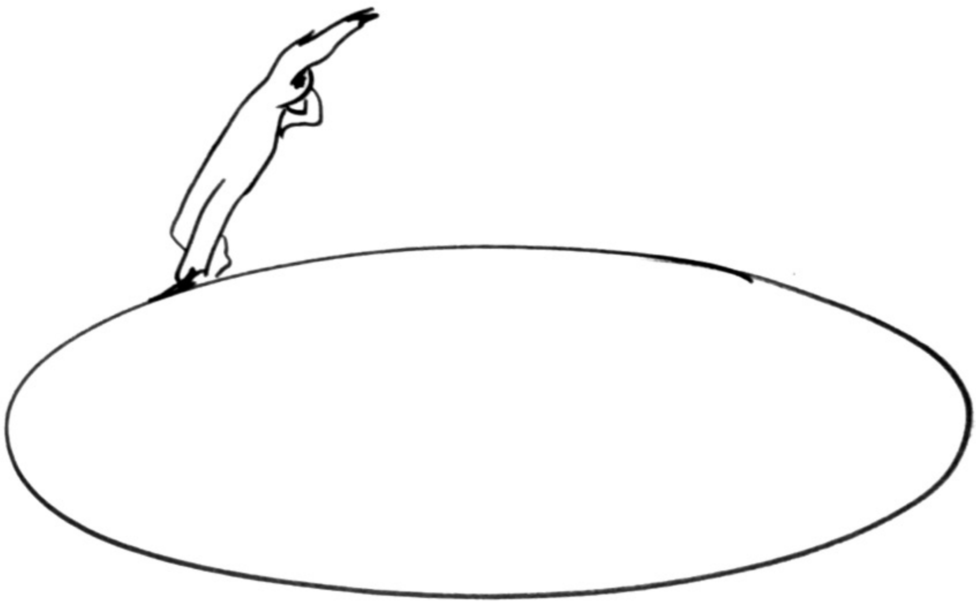

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"I found that if I stepped very quickly round and round a small circle I could lean very steeply in towards its apex. Almost strangely so. And it seemed that I could isolate nearly all the effort to my legs, and that I could abandon most of my weight to a waving flame-like energy that seemed to be rising up the center of the vortex .... I was developing an interest in drawing circles, and was training my hand to the proportions of the seven circles which form the basis of the Star of David and of the Arabic numerals. In my dancing I was banking from orbit to orbit."

Simone Forti's *Illuminations Drawings* were made during the choreographer's experiments in tracing numerals with the body. By undertaking structured movements like these, she proposed the possibility that one could "unconsciously sense a familiar kind of order, [since] form seemed to be the storage place for presence."

Cover Image: *Illumination Drawing* (1972) by Simone Forti, courtesy of the artist and The Box Gallery, Los Angeles

Photograph of *Huddle*, Loeb Student Center, New York University, 1969, by Peter Moore

Simone Forti attended technique classes with the most celebrated modern choreographers when she arrived in New York in 1959, but she was, by her own account, a lousy student. She wrote in her diary that she "couldn't even perceive" what Martha Graham's body was doing, let alone reproduce her movements. Merce Cunningham's "adult, isolated articulation" was just as foreign. She had better luck the following year in a composition class offered at the Cunningham studio by musician Robert Dunn. He introduced her to compositional techniques of John Cage, who was the music director of Cunningham's company. In a technique called *Imperfections Overlay*, Cage would trace any inconsistencies he found on the surface of a blank sheet of paper onto a transparency and then drop the transparency onto a grid. Once the "imperfections" were rationalized, they could be rendered, albeit imperfectly, as events in time and pitch. The scattered score could also become choreography.

In retrospect, I find that *Imperfections Overlay*, with its graph, was my first exposure to a still point of reference that gives a footing for a precise relationship to indeterminate systems. I had the feeling that the resultant piece would be a kind of ghost or trace of all the elements involved, including the original sheets of paper, and the air currents through which the plastic sheets had glided. It seemed to be a kind of notation whose interpretation by the performer would reawaken a partial presence of the original events.

This passage appears in Forti's book *Handbook in Motion: An Account of an Ongoing Personal Discourse and Its Manifestations in Dance*. The book was my first exposure to a still point of reference for thinking about dance. Like Forti, I didn't take a modern technique class until I was in my mid-20s, and I also found it perplexing. Less like Forti, I was at that time in dance class as a diversion from my graduate studies in mathematics. In Forti I find an understanding of movement that is at once enlightening, poetic, and often humorous. For example, she writes, "I saw a man in pajamas walk up to a tree, stop, regard it, and change his posture."

In addition to an observational acuity, Forti reveals habits of mind that in an admittedly self-serving way I have long held to exhibit a mathematical attitude. Some of these analytic tendencies are evident in the

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passage quoted above—at least in her choice of the words "precise," "indeterminate systems," and "elements." Mathematical clues appear elsewhere in the *Handbook* in the form of drawings of numerals and circles. And then there is her enigmatic "proposal: 1 = pi." She has described her early work as "more closed systems than not, arrived at by abstracting and reordering elements of one situation to create another which is of a new order." One of these early works is *Huddle*, perhaps her most widely performed piece.

***Huddle* requires six or seven people standing very close together, facing each other ... One person detaches and begins to climb up the outside of the huddle ... He pulls himself up, calmly moves across the top of the huddle, and down the other side. He remains closely identified with the mass, resuming a place in the huddle ... Immediately, someone else is climbing ... The duration should be adequate for the viewers to observe it, walk around it, get a feel of it in its behavior. Ten minutes is good.**

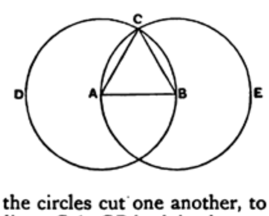
She called this and the other works from the same period dance constructions because she "saw them as being somewhere between sculpture and dance." These constructions, attained through abstracting and reordering elements within a closed system, bring to mind the *Elements* of Euclid and his geometric constructions. As can be seen in the excerpt below, a mathematical construction proceeds by a sequence of precise steps, each justified by axioms or rules of inference, until the desired figure, in this case a triangle, is formed.

PROPOSITION 1.

On a given finite straight line to construct an equilateral triangle.

Let *AB* be the given finite straight line.

Thus it is required to construct an equilateral triangle on the straight line *AB*.



With centre *A* and distance *AB* let the circle *BCD* be described; [Post. 3]

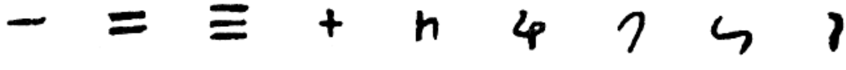
again, with centre *B* and distance *BA* let the circle *ACE* be described; [Post. 3]

and from the point *C*, in which the circles cut one another, to the points *A*, *B* let the straight lines *CA*, *CB* be joined.

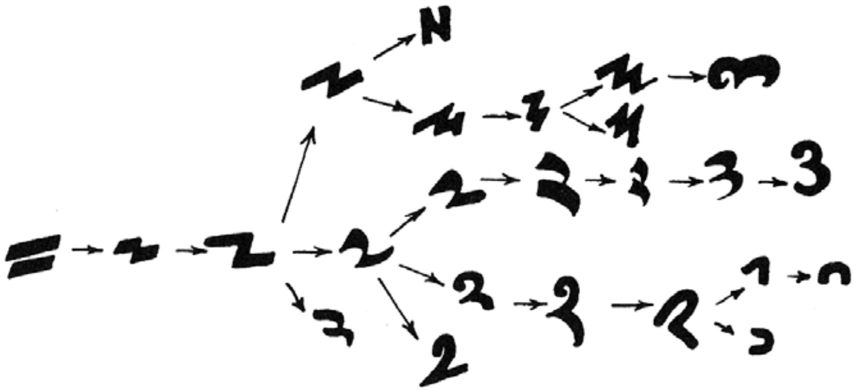
A few years ago, I asked Forti about her interest in mathematics and the enigmatic pi proposal. She paused and, with a gentle smile, replied, "Well, you know we smoked a lot of dope back then." I laughed loudly and felt slight embarrassment for asking something so square. Then, after a moment, she began, "There is something I've wondered about. Do you know how the Arabic numerals got their shape?"

In some sense this is not a mathematical question; a numeral (for example, "3") is merely the sign that signifies the abstract notion of the number (in this case, 3) that it represents. Among mathematicians, there is a sense of pride, of which I am not immune, in the abstraction and purity of the discipline. "Mathematics is a game played according to certain simple rules with meaningless marks on paper," is how mathematician David Hilbert is supposed to have expressed this aloof attitude, whether or not he actually believed it. I had no idea what the answer to Forti's question was when she asked it. Having looked into it, my view of mathematical mark-making has since been complicated.

All evidence shows that the "Arabic" numerals actually originated in India. The earliest known ancestors of our modern numerals date back to the third century BCE empire of Ashoka. These numerals appear in edicts that Ashoka had inscribed on stone pillars in the brâhmî script that denoted the sounds of Sanskrit. Written from left to right, brâhmî is the common source of the large variety of written forms that developed over the intervening millennia in India and neighboring regions. (The name brâhmî also belongs to a Hindu goddess, one of a group known as the Matrikas, and she is depicted on the back of a swan or goose.) Only the numerals for 1, 2, 4, and 6 survive in recorded form. Among the oldest complete set of numerals (excluding zero), dating back to the first or second century CE, is the system of Nasik:

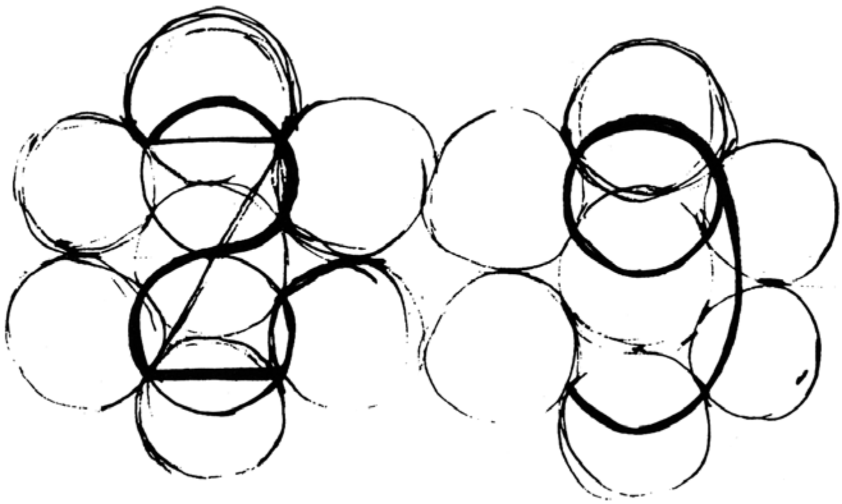


According to *The Universal History of Numbers* by Georges Ifrah, the Nasik numerals then evolved in time and geography through many variations before arriving in their present form, as he painstakingly documents. For example, the diagram below is an evolutionary tree for the numeral "2" (interestingly, one branch, the Tibetan-Nepali branch, ends up looking like our present day "3"):



The mathematical importance of the Hindu numerals owes to the concomitant invention of zero and the place-value system, whereby we speak of the "ones digit," "tens digit," "hundreds digit," etc. These two discoveries permit a remarkable economy of expression that far surpasses additive alphabetic systems such as the one used by the Greeks, Romans, and the Super Bowl. Perhaps it is a testament to the power and naturality of the Hindu numerals that fanciful origin stories proliferate. One particularly neat theory that Ifrah credits to the 10th-century Arab astrologer Haly Abenragel finds all the figures born of a circle and two of its diameters, "as if they were inside a shell."

The system for drawing numerals that Forti found appears to be an elaboration on Abenragel's, although she does not say how she came upon it, except that its template also forms the basis of the Star of David. Her template is a geometric arrangement consisting of nine circles equal in diameter: a pair of vertically aligned tangent circles (a "figure-eight") on top of a central circle, which in turn is surrounded by six mutually tangent circles (which contain the points of the six-pointed Star of David):



It was through her work with performer and composer Charlemagne Palestine that Forti began circling the numerals. Of the generation of "minimalists" including La Monte Young, Terry Riley, and Philip Glass, Palestine is known for the textured sound fields that he produces through repetition and gradual variation in ritualistic performances at the piano or organ. Forti found in Palestine's accompaniment a natural measure of time that resulted from the acoustic phenomenon of beats: "The time unit seems to stem from pitch, or wave length, and from the recurrences emerging in the developing patterns of wave reinforcements and interferences," she wrote. Forti and Palestine had both studied Indian classical music with Pandit Pran Nath, and were inspired by the tonal framework of the raga. "In the Raga," she noted, "the tamboura holds a drone. The drone breaks into harmonics and, being constant, provides a grid in relation to which the voice moves." In this way, she identified harmonic breakdown to be a natural reference unit or unit of measurement for pitch.

If Palestine's accompaniment afforded her a footing for a precise relationship to pitch and time, her improvisations on numerals appears to have been an opportunity to find measures of movement and experiment with units of space and force.

In a sense I use the numerals as a floor pattern, but I try to move through the curves and straight lines as dynamically as possible. In that way my sense of the figures is really kinesthetic; I work with the centrifugal and

other forces with a sense of measure. The reach of my arms gives me my initial radius which I then expand. I usually call this study "Zero" and trace the figures zero through nine.

This context suggests a possible meaning of the "proposal: 1 = pi." Given that π is the circumference of a circle whose diameter equals 1, this could be an assertion that the natural unit of measurement—the "1" on the left side of the equation—is the circumference of a circle. Whether the proposal thus defines a measure of space (based on the reach of her arms) or a dynamic unit of "centrifugal or other forces" is less clear.

No matter how she characterizes her involvement with numbers, Forti's personal discourse betrays an epistemological sensitivity to measurement, if not mathematics per se. Before dropping out of Reed College, she had taken a teacher education course in the New Mathematics, that brief movement in American and European schools to increase abstraction in elementary mathematics education by, for example, introducing the language of sets and set operations.

The emphasis was on the fact that to perceive properties of quantity is one thing. To make notes of these perceptions is another. And to manipulate notation is still another. But even the materials which the children handled to obtain their first hand perceptions of aspects of quantitative variation seemed to be modeled after the standard ideal foot long rod. Absolute position seemed to be the underlying assumption regarding what constituted perception of quantitative variation.

At first glance, Forti's numerals might appear to have been inspired by esoteric mysticism or Kabbalistic tendency, but this passage suggests she may have been interested in drawing numerals simply because they constitute a basic form of notation for measurement. It could also have been that finding a kinesthetic sense of the numerals would "reawaken a partial presence of the original events" that informed the design of numerals. Looking again at the brâhmî figures, I wonder if she recognized that, at least up to 3, possibly 4, there is a ghost image of a tally. The numerals 5 to 9 exhibit an inexplicable shapeliness and movement, but for the others the physical act of writing the numeral is in effect to count the number that it represents.

This is an unusually explicit instance of the way that numbers (and mathematical notation in general) often correspond to procedures. Given that, beyond three, the numerals do not actually carry out the act of counting to their referent numbers, it is somewhat mysterious how the signs actually function in the practice of mathematics. (Unlike letters of the alphabet, mathematical symbols are not phonetic. This basic fact was pointed out to me by my two-year-old son when, after reading an "a"-is-for-"apple" alphabet book together, he asked "what does 3 spell?") Mathematician and philosopher Brian Rotman offers the most compelling explanation: "Numbers are things in potentia, theoretical availabilities of sign production, the elementary and irreducible signifying acts that the Subject, the one-who-counts, can imagine his agent to perform via a sequence of iterated ideal marks whose paradigm is the pattern 1, 11, 111, etc."

In seeking mathematics in Forti's choreography, suddenly mathematics is sounding like choreography. When I read mathematical expressions involving, for example, sums, products, exponents, derivatives, integrals, or other symbols, I often vaguely feel some action unfolding. This is somewhat akin to the feeling I have when reading a recipe before gathering ingredients to cook or reading directions before setting out on a route. To be sure, movement is a widespread and, I find, useful metaphor in mathematics, whether or not time is an intrinsic dimension of the problem at hand. For instance, a number (e.g. 2) may serve to measure quantity (e.g. two sons) or order (e.g. second son); and it is often natural —though not necessary—to conceive of the ordinals in a temporal order. Perhaps the sensation of unfolding is merely a result of first the compression that occurs when a concept is assigned written form, and second the decompression when the full concept is recalled from its signifier. Rotman cites a poetic description of this by French philosopher and mathematician Gilles Châtelet, who "understands the diagrams that pervade mathematics, notably geometry, as frozen gestures that lodge inside the symbols of mathematics."

More generally, I find a parallel between the role of notation in mathematics as a whole according to Rotman and the role that notation serves in Forti's choreography. In the most succinct terms, he claims that:

Mathematical signs play a creative rather than merely descriptive function

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in mathematical practice. Those things that are "described"—thoughts, signifieds, notions—and the means by which they are described—scribbles—are mutually constitutive: each causes the presence of the other; so that mathematicians at the same time think their scribbles and scribble their thoughts.

Reading the instructions for *Huddle*, it is virtually impossible to avoid forming a mental image of a person (possibly yourself) crawling through the choreography. Conversely, watching the pieces performed produces a desire to figure out the rules of the game. The piece and its notation evoke each other. Interestingly, this duality is reflected in the etymology of "choreography," according to dance historian and critic Laurence Loupe:

To choreograph is, originally, to trace or to note down dance. This is the meaning that Feuillet, the inventor of the word, assigns it in 1700, in the title of his work *Choreography, or the art of describing dance with demonstrative characters, figures, and signs.* (The French title contains a savorous hesitation in spelling, a delight for the modern semiotician: we read "l'art de d'écrire," almost as if, in English, one were to read "the art of de-scribing"). Since Feuillet's time, the acceptance of the term has undergone a singular evolution, and today "choreography" refers, not to the activity of notation, but rather to the creation of dance, or to "composition."

Annotating dance is a notoriously complicated project. The topologist René Thom estimated that each configuration of the human body, accounting for the degrees of freedom of movement at each joint, corresponds to a different point in a 200-dimensional space. Forti has stated that she is not particularly interested in choreographed dance, much of her career has been devoted to improvisation, and the movements of her written compositions are decidedly informal. All of which calls into question her need for a "precise relationship to indeterminate systems."

To understand what was at stake for Forti with regards to notation, I find it helpful to consider a mathematical parallel to her concerns about children's first-hand perception of quantitative variation. Her observations from the New Math course recall mathematician Hermann Weyl's warning: "The introduction of numbers as coordinates is an act of

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violence." Without going into detail, his concern is that although "to subject a continuum to a mathematical treatment it is necessary to assume that it is divided up into 'elementary pieces'," the regular division of a continuous space can obscure its intrinsic (i.e. topological) features.

Forti's word for the intrinsic feature that she aims to convey is "presence." As she found by studying Cage's *Imperfections Overlay*, a faithful record serves as "a kind of notation whose interpretation by the performer would reawaken a partial presence of the original events." For the score of her *Face Tunes*, Forti drew several outlines of peoples' profiles on a scroll of paper and instructed a performer to play a slide whistle in such a way that its slide would trace each profile in turn.

I had faith that, since the awareness of variations among similar events is so basic a life process, when [the audience] heard *Face Tunes* they would unconsciously sense a familiar kind of order. As form seemed to be the storage place for presence, I hoped that the act of translating a coherent aspect of a set of faces to a corresponding form might awaken a more primitive level of pattern or ghost recognition.

Sometimes I think Forti is pulling my leg. To recognize people's faces in *Face Tunes*, flutters of wind in a Cagean score, or numbers in a numeral dance seem like unlikely audience responses. This is probably no more harmful than the absurdity perpetrated by mathematics teachers when we expect our students to grasp the idealized objects we define. And yet some students do. Does this mean that mathematics exists in an objective reality? Barry Mazur offers a more skeptical account in terms of his own experience as a practicing mathematician: "One can be a hunter and gatherer of mathematical concepts, but one has no ready words for the location of the hunting grounds. Of course, we humans are beset with illusions, and the feeling just described could be yet another. There may be no location."

It is a strange quality of both mathematics and dance that they have the potential to conjure in us a feeling of presence. Even if it is illusory, Simone Forti persuades me that this presence lends meaning to the game, as when she describes the sensation of watching her father demonstrate historically important chess games move by move:

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I couldn't understand much about the game, but as I sat in the chair in front of the board, I felt that my body was occupying the same space, in relation to where the game was taking form, as had the body of the original player. I could feel and even smell the player. Even smell his moustache under my nose.

*

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