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Movement-space: the changing domain of thinking resulting from the development of new kinds of spatial awareness

Nigel Thrift

Abstract

This paper is an attempt to describe the nature of a new calculative background that is currently coming into existence, a background that will both guide and constitute what counts as 'thinking'. It begins by providing a capsule history of how this background has become a more and more pervasive quality of Euro-American cultures as a result of the rise of 'qualculation'. It then moves on to consider how this qualculative background is producing new apprehensions of space and time before ending by considering how new kinds of sensorium may now be becoming possible. In this final section, I illustrate my argument by considering the changing presence of the hand, co-ordinate systems and language, thereby attempting to conjure up the lineaments of a new kind of movement-space.

Keywords: calculation; movement-space; sensorium; hand; co-ordinate systems; language.

Civilization advances by extending the number of operations which we can perform without thinking about them,

(A. N. Whitehead 1911, cited in Myers 2002: 17)

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Introduction

What is an idea? In this paper, I want to argue that, whatever an idea's exact content might be, it is also important to be able to understand the way in which an idea is framed because that framing has consequences. Yet, it is remarkable how few papers on knowledge actually consider the mundane frameworks in which ideas come wrapped and from which they must spring. This paper is a first attempt to suggest another way of looking at the world of 'pre'-ideas, one that is meant to be both destabilizing and, at the same time, productive. It arises out of a theoretical shift that does now seem to be gathering momentum, one that allows new things to be seen and handled by concentrating on the utterly mundane frameworks that move 'subjects' and 'objects' about.

The paper therefore follows on from some of my other recent work which has attempted to understand the new kinds of electronic background time-spaces that are making their way into the world, and their capacity for changing what we might be (see Thrift 2003, 2004a, 2004b, 2004c; Thrift and French 2002). In particular, I have looked at how, as a result of the intervention of software and new forms of address, these background time-spaces are changing their character, producing novel kinds of behaviours that would not have been possible before and new types of object which presage more active environments. In this paper, I want to extend these thoughts in various directions, hoping to capture the outlines of a world just coming into existence,[1] one which is based on continuous calculation at each and every point along each and every line of movement.

In conventional accounts of the modern world, this 'figured materiality' (Verran 2001) would be regarded as cause for concern. It would be taken as yet another sign of a more rationalized, calculative world, one increasingly bereft of humanity (see, for example, Ritzer 2003), a sign taken for a portent of doom rather than of wonders. I am sceptical of such accounts and want to suggest something rather different; a move towards a world in which new qualities are being constructed, which are based on assumptions about how time-space can turn up which would have been impossible before, spaces which are naturalistic in the sense that they are probably best represented as fluid forces which have no beginning or end and which are generating new cultural conventions, techniques, forms, genres, concepts, even (or so I will argue) senses. This is the rise of what I call 'qualculation'.

The paper is therefore in four main parts. The first and briefest part considers the issue of the growth of artificial paratextual forces, invisible forms which constitute the bare bones of the world, concentrating especially on structures of repetition. The second part of the paper is concerned with the extent to which these forces are dependent upon and operationalized through all manner of forms of quantitative calculation, from the very simplest operations like listing and numbering and counting through to various kinds of analytical and transformative operations. But, more to the point, I argue that in

recent years the activity of calculation has become so ubiquitous that it has entered a new phase, which I call 'qualculation', an activity arising out of the construction of new generative microworlds which allow many millions of calculations continually to be made in the background of any encounter. I argue that it is no longer possible to think of calculation as necessarily being precise. Rather, because of massive increases in computing power, it has become a means of making qualitative judgements and working with ambiguity. In other words, what we are seeing is a new form of seeing, one which tracks and can cope with uncertainty in ways previously unknown.

The problem then becomes how to frame and represent this new kind of space of thinking thinking. This is the subject of the third main part of the paper. I shall argue that this is best achieved by aligning my arguments with the literature on ethnomathematics, which not only demonstrates the wide variety of different kinds of calculation that can be shown to exist, or to have existed, in the world, but also, in its emphasis on the transition from calculation as practised in oral cultures to calculation as practised in literate cultures, provides a kind of model for the transition from a calculative world to a qualculative world.

The fourth and final part of the paper is an attempt to show how these developments are producing a new sense of space as folded and animate, one that assumes a moving point of view, a 'nomadologic' rather than a monadologic (Vidler 2000), which may, for example, be showing up in new forms of anxiety and phobia, which are representative of new stresses and strains, or in new forms of intuition. However, too often discussions of these senses end with this point or are so abstract that they leave the reader to do all the interpretation. Instead, I want to begin to discuss what this might mean concretely. This I shall do by considering the way in which the human sensorium is changing, specifically by considering changes in the way in which the body 'talks' and is addressed.

I also append some brief conclusions.

The world of paratexts

All human activity depends upon an imputed background whose content is rarely questioned: it is there because it is there. It is the surface on which life floats. At one time, the bulk of this background would have consisted of entities which existed in a 'natural order', all the way from the vagaries of the surface of the earth through to the touch of currents of air or the itch of various forms of clothing through to the changes in the sky. But over time, this background has been filled with more and more 'artificial' components until, at the present conjuncture, much of the background of life is 'second nature', the artificial equivalent of breathing. Roads, lighting, pipes, paper, screws and similar constituted the first wave of artificiality. Now a second wave of second

nature is appearing, extending its fugitive presence though object frames as diverse as cables, formulae, wireless signals, screens, software, artificial fibres and so on. It is possible to think of these object frameworks in a number of ways. First, and most obviously, they can be considered as the technological equivalent of the Heideggerian background, but presumably involving a new kind of dwelling. However, there is a problem with such a narrative. The notion of background still clings to its roots in a Greek notion of a bordered and enclosed *topos*, and therefore might be thought of as an inappropriate fit to contemporary developments (Irigaray 1999; Perniola 2004).[2] Second, they can be thought of as like paratexts (Genette 1999; Jackson 1999), 'invisible' forms which structure how we write the world but which generally no longer receive attention because of their utter familiarity. Like the set-up of the page, indexes, footnotes and the rest of the paraphernalia of written thinking, they have become a kind of epistemic wallpaper. Third, they can be interpreted as new kinetic surfaces to the world, along and across which things run (Parks 2003; Thrift 2004c), surfaces like screens which are becoming ubiquitous interfaces and which demand certain kinds of structured engagement, which are both geophysical and also phenomenological in that they may alter our understandings of space, time and movement. Fourth, they can be understood as a new 'technological unconscious' whose content is the bending of bodies-with-environments to a specific set of addresses without the benefit of any cognitive inputs. The technological unconscious is therefore a pre-personal substrate of guaranteed correlations, assured encounters and therefore unconsidered anticipations (Clough 2000; Thrift 2004c). Finally, they can be understood as a methodological challenge. Most notable here is the paraethnographic movement instigated by writers like George Marcus and Annelise Riles, which has attempted to instigate a new kind of aesthetic practice of 'hearing' in order to be able to locate and understand the 'known unfamiliar' and the 'unknown familiar'. The avowed intent is to find a way of discussing subjects that cannot not be apprehended as distant analogues to anthropologists' own knowledge, and are not therefore open to metaphorical interpretation. Many of these subjects are not instrumental but are based on shared appreciations at levels which are often 'on the surface, in plain view, and yet precisely for this reason, unseen' (Riles 2003: 22).

What each of these interpretations shares in common is a focus on (1) the utter mundanity of this second nature, which is also an inescapability: these items act as natural primitives which through their recursivity guarantee the recursivity of the world, (2) the fact that they therefore exist outside the realm of meanings, being known only in their performance, (3) the importance that is consequently attached to the persuasiveness of form, (4) the observation of a kind of fugitive materiality which lives in the interstices of life, the materiality of a ground which receives attention only if its workings are interrupted, but (5) the parallel observation that these items require continuous effort to keep going, in the shape of service and repair, effort that is nevertheless almost never commented upon.

Establishing these frameworks so that they are reliably recursive means imposing four different but closely related frames, which will allow formal self-description and therefore some measure of control, self-description which nowadays will almost always be numerical. First, it requires the imposition of metrics. As the historical record shows, this is an enormous task in itself. Second it requires the imposition of standards which allow what are often different local frames to be crafted into a secure global assemblage. Third, it requires the imposition of a system of addresses so that all parts of the system are able to be located by all other parts. Fourth, it requires the imposition of modularity so that reliable 'objects' can be identified and described. If these frames can be imposed then four further achievements become possible (Manovich 2001). First, variability can be constructed and dealt with. Second, transcoding can occur on a regular basis: lists, records and arrays can be generated and they will mean roughly the same thing at all points in a network. They can also be translated into other formats. Third, it becomes possible to build archives of various kinds which provide a kind of memory and possibilities of reuse (Bowker 2003). And, fourth, automation of many operations can occur, a characteristic which has been much enhanced in the present by programmability.

If all these characteristics can be imposed, then the logic of the system, as it becomes both necessary and general, will gradually become the logic of the world. As this ontogenetic process occurs, so the system will fade from human perception, becoming a part of the landscape which the body 'naturally' adjusts to and which it regards as a normal part of its movement. In the next section I want to start to assemble the components which will allow me to understand this process as it pertains to the construction of quantitative calculation as a norm.

From quantification to qualculation: the growth of calculation

The growth of quantitative calculation in the world, by which I understand the growth of ideas and procedures concerned with number, counting, logic, and consequent forms of spatial and temporal configuration, and the combination and organization of these operations into systems which are clearly 'secular, time-bound, and empirically tainted' (Rotman 1993: 49) is a long and complicated story which can take in all kinds of milestones, from the invention of mathematics in fifth century BC Greece to the current rise of quantum computing. But what seems certain is that the sheer amount of calculation going on in the world has undergone a major shift of late, as a result of the widespread application of computing power through the medium of software, to the extent that many quite mundane human activities are now shadowed by numerous, often quite complex, calculations. Calculation, in other words, is becoming a ubiquitous element of human life. Three facts can illustrate this point. First, there is the sheer growth in computing power, as represented not

just by processing power but also by developments like grid computing which represent distributed means of solving very large problem sets. On one reckoning, the upper bound of human brainpower has been calculated to be 2×10^{16} calculations per second. If computational power continues to conform to Moore's Law then by 2030 just an ordinary PC should compute at around 10^{16} instructions per second (Sharpe 2003). Second, and relatedly, there is the increasing ubiquity of hardware and software, which means that computing can take place in many locations (Thrift and French 2002). Small bits of hardware and software are now part of the hum of everyday life, working away silently on their calculations in all manner of unexpected locations. Third, forms of calculation are changing. Increasingly, analytic solutions are being replaced by brute computing force engendered by mass recursivity with the result that what is regarded as mathematics is spreading far beyond its original kernel of knowledge.[3] The problem then becomes how to represent this increase in calculation and its consequences.

I shall argue that we are in a situation that has a number of historical parallels which have manifested themselves again under the new conditions of computability and which form a kind of cognitive history told through practices of number. One is with the discovery of mathematical deduction itself. The second is with the identification of population as a thinkable entity. The third is with the exact gridding of time and space in the eighteenth and nineteenth centuries. The fourth is with the invention of various filing and listing systems at the turn of the nineteenth century. The fifth is the invention of logistics in the mid-twentieth century. It would be possible to argue that thinking in the modern world is founded on the powering up of these abstractions and extensions of movement and that developments like the growth of surveillance in the twentieth century are but logical outgrowths of them. I want to argue that, just as these developments produced a new sense of the world and new forms of representation of it, so we can see something similar happening now. These developments have, if you like, produced new figured ontologies by decomposing and recomposing the world in their own image: they have been the real winners of the ontological wars, defining not so much what is to be done in any situation but how the situation turns up in the first place. It is a messy kind of purity that is being produced, of course, one which has to work hard to keep itself in place: we simply do not see the work going on.

First, then, the discovery of mathematics. Netz (1999) argues convincingly that this discovery resulted from the transition from a visually based pre-literate society to a verbally based literate culture and especially from the material implementation of the lettered diagram, a limited lexicon and the formula which was the hallmark of Greek mathematical activity. Thinking in and through the tangible tool of the diagram, a limited range of letters, and formulae,[4] Greek mathematicians were led towards a cognitive style that allowed for new kinds of argumentation and a universe of discourse with high degrees of implicitness which acted as a new ontology:

> It is the essence of cognitive tools to carve a more specialised niche within general cognitive processes. Within that niche, much is automatised, much is elided. The lettered diagram, specifically, contributed to both elision (of the semiotic problems involved with mathematical discourse) and automatisation (of the obtaining of a model through which problems are processed).
>
> (Netz 1999: 57)

In particular, the cognitive method called mathematics allowed the world to be seen as concise, transferable and thus manageable, shaping a new kind of necessity. In particular, this method relied on being able to establish *repeatability*, most especially by reducing the scope for variability in both diagram and text and therefore producing 'controlled' results.

Second, the discovery of population (or, more accurately, 'multitude') as a thinkable entity, an entity which can be characterized and summed in different ways. There are many possible dates from which such a cognitive style can be argued to have come into existence. For example, just in English history the date can be placed as early as the twelfth or thirteenth centuries, as a result of the Church's further extension of control over marriage, increasingly close grappling with issues of marriage and procreation among the faithful, the extraordinary development of pastoral expertise and observation, and more general issues of inhabitation brought about by an expanding notion of geography (Biller 2000; Clanchy 1992). Or it can be understood as occurring much later, in the sixteenth and seventeenth centuries, as a result of the rising domestic administrative demands of the state, as opposed to the already familiar demands of raising money and waging war. Similar variations in judgement can be found in many other cultures (for example, see Goody (1986) on list-making and its relation to the move from oral to literate cultures). Perhaps the most obvious observation to make is that the notion of population is caught up with the rise of states and their need both to circumscribe and to enlarge their capacities through synoptic facts. It is a part of what Scott (1998: 80) calls an 'ongoing project of legibility'. Whatever the case, it is clear that a notion of population of the kind that subsequently became common in the nineteenth century has been crucial to the quantification of the world, allowing many modern statistical ideas to come into existence and be applied in the background as a kind of background (Porter 1992).

Third, there is the gridding of time and space in the eighteenth and nineteenth centuries. The story of the standardization of space and time has been told many times but it is no less remarkable for that. For, as various metrics were generalized and standardized, so making different parts of the world locatable and transposable within a global architecture of address, so each and every part of the world could in theory be given an address. The process of achieving this goal had to wait until the late twentieth century to achieve fruition, especially with the advent of GIS and GPS, but the trajectory was clear long before this. For example, Burnett (2003) shows

how in the nineteenth century a number of authors dreamed of a 'chronometrical sea', a sea that behaved like a clock, a sky-like entity which would yield to metrical and mathematical analysis. Such a vision demanded a means of holding the sea in place which could only truly be achieved late in the twentieth century as satellites, computers and lasers provided means of orientation which had hitherto been lacking (cf. Galison 2003). In turn, the technology of address produced genuine locatability in an absolute space and, with it, the possibility of making calculations that had been difficult or long-winded before. In particular, objects could be followed from location to location as a continuous series so simulating movement in a way that was, for all intents and purposes, indistinguishable from movement itself.

Fourth, there is the growth of means of making mass lists and registers. Yates (1994, 2001) has argued that the end of the nineteenth century saw a seismic shift in the technology of list-making, as a result of the invention of technologies which not only recorded, copied, duplicated and stored information but also, in effect, created the modern idea of what information consists of. These technologies included the typewriter, prepared forms, new means of duplication (such as carbon paper, hectographs and stencils), filing systems, card files and new means of indexing. Much of the content and style of these technologies was subsequently translated into modern computers with minimal change, from keyboard layout to various procedures, codes and algorithms.

Fifth, there is the rise of logistics, a set of knowledges synonymous with movement, effectively the science of moving objects in an optimal fashion. This science, which originated with the military in the eighteenth and nineteenth centuries but found its 'ground' in the business world after the Second World War as the realm of thinking about linkages and how to make them as efficient as possible, has gradually become associated with the technology of address. That association has produced a background host of calculations of object movement which have made statistics a part of the normal functioning of the world, and not just a set of summary descriptions (Desrosieres 1998). Most recently, the rise of continuously computed environments has made logistics perhaps the central discipline of the contemporary world – though one curiously unsung – as it has pursued the goal of 'intelligent logistics processes' which:

> have the ability to bring together the right information and materials, spatially and electronically, to the right place at the right time no matter where in the world they originate. In short, this new set of logistical processes requires a logistical environment that is time-based, collaborative and intelligent.
>
> (Greis 2004: 41)

In each of these five practices/apprehensions of number, number does not just describe, it constructs. Numbers take on virtual properties in that they

produce an impetus towards the construction of 'a terrain and a population with precisely those standardized characteristics that will be easiest to monitor, count, assess and manage' (Scott 1998: 81–2). In other words, number tends to cast the world reciprocally in its image as entities are increasingly made in forms that are countable. Number performs number. As importantly, in Euro-American cultures at least, it also performs a notion of a terrain and population existing in a 'similar and immovable'[5] abstract space which has had to be slowly and laboriously built up, one which assumes that there are fixed reference points, cardinal dimensions and the like (Hatfield 1990).

It could be argued that by the middle of the twentieth century most of the building blocks of contemporary developments had already been put in place. All that was left was to implement them – thereby producing a tightly constrained and ordered world of calculation in which potentially every thing and every location (the two increasingly becoming interchangeable) could be given a number and become the subject of calculation, and in which each calculation could potentially be redone several times a minute. This task was able to be achieved because of a number of contributory factors but principally because of the spread of the interfaces and defaults of computer software, which both encapsulated the new possibilities and acted as a vehicle for them (Thrift and French 2002). Whatever the cause, the world has become increasingly one in which a numerical flux becomes central to activities, rather than incidental, giving rise to more and more 'flow architectures', to use Knorr Cetina's felicitous phrase:

> In a timeworld or flow-world. . .the content itself is processual – a 'melt' of material that is continually in flux, and that exists only as it is being projected forward and calls forth participants' reactions to the flux. Only 'frames', it would seem, for example, the frames that computer screens represent in a financial market, are pre-supposed in this flow-world. The content, the entire constellation of things that pass as the referential context wherein some action takes place, is not separate from the totality of ongoing activities.
>
> (Knorr Cetina 2003: 4)

In other words, in a world in which numerical calculations are being done and redone continuously, so that static representation becomes subordinated to flow (not least because 'the image, in a traditional sense, no longer exists' (Manovich 2001: 100)), the nomadologic of movement becomes the natural order of thought. The world is reconfigured as a global trading zone in which network forms, which strive for co-ordination, are replaced by flow forms which strive for observation and projection.

> Like an array of crystals acting as lenses that collect light, focussing it on one point, such mechanisms collect and focus activities, interests, and events on one surface, from whence the result may then be projected again in different

> directions. When such a mechanism is in place, co-ordination and activities respond to the projected reality to which participants become oriented. The system acts as a centering and mediating device through which things pass and from which they flow forward.
>
> (Knorr Cetina 2003: 4)

Treatises from the mid-twentieth century onwards had attempted to understand precisely the large amount of numerical information that was becoming available and, more importantly, how to specify such a situation, work with it and shape it. In other words, it had been realized that the plethora of tightly packed grids of numbers would produce opportunities to frame movement in different ways as the sheer amount of calculative power that was becoming available became apparent and as a world of continuously flickering rotations and transformations and projections hove into view.

An example of this process in action is the rise of cybernetics. Originally conceived as the science of a certain class of machines, cybernetics has, in its various later hybrid forms such as found in parts of computer science, become a part of the way in which number is routinely handled (Mirowski 2002). Thus, forces of recursivity moved from being models on the page to something approaching forces of nature: in Manovich's (2001) terms, the loop – the repetition of a set number of steps – becomes the key figure producing a new form of temporality and spatiality. In contrast to the temporality and spatiality of the narrative, playing out once and for all, we find a progression based on a shuffling between loops which are all active simultaneously, which are constantly changing their character in response to new events and which can communicate with each other in a kind of continuously diffracting spatial montage. There are no longer calculations with definite beginnings and ends. Rather there is a plane of endless calculation and recalculation, across which intensities continually build and fade.

In turn, this process of shaping numerical flow such that it seems to shape us has produced not just new quantities but new *qualities*, based in and around new kinds of perceptual labour and expertise which, or so I claim, are producing a shift in understanding the world similar to that which attaches to the move from oral to literate cultures. These qualities are the subject of the next section.

As a parting shot, I want to emphasize that these developments are producing not only shifts in what is understood as 'human' but also shifts in what is understood as 'environment' since, increasingly, the 'artificial' environment is sentient and has the feel of a set of 'natural' forces blowing this way and that. It is possible to argue that, as a result, the world is becoming re-naturalized and resembles nothing so much as a Spinozan universe of geometrical laws but one that has been constructed rather than one that is necessarily extant.

New apprehensions of space and time

Much has been written of late about new sensings of space and time. In particular, three related characterizations seem to have become dominant, each of which triangulates with the others. First, there is the issue of relative space: it is reckoned that a more plastic sense of space and time has come into existence, one that recognizes space as folded and animate because everything can be framed as in perpetual movement: 'the shape of this space is that of a river: not the surveyor's river which is simply a gap on the map, a frozen interval, but the river as serpentine motion, as an evolving pattern of vortices, expanding and collapsing' (Carter 1992: 92). Second, this perpetually mobile space is seen as one in which joint action arising out of several causes brings new things into the world. The realm of the virtual or quasi-causal is recognized as having an existence, one which continually marks up the world. Third, spacetime is seen as arising out of multiple encounters which, though structured, do not have to add up: as myriad adjustments and improvisations are made, so new lines of flight can emerge. The fabric of space is open-ended rather than enclosing.

However, it must be noted that these sensings would be impossible without the fine grid of calculation which enables them: they are not, as many writers would have it, in opposition to the grid of calculation but an outgrowth of the new capacities that it brings into existence. A carefully constructed absolute space begets this relative space.

Most importantly, I shall argue that the sheer amount of calculation that is now becoming possible at all points of so many spaces is producing a new calculative sense, which I will call 'qualculation' (Callon and Law 2004). That sense has the following characteristics. First, speed. Calculations are done all but instantaneously, to the point where many calculations become part of a background whose presence is assumed. Second, faith in number. We might say that the kind of obsessive faith in number exhibited by luminaries like Galton in the nineteenth century has become generalized (cf. Gillham 2002). Almost anything is thought susceptible to counting, ranking and the like, as evidenced by the current mania for ranking just about anything, often in what might seem completely inappropriate ways (Kimbell 2002). Third, and at the same time, only limited numerical facility is available in the bodies of the population. Though much of the population is innumerate, this no longer necessarily matters because the environment acts as a prosthesis which offers cognitive assistance on a routine basis. Fourth, some degree of memory. This memory will be based upon producing symbols (e.g. personal surnames, stable national languages, currencies, fingerprints, barcodes and other addresses) that can be used as stable identifiers and, increasingly, these have taken on numerical form (Scott 1998). Again, the general population seems to be in the grip of a mania for 'remembering forwards' by recording their lives which, in part, seems to be an echo of this desire to identify, as well as a new way of dreaming (Carter 1992).

In turn, we might argue that qualculation demands certain kinds of perceptual labour which involve forms of reflexivity that position the subject as an instrument for seeing, rather than as an observer, in which a number of the mechanisms that we take for granted have been integrated into larger systems or into specialized feedback processes. Increasingly, subjects do not encounter finished, pre-existing objects but rather 'clearings' that disclose opportunities to intervene in the flow (Knorr Cetina 2003).

How to characterize this qualculative sense more generally? I want to argue that the best way of thinking about this characterization is to take a leaf from the book of ethnomathematics and to think thereby about transitions to new cognitive modes occasioned by adding new features to physical matter (and especially all manner of pervasive infrastructures) which, arguably, alter the sense of what matter is about. In particular, the new qualculative sense involves a different sense of number and counting and series,[6] a sense which relies on (1) a series of prostheses which routinely offer cognitive assistance and which do much of the work of navigation automatically, (2) a highly provisional sense of spatial co-ordination which is based in the continual spatial and temporal revisions made possible by track and trace systems (the so-called 'elasticity of synchronicity'), (3) a sense of continual access to information (so-called 'ambient information') arising out of connectivity being embedded in all manner of objects, which means that the effort involved in foraging is much less than was the case, (4) a more flexible sense of metric and (5) much less sense of locations as places of return or permanent gathering of the kind constructed around the institution of the domestic house in Euro-American societies from the fourteenth century onwards (Smith 2003).

Ethnomathematics argues that 'there is no single, universal path. . .that. . .mathematical ideas follow' (Ascher 2002: 2). Ethnomathematics is therefore concerned to value systems of number and calculation which do not conform to the base ten numeration system of modern mathematics and which do not regard this system as necessarily at the apex of numerical perfection. Different numerical systems are treated as akin to different languages (suggesting the need for 'bilingual' forms of mathematical teaching in many parts of the world, for example) and are not, as they were in the past, interpreted as indices of differential degrees of civilization or as found entities complete unto themselves. Indeed, part of the attraction of ethnomathematics is that it easily makes space for the complexity of mucking about with numbers that typifies much of everyday life, a complexity which cannot easily be reduced to a 'culture', not least because numbers are figured in multiple ways – usually as little rituals of gesture, utterance and the use of appropriate prostheses – and are not easily reduced to a singular activity called 'calculation' (Lave 1996). This is to say more than that the use of numbers varies with context. It is also to say that the use of numbers is inevitably partial, performative, distributed and often integrated into other activities (for example, navigation, decoration, calendrics, religion) rather than understood as a discrete activity carried out for itself. Another part of the attraction of

ethnomathematics is its understanding of how number interpellates subjectivity by producing particular forms of link. Thus subjects may increasingly understand themselves as the subject and object of number and numerical calculation (cf. Eglash 1999; Mimica 1992).

But what ethnomathematics, in its understandable desire to show up difference, is perhaps less effective at seeing is how the spread of various prostheses is producing an allegiance to base ten means of ordering almost by default. More and more of the world is brought into this means of ordering through the operations of various forms of code and the ordering microworlds that they generate.

What is the cognitive style of the figured materiality in which the North and increasing parts of the South now participate? I have already begun to argue that this is best described as 'qualculation', a style arising out of the sheer amount of calculation now taking place. This style of calculation arises out of the generality of the numbered fields against which and with which so much activity now takes place, the increasing amount of calculation done via machinic prostheses – often to the point where 'human' intervention is distant or even non-existent for long periods of time – and an increasing tendency to frame number as quality, in the sense that calculations are so numerous and so pervasive that they show up as forces rather than discrete operations. Number both frames movement and is framed by it: the two reciprocally confirm each other and provide a window on to a perception of a world which sways and shimmies with the force of qualculation, which folds and flows in numerous ways as different architectures of flow meld and then melt away because of the increased elasticity of synchronicity (and 'synchoricity') that has been made possible.

One word of caution is in order, however. The idea of spaces that fold and flow is hardly a new one. As Carter and many others have pointed out, such a depiction was the stock in trade of a certain kind of modernism and has circulated since at least the beginning of the twentieth century in forms as differently similar as Bergson's philosophy, various art forms (Clark 1999) and numerous works of literature. What is different, however, is that the means to realize this world have now come into being as a result of much enhanced calculation, allowing all kinds of entities which could be imagined but not actualized finally to make their way into the world.[7]

How might we understand how this qualculative world shows (or will show) up? How will it be experienced? In the next section, I want to begin the task of working through how a new sensorium based on qualculation – which assumes a world of movement – might look and feel.

It is important to note right from the start that we already have considerable evidence that what counts as the senses varies cross-culturally. There is no reason to believe that what we count as 'senses' has to be static in character. The sensory orders of cultures can vary radically and so, therefore, can the expectations of what counts as perception and experience. For example, Geurts (2002) outlines a sensorium connected with a number of West African cultures

which is quite different from the Euro-American folk model of five senses which inhabit habitual bodily practice, not least in the fact that there seems to be no articulated sensorium and therefore one has to be imputed. With that caveat in mind, Geurts is able to build up a model of a sensorium less attuned to a standard Euro-American depiction of a strong divide between physical sensation and mental process and between external environment and internal state[8] and which, furthermore, seems to map over into judgements of moral character (Table 1).

The point of Geurts's work is that it shows that there is no need to think that what we name as the senses has a predetermined or stable character. In all likelihood, the constellation of senses and what we may consequently regard as sensations goes through periods of regular redefinition and re-embedding (Howes 2003).[9] Using this insight, the next section takes up the challenge of understanding the qualculative world.

A new sensorium?

How might we expect qualculative developments to make themselves known in the sensorium? It is possible to make a loose analogy with what happened when the material form of the Euro-American city changed in the nineteenth century. Then, a whole set of new habits and their accompanying anxieties had to be learnt: new ways of walking and talking were developed as new addresses for the body were laid down by the new spatial orders (Joyce 2003). What kinds of indices might suggest a similar reshaping of experience?

One of the ways that qualculative developments are most likely to surface is as so-called *mental conditions* in which what is generally a part of the technological unconscious is able to make itself known again as various anxieties and phobias. In the past, there have been a number of examples of such manifestations, including the phenomenon of so-called 'mad travellers' (Hacking 1998). What are the corresponding anxieties and phobias which might become apparent under the new regime of movement-space? Carter (2002) has argued that the range of symptoms known as agoraphobia (which,

Table 1 The indigenous Anlo sensorium

Aural perception or hearing
A vestibular sense, balancing, equilibrium from the inner ear
Kinaesthesia, walking, or a movement sense
A complex of tactility, contact, touch
Visuality or sight
Terms used to describe the experience of tasting
Olfactory action or smell
Orality, vocality, and talking
Feeling in the body; also synaesthesia and a specific skin sense

Source: Geurts (2002: 46–7)

by some estimates, affects up to 5 per cent of Euro-American populations) should be understood as a movement inhibition arising out of an 'environmental unconscious' which has been generated by specific spatial arrangements and the kinds of 'body talk' that these arrangements make possible. But Carter's discussion remains frustratingly oblique about many aspects of these symptoms and other ambulatory conditions: too often in his account the allusive becomes the elusive. That said, his book lays down a challenge to think about how, as spatial arrangements and their consequential modes of body talk are changing, so a different kind of environmental unconscious may be coming about, one in which space is reworked, providing new kinds of locational fantasies and fears, new ambulatory tropisms and tendencies.

Another way in which qualculative developments might make themselves known is through the rise of new forms of *intuition* (Myers 2002). Such forms of rapid reasoning might be expected to alter as the new qualculative background makes itself felt, especially by enhancing intuitive expertise and teaching new forms of intuition. For example, it has been hypothesized that our ability to frame and read 'thin slices' of behaviour may have increased because we live in a world where all kinds of mechanical additions demand (and reveal) fast responses (Thrift 2004b). Again, there is a challenge to think about new kinds of locational knowledge and how they sink into and condition normal social interchange.

In the final major part of this paper, though, I want to try to work through what the experience of a qualculative world might be in a somewhat more systematic fashion. I can only begin this task, however, not least because few accounts have tended to work out in any detail what the space-time signatures of a lifeworld that was heavily calculated (or, as I would have it, qualculated) would look like, even though it could be argued that this is the world that we are increasingly living in, without resorting to the crudest kinds of technological determinism. Often, it is assumed that such worlds would somehow be less human because more 'rational' and 'flowsy'. But perhaps something quite different would happen: new qualities might become possible which assumed this enhanced calculativity as a space-time background through an array of new co-ordinate systems, different kinds of metric and new cardinal points, backed up by much enhanced memory and a certain limited predictive capacity. This background would enable new kinds of movement to occur, against which all kinds of experiments in perception might become possible, which might in turn engender new senses, new intelligences of the world and new forms of 'human'. Necessarily, at this point, I must move to the very limits of conjecture, and perhaps beyond them. But, in order to get some form of grip on these issues this seems to me to be a worthwhile risk to take.

Perhaps it is possible to get at least some sense of the new sensorium that might become possible by considering the reworking of space and time that is being written into the human body and language which, in turn, is instilling a different sense of how things turn up. For what is clear straightaway is that there are and have been considerable shifts in the way in which space and time

have been perceived, shifts which work at a very basic level and which call to the body in different ways. I want to suggest just a few of these, each of them related to the others. The first is the body itself. I shall argue that the hand is changing its expectations. Second, the address. I shall argue that, because things are now instantly locatable, space is changing its character. Third, language. I shall argue that the basic cardinals of what we regard as space are subsequently shifting. In other words, I want to argue that we are increasingly a part of a 'movement-space' which is relative rather than absolute – but which, as I have already pointed out, relies on an absolute space for its existence – in which 'matter or mind, reality has appeared to us as a perpetual becoming. It makes itself or it unmakes itself but it is never something made' (Bergson 1998 [1911]: 272). This making has retreated into the background whence it directs more and more operations. We sense it as a different kind of awareness of the world, one in which space itself seems to perform.

Let me begin with the body. It has become increasingly apparent that to understand the body it is vital to take in the world in which the body finds itself. For example, recent research shows that the body schema extends well beyond the body's apparent physical limit, taking in items like the body's shadow as explicit means of gauging where the body is and how it is moving in relation to other objects. Certain parts of the body are particularly important in acting as bridges to the world and here I concentrate on one of the most important of these – the hand. The sensory system of the hand is complex and capable of exquisite fine-tuning. It is not just an 'external' organ: it is so vital to human evolution that it seems quite likely that parts of the brain have developed in order to cope with its complexities rather than vice versa, thereby providing a sense of the world deep in the supposedly enclosed human body as new kinds of distance have opened up between organism and environment which need to be crossed. A convincing case can be made that the development of the hand has driven human intelligence by being the first, 'ur-tool' (Tallis 2003), a tool able to localize objects precisely in space and apply muscular force to them (Vogel 2001), thereby also, incidentally, giving the body a much greater sense of its own self and existence by labelling actions as 'mine'.[10]

The hand is particularly important in providing not just active manipulation of the world but also a sense of *touch* (Field 2001). As Tallis puts it:

> In the cerebral cortex, different components of touch are integrated into more complex tactile awareness. The movement of the fingers over a surface creates a sense of texture. The overall pressure detected by a large number of displaced sensory endings gives an idea of weight and size. Active manipulation gives a sense of the malleability of the object. The combination of weight and size (and inferred from that, density) of the texture, gives a notion of the material of which the item is made and, indeed, its general identity. This is. . .far from dim groping: it is a highly cerebral matter, as is demonstrated by the huge expansion

> of the cortical representation of the relevant fingers in individuals who use their hands for skilled tasks – violinists, Braille readers.
>
> (Tallis 2000: 29–30)

I want to argue that in a qualculative world the hand will take on some different styles of haptic inquiry: it will *reach* out and *touch* in different ways. In particular, the sense of touch will be redefined in three ways as haptic engineering moves beyond today's primitive keyboard, keypad, mouse and data glove. First, from being conceived as a heavily localized sensation, touch will increasingly be thought of as a sense that can stretch over large spaces, as a 'being of movement from here to there, from one to the other' (Virilio 1997: 24). In addition, through multilinking, more than one site will be able to be touched at a time (Goon, 2004). Second, entities that are able to be touched will correspondingly expand; all manner of entities will be produced with an expanded sensory range. Third, paramount among these newly touchable entities will be data of various kinds which, through haptic engineering, will take on new kinds of presence in the world as something closer to what we conventionally regard as 'physical' objects. In other words, the hand will extend, be able to touch more entities and will encounter entities which are more 'touchable'. The set of experiences gathered under 'touch' will therefore become a more important sense, taking in and naming experiences which heretofore have not been considered as tactile and generating haptic experiences which have hitherto been unknown. Equally, we might expect that descriptions of tactile sensations like 'soft', 'hard', 'rub', 'stroke' and 'caress', 'hold', 'shove', 'push', 'grasp', 'hit', 'strike' and 'seize' will change their meanings. Whether, as in the Anlo world that Geurts studied, a distinctive sense called touch will no longer be encountered as the spectrum of haptic experiences expands is a moot point.[11]

Let me move now to the nature of the co-ordinate system itself. The environment can be laid out in a large number of ways. But what seems certain is that, increasingly, the world will come loaded up with addresses. It will become normal to know where one is at any point, a mechanically induced version of the sense of direction which is similar to that of the cultures that have this facility that were discussed in the previous section. As importantly, the ability to tag addresses to moving objects which started with barcodes and credit cards and is now expanding and becoming more information-rich with the rapidly expanding use of radio frequency identifier chips will mean that over a grid of fixed co-ordinates will be laid a series of moving addresses specific to particular entities. This move is already having consequences which call up an analogy with the kinematics of the reach of the hand. Hands which are reaching out will hover over a moving set of co-ordinates (which Tallis (2003) likens to a flickering flame rather than a single spot), thereby maximizing degrees of freedom until the last possible moment. Similarly, it is possible to see a new locational background appearing in which most of the difficulties of spatial co-ordination will be solved in the same way, by large

numbers of calculations, many of which will be just-in-time. In turn, this should allow new kinds of *exploration* which we are only just beginning to show up (see Parks 2003).

Then, finally, I want to consider the matter of language. Here I want to consider some findings from the anthropology of cognition. For what this anthropology has shown is that thinking about space can vary quite radically from culture to culture, down to and including the most basic frames of reference such as what counts as the characteristic shape of an object, sense of direction, the spatial relation of bodies as they are pointed to and the sense of where a body is in its relation to larger surroundings. In turn, these frames of reference define basic spatial competences such as shape recognition, navigation, sense of where parts of the body are and control of the arm and hand in reaching for something, competences which are regarded as central to most cultures, to the point where not having one of them can be regarded as a sign of madness. Perhaps the most studied of these frames of reference and their corresponding competences is the ability to specify where things are and to wayfind by using various co-ordinate systems. This is convenient since I wish to argue that it is these co-ordinate systems which are most being changed by the numbered materiality in which we now live. It is also convenient because it is clear that cultures vary, and sometimes vary quite radically, in the way that they name and operate cognitively on space in terms of memory, inference, navigation, gesture and so on. For example, Levinson (2003) shows that a number of languages do not operate with the kind of egocentric co-ordinate system which is implied by the English expression 'left of'. In one Mayan area of Mexico there is an absolute co-ordinate system consisting of 'uphill', 'downhill' and 'across' but although 'there are body-part terms for left and right hands and a few speakers find it acceptable to talk about, for example, left and right breasts during breast-feeding. . .there is certainly no way to use these terms to indicate left and right visual fields' (Levinson 2003: 149).

As another example, Levinson shows that a number of cultures have what might be considered an uncanny sense of direction in Western eyes, seemingly having something like a mental compass, a learned ability to maintain fixed bearings at all times arising out of the co-production of brain and gesture, which enables them to point to known locations with very high levels of accuracy.

As one more example, Levinson shows that a number of cultures have massively extended vocabularies for describing spatial configuration, in part apparently developed out of a plethora of material possessions which require fine description (e.g. types of vessel). Other cultures do not, at least in part because they have few material possessions but rely on intimate descriptions of the environment instead, which use other spatial anchors (e.g. place names, topological and topographical correlates).

This discussion makes it possible to speculate about how vocabularies for describing spatial configuration will change in a qualculated world in which

much greater cognitive assistance is routinely available. First, sense of direction will become a given. It will no longer be something that has to be considered. Second, and similarly, wayfinding will become a much easier matter, with much of the effort of search moving into the background.[12] Third, space will increasingly be perceived as relative, strengthening Poincaré's dictum that 'absolute space is nonsense, and it is necessary for us to begin by referring space to a series of axes invariably bound to the body' (cited in Levinson 2003: 9) but this will be a normal means of perception because an absolute space has been established which allows how bodies are moving in relation to one another to be established. It may be that egocentric co-ordinate systems will be strengthened, precisely because that movement is able to be more fully registered. Finally, vocabularies of spatial configuration will multiply. The critical importance of spatial distribution in flow architectures will produce an extended spatial vocabulary which will provide new opportunities for thinking the world, opportunities which will themselves be constitutive of that world. We can already see something of this going on in the practical aesthetics of fields like architecture, performance and film where an emphasis on flow and plasticity has been able to arise out of the numerical weave occasioned by the use of common software packages which, in a certain sense, allow objects to remain in the process of conception and outwith standard perspectival norms (Vidler 2000: 253–4).

Conclusions

What I have tried to do in this paper is to begin the work of trying to demonstrate how exactly a qualculated world will show up, and especially the kinds of movement awareness/cognitive assistance that will be promoted by it. Such a world assumes a certain kind of relative space (though, as I have underlined, riding on the back of the most absolute of absolute spaces) and the migration of a good many spatial skills and competences into the technical background where they are neither seen nor heard but still exert an influence through the agency of software and other recursive entities, calculating each move down to the last instant, so to speak.

What I have been particularly intent on showing is that the realm of ideas exists within a shifting framework which dictates not just how ideas will show up but also a good part of their content. None of this is meant to suggest that ideas cannot have emergent properties and cannot throw themselves forward into new domains. But it is to suggest that it would be foolish to ignore the presuppositions imposed by the generally unremarked backgrounds I have tried to set out here.

Throughout the paper, I have been acutely aware that I am walking a tightrope between the kind of techno-hyperbole which is all too common in this area of work and my desire to start thinking about how the background

hum of thinking will be changed by developments like flow architectures. I am sure that I have overbalanced several times but it seems to me that it is only through instigating this kind of sometimes fevered projection and coupling it with an attention to the basic basics of everyday life that it is possible to obtain some measure of what is going on and what is falling away as new kinds of subjectivity are forced into existence by spaces and times that, through the power of what I have called qualculation, exceed and transform existing spaces and times as they apply a new set of arts of distribution, which bring with them new problems and new solutions (Batchen 2001). This is surely how the history of the present will have to be written.

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Notes

1 In so doing, I am attempting to move just a little way ahead of the past, and produce what Manovich (2001) calls, not simply following Foucault, a theory of the present. See also Thrift (2004c). Necessarily, the paper is therefore speculative in parts but I do not apologize for this. Rather, through this speculation, I want to show the possibility of new properties emerging in the world.

2 As Irigaray (1999: 20) puts it, 'When Heidegger questions the danger of a modern physico-technological project for man's inhabitation of space, isn't this questioning still posed through a Greek perspective? The opening that is brought about by the modern prospecting of space is closed up again by a topo-logic that is still Aristotelian, and, to some extent, pre-Socratic.'

3 Authors like Wolfram (2002) argue that the world should be described in algorithmic terms.

4 'Now we have finally found [the Greek mathematician]: thinking aloud, in a few formulae, made up of a small set of words, staring at a diagram, lettering it' (Netz 1999: 167).

5 To use Newton's well worn phrase in *Principiae*.

6 For an elaboration of these points, see Thrift (2004c) and Fraser (2002).

7 Perhaps the best example of this is a number of modern fighter planes which are inherently unstable and are able to fly only because of the numerous calculations and recalculations made by on-board computers which keep the plane in trim.

8 Interestingly, Anlo seem more concerned with stabilizing the internal state than the external environment.

9 So, for example, the interoceptive and proprioceptive sensations get comparatively short shrift as formal categories of the senses in Euro-American societies, even though their importance can hardly be denied.
10 At the same time, the hand allows humans to think of tools as separate from themselves in a way which animals would find difficult to do.
11 In the Anlo world, for example, touching something soft and touching something hard are regarded as two quite distinct phenomena, two separate ways of touching and experiencing.
12 Activities like geocaching seem to me to be the first of many attempts to make new kinds of way in a world where co-ordinates are easily established. In a sense, they are new rounds of exploration of an already explored world.

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