Number and Numeral

Friedrich Kittler

Editors' Notes

In his essay *Thinking Colours and/or Machines*, Kittler hints at a key point in the emergence of modern European culture: the point at which 'letters and numbers no longer coincide'. In the present article – first published in 2003 as *Zahl und Ziffer* – Kittler traces this split between numerals and numbers in sweeping historical detail. This is part of a much larger project, the aim of which is to think about technology, history and culture anew by considering the ways in which 'letters, numbers, images and tones' have been differentiated and re-integrated through the emergence of different notation systems and media technologies. In this article, Kittler is concerned specifically with the question of number. His argument is that numbers and numerals have not always been separate. In Old Hebrew and even nursery rhymes, for example, numbers are in fact words. This might seem like a banal observation, but for Kittler it is crucial as, historically, mathematics proper only developed 'in cultures in which numbers are present as numerals', a development which entailed the transformation of numbers from signifiers ('a matter of hearing') into signifieds ('a matter of reading and writing') and which rested on the emergence of storage and transmission media that Kittler calls 'the media of mathematics'. This connection between media and mathematics is explored through a wide range of philosophical sources: Plato, Philolaus, Aristotle and Aquinas, to name but a few. Kittler is fascinated by the inscription technologies that make mathematics possible, and which at the same time structure cultural forms as well as our bodily experience of them. As he puts it in a programmatic aside, 'media studies only make sense' if they focus on how 'media make senses'. Hence his focus on the Greek phonetic alphabet: for Kittler, its superiority has less to do with its ability to reproduce the spoken words of any language, but with the fact that at one point it was used to handle language, music, and mathematics – that is, one and the same set of signs was used to encode letters, tones and numbers. This, however, was not an abstract undertaking but developed in constant feedback with specific instruments or media, especially the lyre and the bow. It was here that fundamental concepts such as *logoi* were first developed that were subsequently distorted, misunderstood and deprived of their musico-technical origins by philosophers such as Aristotle. Kittler's essay is thus also part of a larger cultural project, indebted in particular to Martin Heidegger, whose aim it is to ferret out the different, as yet unrevealed beginning of occidental culture. Moreover, while it was necessary for the evolution of modern mathematics that numbers receive a notation system of their own that will

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allow for ratios and decimals, among others, it is obvious that Kittler sees the computer (as first envisaged in Alan Turing's mathematical modeling) as a return of a universal alphabet that operates in constant feedback with a medium that shapes our senses: 'In the Greek alphabet our senses were present – and thanks to Turing they are so once again.'

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> We are so apt to take it for granted that AEIOU constitute the only vowels there are, that we do not stop to consider how the possession of these particular five by our alphabet is a peculiarity requiring historical explanation. (Carpenter, 1938: 67)

Philosophy, Martin Heidegger said, has come to an end and is running as informatics in machines; what is necessary now is called thinking (see Heidegger, 1966).

In 1971, that is, seven years *after* a bestseller entitled *Understanding Media*, Marshall McLuhan wrote almost, but not quite the same to the president of his university:

> Dear Claude:
>
> On Sunday I made the biggest discovery of my life. It happened while I was working on the preface for [Harold] Innis's *Empire and Communications* which the University of Toronto Press is bringing out. Put in a word, the discovery is this: for 2500 years the philosophers of the Western world have excluded all technology from the matter–form entelechy treatment. Innis spent much of his time trying to explain how Greek culture had been destroyed by writing and its effects on their oral tradition. Innis also spent much of his life trying to draw attention to the psychic and social consequences of technologies. It did not occur to him that our philosophy systematically excludes *techne* from its mediations. Only natural and living forms are classified as hylo-morphic. (1971: 429)

These few lines remain true even though they are brimming with mistakes. First, there is no Western world but only the Greeks and us occidentals. Second, Aristotle's metaphysics, to which we owe the fancy term entelechy, has its share of technological forms: when, for instance, in the innermost sanctuary of the temple the bronze of a statue and the sight of the god merge like matter and form (υλη and ειδος) into the truly real (Aristotle, *Metaphysics*, 1921: *Z* 10 1035a 6–14; *Z* 11, 1036b 7–14). Third, it is utter nonsense – though one that media theory unfortunately keeps copying from Innis and McLuhan – that Greek culture was destroyed by writing as such (rather than four to five centuries later by Socrates and his ilk, including Aristotle). What remains true of McLuhan's insight is nothing but the reverse conclusion that here and now technology has to be thought in ways that philosophy never did. In other words, we need to unfold the essential unity of writing, number, image and tone. Lectures and essays can only concentrate on one at a time. In this case, it will be number.

1

Countless nursery rhymes, whether we remember them or not, attest to it: Numbers were once words among words; it was enough to merely listen to them:

> Eenie meenie minee mo,
> catch a tiger by the toe.

In consonantal writing systems such as Old Hebrew that have neither numerals nor vowels, this screams to high heaven.

The first Book of Kings recounts in all innocence how Solomon had Hiram of Tyre in Phoenicia come to Jerusalem to build his temple. Apparently the indigenous workforce was out of the question; in Phoenicia and Northern Syria, however, consonantal alphabets had been around for centuries. Hiram poured a circular sea of molten brass in front of Solomon's temple whose numerical ratios were written out in plain words: 'ten cubits from one brim to the other', and 'a line of thirty cubits did compass it round about' (1 Kgs, 7: 23). Dividing the 30 cubits by 10 reveals that all of Solomon's wisdom was barely able to confuse the ratio of the circumference of a circle to its radius with the natural number 3. Egyptian or Assyrian approximations of π, on the other hand, were a great deal more accurate (Chabert et al., 1999: 139). This may have had little impact on the porch of Solomon's temple, but it did hinder thought.

In other words, mathematics only exists in cultures in which numbers are present as numerals. Everything else – to quote the Wisdom of Solomon, which simply parrots Philolaus of Croton and his covert student Plato (see Fredel, 1998: 85–107; Huffman, 1993: 410) – remains in the domain of measuring, counting, and weighing. *Omnia in mensura et numero et pondere disposuisti* (Sap., 11, 21)[1] reveals that this God, as Leibniz scoffed, is unable to grasp the concept of numbers (see Leibniz, 1992: IV: 42).

It is the transformation of numbers into numerals, this culturally highly advanced magic wand, which separates signifieds (a matter of reading and writing) from signifiers (a matter of hearing). Storage and transmission media are therefore an indispensable part of mathematics. St Thomas Aquinas had already entrusted this in all philosophical clarity to the storage medium of his notorious manuscript. In the very beginning of the *Summa Theologiae*, in the first part of the first chapter which is dedicated solely to God, it is written:

> *Eandem enim conclusionem demonstrat astrologus et naturalis, puta quod terra est rotunda: sed astrologus per medium mathematicum, idest a materia abstractum, naturalis autem per medium circa materiam consideratum.*
>
> Both an astronomer and a physical scientist may demonstrate the same conclusion, for instance, that the earth is spherical; the first, however, works in a mathematical medium prescinding from material qualities, while for the

> second his medium is the observation of material bodies through the senses. (Aquinas, 1964: 9)

In the following, I will try to unfold the media of mathematics in the only way possible, namely, the historical. But first we had better listen closely to the Aquinate in order to realize that our Latin concept of medium is itself a copy. What he calls 'abstract' is in fact not abstract at all, which is what allows him to rephrase St Paul's 'for now we see through a glass, darkly, but then from face to face' (1 Cor. 12: 13) as *nunc videmus ut in speculo*.[2] For ever since Thomas's great idol Aristotle, that particular matter which all but evades our senses yet facilitates sensual perception in the first place is called *to metaxi* ('the middle', Latin *medium*). Aristotle, in other words, shaped the concept of media; yet he did not do so with his syllogisms in mind but rather in order to support the physico-physiological assumption that (regardless of what ancient doctrines of atomism may say) eyes are not able to see anything without media. Prompted by an ontological abhorrence of the void, Aristotle has, thanks to an air 'in between', visual rays running straight from objects into pupils – the latter, incidentally, named *kore*, or girl, rather than 'little doll'[3] – and then thanks to water straight from said girls to the retina (*De sensu* 1921: 438 b 4). To rephrase this along Heidegger's lines: Precisely because the eye sees neither the air nor the water involved, media, that is, the invisible matter (υμαι), grant an unconcealed view of being or, in Aristotle's words, they reveal the actively real (ενετελεχεια) of an unconcealed being (ουσια).

2

According to modern physics, however, wavelengths and/or photons are able to reach us even when traveling through a vacuum. So what, then, have media to do with mathematics? Everything or nothing. First, modern physics no longer narrates; thanks to interposed computers, it translates countable subatomic events into systems of equations. Second, it was the obvious goal of Aristotle's doctrine of the revealed *eidos* to refute an older type of essence which – in those days of the '*gigantomachia*' about being (Plato, 1993: 246a) – was tantamount to getting rid of it altogether. Everything that is (τα εοντα), Philolaus wrote a century earlier in 460 BC, is defined by the fact that it can be measured, counted and weighed, but even before a number is counted, it is characterized by a distinct form: it is either odd or even (Freeman, 1957: 74). Despite all their mathematical abilities, the bureaucratic scribes of Egypt and Babylon had missed out on this; it was the free Greeks who hit upon it. But it is only on the basis of these distinct forms that the manifold aspects of being are offered to the senses. They are all relationships (σχέση) or harmonies (αρμονια) that are at work between odd and even. And with that, science came into existence.

According to his *Metaphysics*, Aristotle was so unsettled by Philolaus's unity of being and number that he fled Plato's academy on the very day that the latter appointed as his successor his mathematically more gifted son-in-law rather than Aristotle. In addition, according to his *Politics*, Aristotle was unable or unwilling to learn a musical instrument; hence he could not fathom what Philolaus had in mind when he related being to the harmony of odd and even.

Media studies, however, only make sense when media make senses. We are still sorely lacking a media history of numbers; thanks to Aristotle, we thus far have had to make do with an ontology made up of form and matter, meaning and non-meaning, spirit and body and all the other absurdities that have been around since 330 AD. The story is well known, whether it occurs in Aristotle or elsewhere: Conceptually, media – from tally sticks to screens – belong to the realm of matter or carriers such as wood (in Homer's parlance, υλη), while the media contents are grouped with an essence (*Metaphysics*, 1921: *Z* 17) that merges with λογος. Write a consonantal letter such as Γ, Aristotle writes in, of all places, his *Poetics*, which, if sounded, amounts to meaningless (ασημος) execrable croaking. Add a second consonant such as P to the Γ and you will perceive that remains just as meaningless. If, however, ΓP is followed by a vowel such as A the nonsense suddenly flips over, for suddenly a 'non-significant composite sound' – what the Greeks later referred to as syllable – emerges. But neither Aristotle nor his thousand interpreters ever divulged that the syllable ΓPA stands at the beginning of the word ΓPAMMA – in plain English, the letter. Starting with the literal element (στοιχειον), but scrupulously avoiding the older word in order to arrive at a meaning or λογος, the definition has come full circle. Hence media studies is free to forget the whole 'hylo-morphism' that from Aristotle to McLuhan suppressed letters, syllables and words. Instead it is charged with the straightforward duty of revealing the letter as a medium behind the veils called substance and form, ore and image, mat(t)er and semen.

But if the signified, the meaning of the word, only exists in writing, then the question becomes all the more urgent: who equipped the Greeks with numerals? Why did Philolaus of Croton, unlike the Ionian philosophers, not think of being in the singular, but of a strange plural being (α εστω) that he put in numbers?

The answer may sound a bit fatuous though it comes in two parts. First, around 800 BC, a nameless Greek who presumably worked at a Euboian court reshaped the Northern Syrian consonantal alphabet by adding five vowels for the exclusive purpose of transmitting the oral-musical *Iliad* and *Odyssey* down to the present age (for the following, see Powell, 1991). Unlike those of the Near East, there is not a single archaic Greek inscription that deals with matters of trade, government or the law; they all emulate the *Odyssey* by invoking wine, women and song (see Heubeck, 1979: 151). And this had consequences. For – and this is the second part of the answer – around 450 BC, possibly even earlier, the Greeks evolved a number system from their vowel alphabet. The first nine letters from alpha to theta represent the ones, the letters from iota to kappa the tens, and those from rho to sampi the hundreds. Thus cardinal numbers arose from the ordinal sequence of the alphabet that the Euboian adapter had unwittingly copied from the Phoenician system. As the phonologically obsolete signs koppa and sampi reveal, a second adapter must have recognized the rules underlying the game and turned signs into numbers. Whenever readers came across a sequence of letters which unlike all the others could not be translated into a sequence of sounds and thus into meaning of *logos*, it turned out to be a combination of hundreds, tens and ones, that is, a number. This use of letters as numerals, as Thomas Heath was right to insist, is certainly original with the Greeks (1921: 32).

As a result, things could be written down. In order to teach singers and musicians by what stretch they had to shorten the string of their lyre in order to sound the fourth instead of the keynote, Philolaus simply put down δ και γ: Pluck the string at the point that marks the ratio four to three!

This instruction differs from the ontology of Aristotle in two elementary ways: First, it is without a doubt true; and, second, it can effortlessly be proven. Whoever has ears to hear can simply follow Philolaus and discover that a lyre is not only a musical instrument such as exists in any culture, but also a magical thing that connects mathematics to the domain of the senses; it is, to use Hans-Jörg Rheinberger's neologism, an 'epistemic thing'. Such manifestness appears to be the only meaning of meaning, that is, the only meaning that *logos* can take on under computerized conditions. After all, Philolaus and his followers, the 'so-called Pythagoreans' (Aristotle, *Metaphysics*, 1921: *A*.5 985b 23), literally referred to the 4:3 ratio of the fourth, the 3:2 ratio of the fifth, and the 2:1 ratio of the octave as *logoi*. For these three ratios, each of which in turn combines even and odd, are sufficient to assemble the whole, the octave called harmony, from its parts:

> The Content of the Harmony is the major fourth and the major fifth (Freeman, 1957: 74):
>
> $$\frac{2}{1} = \frac{12}{6} = \frac{4}{3} \times \frac{3}{2.}\ \text{q.e.d.}$$

This act of writing achieved the same as the λογος of Aristotle: a definition. But beyond all philosophy this epistemic thing also produced something that will forever elide all verbal definitions: Harmonically tuned strings produce tones and successions of tones which, ever since Euripides, the Greeks indicated with a letter from their alphabet rather than marking them, as we do, on staves.

Thus, in the end, the first and only alphabet – which thanks to its vowels allowed writing to silence all that was said and sung and reading to restitute its voice – returned to itself. Called forth by the songs of heroes and sirens, the alphabet concluded in a knowledge (αθησις) of harmony – it is no coincidence that, according to mythology, Cadmus, the inventor of the alphabet, was married to Harmonia[4] (Pausanias, 1965: 459). Precisely because the zither resounded in order to accompany song, the tone letters struck up and did what vowels, as indicated by their very name, are said to do: they called – and like the sirens they called out to their hero in hexameters: ‘Come closer, famous Odysseus – Achaea’s pride and glory!’ (Homer, 1996: 277).

In other words, it is not the meaning of signs to make any sense, they are there to sharpen our senses rather than ensnare them in definitions. It is not the meaning of media to transmit meaning; rather, they are to pass on to the senses of others what would otherwise fade away in the present:

> Many years after Philolaus’s death a shepherd came to his grave in broad daylight and heard it sing. The shepherd reported this to Eurytus who had been one of Philolaus’s students. ‘By the gods,’ Eurytus asked, ‘which harmony?’ (Diels, 1951: 419)

The grave of Philolaus must have been somewhere out in the open between Heracleia and Tarentum, where the roses grow and Italy’s heaviest wine. Maybe on that very same day the shepherd, with wits sharpened, started to learn fourths, fifths and octaves, letters, numerals and symbols. Eurytus had him write so that nothing of that which Philolaus bequeathed to us in death will ever cease to resound. Man as the shepherd of being – no more, no less.

3

The European Middle Ages demolished this trinity of writing, tone and number for good – or so it seemed. It was not until the days of Alan Turing and John von Neumann that we once again had universal alphabets. In the meantime, however, letters were one thing, notes on staves another, and the numerals imported from India via Baghdad something altogether different. This variety guaranteed that poems, songs, and calculus were unmistakable; as Sybille Krämer has shown, it allowed the replacement of numbers by letters (Krämer, 1991). Formulas such as Fermi’s grand assumption a ^ n + b ^ n = c ^ n could be written down without the fear that any threefold of whole numbers would fulfill it in the same way as Pythogoras’s $3^2 + 4^2 = 5^2$ had. Yet the general nature of these signs also raised the question whether numbers other than real numbers would pass the test just as effortlessly. The answer was an unqualified yes. With zero as a new operator, Europe had introduced a numeric positioning system that allowed for the transcription (and computation) of irreducible Greek in the shape of decimal fractions: after the decimal point, you proceeded just as you had before. Ever since Simon Stevin, the quartermaster-general of Maurice of Orange, 4:3, the perfect fourth, can also be written in decimal numbers as 1.3333. . . . As a consequence, Stevin was compelled to ask how many numbers between one and zero could be written in this particular way.[5]

The answer was: an infinite number – and this effectively put an end to everything that had been handed down from the Greeks. Aristotle had allowed for media or means to reside between object and retina but under no circumstances between whole numbers, since 'there is not contact in numbers, but succession', that is to say, there is nothing 'between the units' (*Metaphysics*, 1921: *M* 9, 1085 a 3–4). Stevin's real numbers allow for the exact opposite: a well-nigh physical medium out of which whole or at least rational numbers occasionally emerge like islands from the sea. 'Un coup de dés jamais n'abolira le hazard.'[6]

In music, this sea is called the siren, a device of 1819 capable of continuously traversing the entire auditory space in two media, air and water (see Charles, 1819). Hence Simon Stevin proceeded (although already in 1595) to bid farewell to Greek music. If for Philolaus the harmonics called octave was a double step of perfect fourth and fifth, Stevin recognized decimal fractions to be a feasible way of basing all keys on a single, albeit irrational ratio. Intervals whose essence or purity resided in their difference were replaced by the twelfth root of two, that is approximately 1,05946 . . . as a tempered semitone. There was no other way in which Greek fifths and late mediaeval thirds could be turned into fugues. In Stevin's 'Theory of the Art of Singing', which expunges the Greek word music from its very title, the new root signs appear on the left and the decimal approximations of seconds, thirds, fourths, etc. on the right (1966: 426f.). This is what we know as well-tempered piano.

Thus, a mathematical medium, the early modern invention of real numbers and general exponents, brought forth an acoustic medium. Centuries had to pass until all musicians, composers and instrument builders bowed to Stevin's numerals, but in the end they all did. It is only since then that enharmonic confusions – that is, modulations through all 24 keys – have been possible; and only since then can we listen to the sounds of symphonies, sonatas, soulful thirds and seventh chords. A mere sign, 2^1/12, has equipped us with historically unheard-of ears. Lacan's psychoanalysis states:

> At a certain moment in time, man learned to emit and place the discourse of mathematics in circulation, in the real as well as in the world, and that discourse cannot function unless nothing is forgotten. It only takes a little signifying chain to begin to function based on this principle, for things to move forward as if they were functioning by themselves. (Lacan, 1986: 236)

Once again, the principal difficulty resides in not submitting our world made up of mathematical calculus, epistemic things and technological media to a supreme being, be it God, Meaning, or Man – something the early modern age was incapable of doing. From Leibniz to Kronecker,[7] the simplest of numbers (binary or natural) were said to be a gift from God; and from Descartes and Hegel to Dilthey the 'meaning' imposed by subjects on objectivities or media was a covert resistance against thinking about technology. Evidently numbers had to leave humans behind and become part of machines that run on their own in order for technology to appear as a frame that conjoins being and thought. This turn was completed by Alan Turing when he devised his paper machine, the principal switch of all possible discrete computers.

For suddenly out of the sea of real numbers an alphabet emerges – just as it had in Greek times from the sea of sounds. 'The "computable" numbers may be described briefly as the real numbers whose expressions as a decimal are calculable by finite means' (Turing, 1965: 116). Their machine quality is due to the simple fact that although 'the class of computable numbers is so great, and in many ways similar to the class of real numbers, it is nevertheless enumerable' (1965: 116). To each computable sequence there corresponds at least one description number of finite length or, in more old-fashioned terms, a closed algebraic expression, to which, ever since 1945, and thanks to John von Neumann, there corresponds a computer. But these computers are universal machines only under the strict condition that they are no longer analog, as they had been in Boston or Liverpool. The alphabetization of the real excludes an infinity of symbols or 'states of mind' simply because 'some of them will be "arbitrarily close" and will be confused' (Turing, 1965: 136).

The molten sea in front of Solomon's temple has been emptied; π, rather than being distorted into the number 3, has solidified into a computable real number. Unlike the early modern age, Turing's epoch does not implement Stevin's 2^1/12 in ironware such as the valve horn or the guitar string that operates at a human level; it buries the half-step much deeper, it miniaturizes it into a programmed algebra that may be software or (under its proper name, real time) silicon hardware. Though most end users are unaware of it, harmonics, even the most unexpected, are at work: Simon Stevin's early modern age lives on in the chords or the keyboards of digital synthesizers, and in their harmonics and Fourier series the sayings of Philolaus live on in all eternity, whether we hear them or not.

The same was contained in a saying by Heraclitus which in the mouth of modern philosophers has become dry and devoid, emptied of music: 'The hidden harmony is stronger than the visible' (Freeman, 1957: 28). But the original Greek itself hides whether the hidden afflicts ears or eyes. In the Ephesian Ionic, the dark syllables – short or long, high or low – merge into a harmony all on their own. Heraclitus spoke in hexameters:

αρ ονια αφανης φανερης κρσσσων

In the Greek alphabet our senses were present – and thanks to Turing they are so once again.

(Translated from the German: Geoffrey Winthrop-Young)

Translator's Notes

1. 'But thou hast arranged all things by measure and number and weight.'

2. In the Latin version, the phrase from 1 Corinthians reads '*nunc videmus per speculum*'. Following Kittler, the prepositional switch from *per speculum* (through a mirror) to *ut in speculo* (as in a mirror) is meant to suggest different refractive, and hence medial, qualities.

3. A reference to the derivation of pupil from Latin *pupilla* (diminutive of *pupa*) that can mean either little girl or little doll.
4. According to certain versions of the Cadmus myth, Zeus gave him Harmonia, a daughter of Arews and Aphrodite, as his wife. At his wedding, Cadmus became one of the very few mortals to hear the Muses sing.
5. Simon Stevin (1548–1620), Belgian mathematician and engineer. He made important contributions to geometry and physics as well as to the arts of fortification and bookkeeping.
6. 'A Throw of the Dice Will Never Abolish Chance' (a famous poem by Stéphane Mallarmé frequently referred to by Kittler).
7. Leopold Kronecker (1823–1891), German mathematician, whose primary contributions were in the theory of equations and higher algebra.

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