitioners talk as if it is discovered, because invention is arbitrary, but discovery is constrained by what already exists.

The mathematician's day-to-day viewpoint resembles Plato's philosophy of the existence of ideal forms. However, mathematicians do not really believe that their concepts have an independent existence. The illusion that they do arises from the richly structured shared logical context in which all mathematicians work. Each new idea must fit into the existing pattern: what is possible is dictated by what already exists. Mathematics builds new discoveries upon old ones, and more than once an 'obvious' fact has turned out to be false. Just one false brick can seriously damage the entire mathematical edifice, so mathematicians are obsessive about having watertight proofs.

Ramanujan not only lived in this mental world: he was completely at home there, roaming with little apparent effort through its mazes and jungles. The absence of effort may also be illusory: only the mathematician knows the intense mental struggles that lead to new insights and discoveries.

What kind of mathematican was Ramanujan?

He was a natural. Inspiration came to him unsought; sometimes – he said – in dreams. Often he 'knew' a mathematical result to be true without having any idea why this was so. In consequence his concept of proof was less stringent than that of his colleagues: if his intuition told him a result was true, that was enough for Ramanujan. Research mathematicians often start out with wild leaps to undemonstrated conclusions, but they then spend a great deal of time trying to bridge the logical chasms. Such thinking did not come naturally to Ramanujan, for whom there were no chasms. Above all he loved numbers, and many of his deepest results are about whole numbers, 1,2,3, . . . From such simple ingredients one might expect a simple kind of mathematics; but quite the opposite is true. Carl Friedrich Gauss, possible the greatest mathematician of all time, called number theory *'The Queen of Mathematics'* because of its central importance and its remarkable difficulty.

Another interest was approximation: the art of finding simple quantities that determine the general order of magnitude of more complicated expressions. One of Ramanujan's most celebrated results, obtained in collaboration with Godfrey Harold Hardy, combines these two strands. Hardy and Ramanujan were seeking an approximate formula for the number of partitions of an integer – the number of different ways of breaking it up as a sum of smaller integers. For instance, 4 can be broken up as 1+1+1+1, 1+1+2, 1+3, and 2+2, so there are four different partitions of 4. The number of partitions grows rapidly with the size of the integer concerned – thus there are precisely 180,569,292 different partitions of the integer 100. Partitions are important because many mathematical processes depend upon breaking things up into smaller pieces.

Unprecedentedly, and paradoxically, the "approximation" that Hardy and Ramanujan discovered was so accurate that it could be used to calculate the number of partitions exactly! John Edensor Littlewood, another of Hardy's collaborators, has described the strange quality of this discovery: *"There is indeed a touch of real mystery. If only we knew there was an exact formula, we might be forced, by slow stages, to the correct expression. But why was Ramanujan so certain there was one?"*

Mathematicians either think geometrically or formally – in terms of pictures or in terms of formulas. Ramanujan's work is formal: he liked nothing better than discovering that two intriguing formulas of very different appearance were in fact identical. It is this emphasis on formulas that lends his work the superficial appearance of being outdated, for at the start of the twentieth century the trend had shifted away from special formulas, however beautiful or surprising, towards massive general theories.

But so curious are many of Ramanujan's formulas, and so strange the ideas needed to prove their validity, that more than once an elaborate general theory has grown for the seed that Ramanujan sowed. His discovery that the number of partitions of an integer of the form 5k+4 is always a multiple of 5, for example, has led to an entire range of new techniques in combinatorics; and his conjectures of 1916 about the tau function remained unproved until 1975, succumbing only to new and very powerful methods.

Hardy remarked that *"there is always more in one of Ramanujan's formulas than meets the eye."* Seventy years after Ramanujan's tragic and premature death, mathematicians are still discovering just how much more.

Dr Ian Stewart is a Reader in Mathematics at The Mathematics Institute, The University of Warwick.
These two articles were specially commissioned for *Correspondences*.

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Correspondences:

The work and imagination of mathematician S. Ramanujan (1887–1920)

A Bharatha Natyam dance opera by Shobana Jeyasingh Dance Company

Programme

PART 1

Namagiri

"A mathematician, like a painter or a poet, is a maker of patterns. The mathematician's patterns . . . must be beautiful. Beauty is the first test: there is no permanent place in the world for ugly mathematics." G.H. Hardy.

"He himself believed that Goddess Namagiri inspired him in his dreams with formulae which, rising from his bed, he would jot down and verify." S. Srinivasa Acharya, college friend of Ramanujan in Madras.

Kumbakonam

"All that I can tell you is that day and night he worked on sums. He didn't do anything else. He wouldn't stop work even to eat. We had to make rice balls for him and place them in the palm of his hand." Janaki, Ramanujan's wife.

"He often used to say that in mathematics alone one could have a concrete realisation of God." K.S. Viswanatha Sastri, a childhood acquaintance of Ramanujan.

A Decision to Leave Home

"I remember the trip to Nammakal with my grandmother, father and Ramanujan. Ramanujan and my father went to Nammakal and stayed in the temple of Goddess Namagiri at night for three days. On the last night Ramanujan got a command from the deity to go to foreign countries. Only after this he accepted to go to England." N. Subbramaniam, childhood friend of Ramanujan.

"He arrived there (the common room of the Assistant Professors in the Presidency College, Madras) with a huge suitcase in which he had packed quite a few articles of western dress. He laid them all one by one on the table and sought the help of those among us who were accustomed to wear western dress. He went on expressing his diffidence as to how he would be able to conform rigorously to the austerities and observances of orthodox hindhu life in regard to food and other forms." R. Gopala Aiyar, professional associate of Ramanujan.

"I took him to a house of a friend living in European style to initiate him in the mysteries of the fork and knife. He was not happy. He was not very jubilant over his future journey and over his assured distinction to come. He seemed to have moved as if he was obeying a call." R. Ramachandra Rao, one of Ramanujan's earliest patrons.

The Journey to England

"His passage to England was booked by steamer "Nevasa" which then came to Madras. Ramanujan looked trim in his newly cropped hair and his close fitting trousers. The captain of the ship came down to cheer up Ramanujan and told him that he would take every care of him on the voyage provided he did not pester him with mathematics." K.S. Viswanatha Sastri.

INTERVAL

PART 2

Cambridge

"He felt the petty miseries of life in a strange civilisation but he was a happy man, revelling in the mathematical society which he was entering and idolised by the Indian students. Loss of caste was a price he was prepared to pay for coming to England, but he kept the price as low as he could by adhering as closely as circumstances permitted to the observance of his religious practices and in particular in maintaining the strictest vegetarianism." E.H. Neville, Professional colleague of Ramanujan.

"The picture I want to present to you is that of a man who had his peculiarities like other distinguished men, but a man in whose society we could take pleasure in, with whom one could take tea. . ." G.H. Hardy.

Decline

"The long illness and spells of comparative solitude have undeniably had an effect and he has been subject to fits of depression and been difficult to manage." G.H. Hardy.

The Return to India

"When he arrived in Central Station, I met him at the platform but alas I found him not the cheerful, chummy and affectionate Ramanujan that he was but a thoroughly depressed sullen and cold Ramanujan even after seeing me, a close and affectionate friend of his." K.N. Iyengar, a friend of Ramanujan from his Madras days.

"Fate had ordained that I should see him almost on his death bed in Kumbakonam. He was down with TB and in very poor shape. His brother told me he was not in a position to see anyone. But when he did allow me in I stood near a ramshackle bed in which (Ramanujan) lay as a bundle of bones. Ramanujan had powerful and penetrating eyes. For a moment his eyes flashed a look of recognition and he mumbled almost inaudibly "Radhakrishnan?" R. Radhakrishnan Ayyar.

The Mock Theta-functions

"Had Ramanujan not left India he might be alive today: but he would have had always the sense of power and frustration, not of power and accomplishment. Death too was a frustration but the life's purpose of which his mother dreamed was at last in part fulfilled and it is better to be frustrated by unsought death than by life." E.H. Neville.

The programme runs for approximately 100 minutes including a 20 minute interval.

Devised and choreographed by **Shobana Jeyasingh**
Directed by **Steve Shill**
Original music by **Kevin Volans**

Design: **David Blight**
Lighting design: **Steve Shill**
Spoken text prepared from original source material by: **Steve Shill**
Voice on tape: **Bhasker**

Contributing librettist: **Roger Clarke**
Costumes made by: **Henrietta Webb**
Technical manager: **Steve Mann**

Dancers: **Subathra Shanteepan, Girija Murali, Shobana Jeyasingh, Monisha Patil.**

Musicians: **The Smith Quartet**
Singer: **Llewellyn Rayappen**

Notes on the Production

M. Anantharaman, one of Srinivasa Ramanujan's childhood friends stated that Ramanujan loved the traditional street theatre so much that he once walked five miles across a cremation ground at night to see a performance. The journey to this production of *Correspondences* has certainly been an exciting and challenging one. From an idea that I had in 1988, it has taken me (and all whom I chanced to meet!) through one year of research both in Britain and India.

The appeal of Ramanujan was manyfold. Firstly there was the obvious one that both he and Bharatha Natyam came from the same region in India (Tanjore district in Tamil Nadu) and therefore shared the same cultural roots. It was a culture that traditionally prized numeracy a great deal and its interest in calculation and fine manipulation of number can be seen in both Ramanujan's own chosen area of mathematics as well as in the dance. For Bharatha Natyam is influenced strongly both in movement dynamic and in choreographic practice by the arithmetical nature of the tala system of Indian music with its detailed partitioning of numbers.

In realising this dance work as something that would speak to a British audience I have drawn on many resources. The most invaluable one being the classical dance of Bharatha Natyam itself. A training in Bharatha Natyam is not only a training in a specific physical alignment and aesthetic but also necessarily in the cultivation of a specific sensibility. This and the inherently abstract quality of the dance has stood me in very good stead.

Apart from dance (Nritta), Bharatha Natyam also encompasses the different but related technique of mime or *"Nritya"* which in turn allows for Natya dharmi (stylised movement) and Lokadharmi (behavioural, everyday movement). Traditionally, the imagery of classical poetry which forms the sung accompaniment transmutes the mime from being purely literal and illustrative. In the case of *Correspondences* the absence of similar accompaniment meant that other strategies had to be explored in Nritya.

Correspondences is in no way meant to be a definitive and comprehensive portrait of Ramanujan. Like most human beings he seemed different things to different people (speculative and religious to some, a rationalist to others; quiet and shy to some, an irrepressible raconteur to others). Unlike most human beings he was a genius. Therefore *Correspondences* can only be one way of looking at this remarkable man and what his life tells us about the intuitive and imaginative nature of pure mathematics.

Correspondences, needless to say, would not have been possible without the invaluable support and individual visions of Kevin Volans and Steve Shill. Together we have tried to meet the challenge of both the formalism and the strong intuitition that characterised Ramanujan's method.

The result is bound to be unusual. By all accounts Ramanujan *"used to evince a great curiosity in all odd things"* (M. Anantharaman). One of his closest friends Professor E.H. Neville also records: *"He loved a paradox . . . the paradoxical element in some of his own earlier work must have made him aware that the wildest nonsense of today may receive a logical interpretation tomorrow"*.

If any of the wilder seeds we have sown in *Correspondences* proves to be of some use to the future of Indian Dance Theatre in Britain, an important purpose of this work will have been achieved.

Shobana Jeyasingh: Artistic Director

$$\frac{a^x}{\Gamma(1+x)}\,dx$$

Steve Shill, Shobana Jeyasingh, Kevin Volans

Correspondences is an unusual project for a theatre director to be involved in as the major component is dance. However, we were agreed that it would be useful to add a directorial dimension to a show which sought to be articulate about Srinivasa Ramanujan.

I realised early on that I should set aside my normal way of working. Typically, as director, I bear the full burden of responsibility during rehearsals. In the case of *Correspondences* Kevin, Shobana and I have taken turns to carry that load.

Kevin and Shobana worked in tandem, creating the music and the dance. I brought up the rear, having watched the material emerge, making suggestions and the three of us discussing structure and my vision of the finished piece.

I felt my job was not to get in the way of the music or the choreography. As director, I wanted my collaborators to maximise their potential and then for me to give their work a context. This is done through placing the singer on stage, the addition of voiceovers and titles, design and lighting. It is an attempt to make our metaphor for higher mathematics and the life and work of one of its most extraordinary practitioners, absolutely clear.

Steve Shill: Director

Whereas the composition of a work for voice, instruments and dance normally begins with the libretto and ends with the choreography, the stages in which *Correspondences* was put together were by and large reversed.

In the set dance pieces Shobana supplied the rhythms of the foot patterns first. These I "set" with varying degrees of freedom – rather as one sets a text. The vocal line was composed as an integral part of the instrumental texture. The libretto (consisting of "found objects" such as Ramanujan's formulae, extracts from Bhaskara's *Lilavathi* – a 13th Century mathematical treatise, a sanskrit prayer) was often added last. However the final result does not necessarily reflect this process. Llewellyn Rayappen's vocal presence, the counterpoint between dance, music and text, means that foreground and background merge and overlap.

Kevin Volans: Composer

$(x^2 + x - 2)$

Kevin Volans: Composer

Born in Pietermaritzberg in South Africa, Kevin Volans followed a degree in the University of the Witwatersrand, Johannesburg, with post-graduate study at Aberdeen University. From 1973 to 1981 he was a pupil (and later teaching assistant) with Karlheinz Stockhausen. From 1986 to 1989 he was Composer-In-Residence at Queen's University, Belfast.

Volans has appeared throughout Europe and on radio and TV. Many hundreds of concerts and broadcasts of his work have been given worldwide. Recent performances include the Berliner Festwoche, the Salzburg Festival, Lincoln Center, Next Wave Festival (New York), New Music America (Miami), Interlink Festival (Tokyo), World Music days (Bonn), Belfast Festival, Adelaide Festival, Montreal Jazz Festival, The QEH, National Theatre, ICA, Wigmore Hall, Riverside Studios etc.

He has recently been commissioned to write a chamber opera for The English National Opera based on ideas by Bruce Chatwin. He is also writing an orchstral piece for the Ulster Orchestra, to be premiered in 1991's Japan/UK Festival. A CD of his work has been released on the Novello/Barcelona label in October 1990 featuring his composition for Rambert Dance Company, *"White Man Sleeps"*, played by the Kronos Quartet.

Steve Shill: Director

Steve Shill works at the forefront of new British theatre as writer, director and performer. He was a member of the seminal Impact Theatre Group from 1980 to 1986 whose innovative work included *"Carrier Frequency"*.

His most recent shows are the acclaimed *"A Fine Film of Ashes"*, *"The Empire"* and *"Ode to St Cecilia"* which won an award in the 1989 Sunday Times National Student Drama Festival. Direction credits include *"The Menaced Assassin"* for The Royal Opera House's May 1989 season of the new opera and *"Radio Sing Sing"* for Man Act. He has recently written a novel adaptation for the BBC's Screenplay. As an actor he appeared in Martin Scorsese's *"Last Temptation of Christ"* and in *"The Missing Reel"* on Channel 4. In Summer 1990 he directed *"Promises"* in Sarajevo, Yugoslavia.

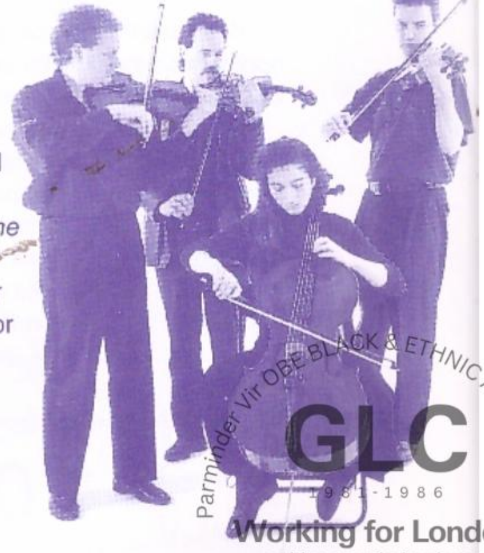
Shobana Jeyasingh: Choreographer, Dancer

Shobana Jeyasingh, based now in London, was born in Madras and trained in the Valluvoor style of Bharatha Natyam by the distinguished teacher and choreographer Valluvoor Samaraj pillai. She has performed the classical repertoire extensively as a soloist and has directed Shobana Jeyasingh Dance Company since 1988.

Recent choreography includes *"Configurations"* (with music by Michael Nyman), *"Defilé"* (incorporating the choreography of Lea Anderson and based on work done in France for The French Bicentennial), *"Late"* (with music by Orlando Gough) and *"Janpath"* for the National Youth Dance Company. Her work for TV includes *"Map of Dreams"* (After Image Productions) and *"Dancing by Numbers"* (Bandung File), both for Channel 4 TV, and The Late Show and Network East for the BBC.

She was awarded a London Dance and Performance award in 1988 and receives her second Digital Dance Award this year.

Her work for theatre includes choreography for *"The Broken Thigh"*, *"The Clay Cart"* and *"The Abduction"* for Tara Arts, *"The Lost Ring"* and *"Twelfth Night"* for Theatre Royal Stratford East and *"Blood Wedding"* for the Asian Theatre Cooperative.



Girija Murali: Dancer

A Gold Medallist in Bharatha Natyam and Mohini Attam from the prestigious Kerala Kalamandalam institute in South India, Girija Murali is a highly acclaimed dancer both in India and abroad and is also a well-established teacher. She is currently teaching for Mrittika Arts in the UK. She worked with Shobana Jeyasingh in France for the 1989 Bastille Day celebration in Paris.

Monisha Patil: Dancer

Monisha Patil trained for 20 years in the Tanjore style of Bharatha Natyam with Guru Kalyanasundaram of Rajarajeshwani Bharata Natya Kala Mandir, Bombay and now lives in London. She has performed extensively all over the world, both classically and with projects combining Indian and European music and dance. TV appearances include Channel 4's *"Here and Now on 4"* and as a part of Shobana Jeyasingh Dance Company, BBC2's *"The Late Show"*.

Subathra Shanteepan: Dancer

Subathra Shanteepan started her initial dance training in Sri Lanka before obtaining an advanced diploma from Bharatha Kalanjali, the academy run by V. P. and Shanta Dhananjayan in India. In Britain she has taught extensively and has taken part in the two major dance productions of the Academy of Indian Dance. She performed in the Company's *"Orientations"* production last year and her TV appearances with the Company include BBC's Network East and BBC2's The Late Show.

The Smith Quartet: Musicians

Set up in 1988, The Smith Quartet stretches the boundaries of the classical string quartet, working with composers and the most popular types of music not normally associated with the medium. Trained at the Royal Northern College of Music and The Guildhall, individual members of the quartet have played with the UK's leading chamber orchestras. Last year they played Kevin Volans' *"White Man Sleeps"* for Siobhan Davies Dance Company with whom they collaborate again this autumn. Performances this season include their London debut at The Almeida Theatre in December and Kevin Volans' *"The Man with the Soles of Wind"* for Dance-lines Productions and the English National Opera.
Violins: Steve Smith, Clive Hughes, Viola: Nic Pendlebury, 'Cello: Sophie Harris.
Contact: 071 286 3944/071 249 2523

Llewellyn Rayappen: Singer

Llewellyn Rayappen was born in South Africa of Anglo-Asian parents and came to the UK aged ten. He gained a scholarship to the Royal College of Music, studying piano, voice and choral singing. He is currently Chorus Master for the Royal Ballet School and has recently attended the Else Meyer-Lisemann Opera Workshop. He has performed in London and in Europe and future plans include solo recitals and a musical.


Llewellyn Rayappen

David Blight: Designer

David Blight has designed extensively for theatre and opera. His theatre credits include *"Present Laughter"*, *"The Doll's House"*, *"Arturo Ui"*, *"Death of a Salesman"*, *"A Christmas Carol"*, (Sheffield Crucible), costumes for *"Lennon"* (transferred to London Astoria), and costumes for Steven Berkoff's *"Salome"* (transferred from the Royal National Theatre). Opera work includes *"The Coronation of Poppea"* (Christchurch, Spitalfields), and many designs for the Endymion Ensemble at the Donmar. He won the BMW prize for the best design for his work on *"63 Dream Palace"* for this year's Munich Festival. He has just designed *"Greek"* for The English National Opera and BBC TV.

$+\frac{1}{2\pi}$

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THE PLACE THEATRE

COPUS

Dance Umbrella '90

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$$F(q) = 1 + \frac{q^2}{1-q} + \frac{q^8}{(1-q)(1-q^3)} + $$

$$\phi(-q) + \chi(q) = 2F(q)$$

$$f(q) + 2F(q^2) - 2 = \phi(-q^2) + \psi(q)$$

$$= 2\phi(-q^2) - f(q) = \frac{1-2q+2q^4-2q^9+}{(1-q)(1-q^4)(1-q^6)(1-q^9)}$$

$$\psi(q) - F(q^{24}) + 1 = q \cdot \frac{1+q^2+q^6+q^{12}+q}{(1-q^8)(1-q^{12})(1-q^{28})}$$

Mock ϑ-functions (of 5th order)

$$f(q) = 1 + \frac{q^2}{1+q} + \frac{q^6}{(1+q)(1+q^2)} + \frac{q^{12}}{(1+q)(1+q^2)(1+q^3)} +$$

$$\phi(q) = q + q^4(1+q) + q^9(1+q)(1+q^2) +$$

$$\psi(q) = 1 + q(1+q) + q^3(1+q)(1+q^2) + q^6(1+q)(1+q^2)(1+q^3)$$

$$\chi(q) = \frac{1}{1-q} + \frac{q}{(1-q^2)(1-q^3)} + \frac{q^2}{(1-q^3)(1-q^4)(1-q^5)} + \frac{q^3}{(1-q^4)(1-q^5)(1-q^6)(1-q^7)}$$

$$F(q) = \frac{1}{1-q} + \frac{q^4}{(1-q)(1-q^3)} + \frac{q^{12}}{(1-q)(1-q^3)(1-q^5)}$$

have got similar relations as above.

Mock ϑ-functions (of 7th order)

(i) $1 + \frac{q}{1-q^2} + \frac{q^4}{(1-q^3)(1-q^4)} + \frac{q^9}{(1-q^4)(1-q^5)(1-q^6)}$

(ii) $\frac{q}{1-q} + \frac{q^4}{(1-q^2)(1-q^3)} + \frac{q^9}{(1-q^3)(1-q^4)(1-q^5)} +$

(iii) $\frac{1}{1-q} + \frac{q^2}{(1-q^2)(1-q^3)} + \frac{q^6}{(1-q^3)(1-q^4)(1-q^5)} +$

These are not related to each other.

Ever yours sincerely
S. Ramanujan