3 Wedge

What is the archetypal pervasive device, the basic and ancient instrument from which portability, invisibility, everydayness, and participation in discrepancy might derive? It surely is an instrument of adjustment. The search for the prototypical device usually is overridden by the celebration of conspicuous buildings and structures that are thought to realize divine geometries. My argument emphasizes the existence of small-scale interventions into the environment that presage contemporary digital devices. I also emphasize the device ahead of the all-encompassing systems and infrastructure networks, of which devices might form a part. I also emphasize the material device ahead of some ubiquitous all-pervasive field of interaction. The key to understanding the relationship between pervasive digital media and place is in material, tangible, and nonconforming artifacts, outside of some abstract frame of reference.

Much is made in the ancient literature of the procedures for imposing divine order on the apparent disorder of nature,[1] or of identifying the order in the apparent chaos.[2] Certain rituals imply procedures for constructing symmetrical celestial geometries, the so-called pre-Copernican universe.[3] The detection of sunspots referred to in chapter 2 is emblematic of the apparent ancient sublimation of imperfection.[4] Sunspots have been observed on the face of the sun since ancient times but seemingly were ignored. They were difficult to detect, but more important, they suggested imperfection in the entity at the very pinnacle of a perfect universe—namely, the sun. In fact, even with the solarcentric conception of the cosmos, the invention of the telescope, and Galileo's recordings of the migration of sunspots across the sun's surface, there were those who maintained that sunspots were not discolorations on the face of the sun but must be the paths of planets.

There is covert recognition in the Western traditions of the fine adjustments that need to be made, the glitches in the process, the inevitable discrepancy between the ideal forms and the way things actually appear, which point to a "higher mystery." Negotiation of this gap between the ideal and the actual is a practical matter, less prone to regularization, order, and rule. Aristotle highlighted the practical virtue of *phronesis*, the ability to make appropriate judgments in everyday contingent circumstances.[5] There is wisdom in deriving rules of good conduct and forming them into laws and classifications, but the everyday application of those rules requires skilled judgment that is acquired by experience, learning from others, practice, and bodily engagement. Sculptor David Pye points to the need for such judgment in workmanship: "Some contrast and tension between regulation and freedom, uniformity and diversity, is essential."[6] The exercise of such contingent practices across the gap is evident in the way people would hold the stylus in calibrating the old-style touch screen, a subtle practice by which the user would negotiate the space between the device's demands for regularity and the free movement of the hand. Translating a regularized temperature reading into a decision to take a coat with you to the park involves similarly contingent practices, as is the case with the tuning of a violin, and laying bricks to create a wall. Making and constructing provide good cases of the human dependence on careful judgment and the ability to deal with discrepant conditions.

In an imperfect world, managing traditional building processes becomes a process of gap management. The master builder may claim to have the whole design in mind, but the trades people have the know-how to manage the intricacies and ameliorate the problems at junctions, where the ideal hits the contingent, where conditions differ from what they should be,[7] identified by architectural theorist and historian Colin Rowe as "the conflict between the absolute and the contingent, the abstract and the natural; and the gap between the ideal world and the too human exigencies of realization."[8] Successful architecture accomplishes a reconciliation of the mind to "some fundamental discrepancies in the program."[9]

Contemporary ad hoc adjustments on the construction site are anticipated by the classical tradition of arranging architectural elements. Vitruvius focuses on the ends rather than the means, but of necessity invokes adjustment: "The length of a temple is *adjusted* so that its width may be half its length"[10]; "Order . . . is an *adjustment* according to quantity" (my

emphasis).[11] It seems that harmony, order, and symmetry depend on proper adjustment, as if things need to be brought into alignment from an initial position that is a deviation from the norm or the ideal. Adjustment is an active term, and resonates with activity on a construction site. Blocks of stone do not simply fall into place, but have to be maneuvered. The Latin word rendered as *adjustment* in English translations of Vitruvius is usually *temperantur*, a form of the verb *temperare,* to which temperature also relates, and which, according to the *Oxford English Dictionary* , carries connotations of dividing proportionally, combining properly, keeping within limits, regulating, and of course tempering. To temper is to modify something so that it does not go to extremes. The creation of even temperament in music is such an adjustment.

Vitruvius makes reference to visual correction in terms of adjustment. If columns are built with straight vertical sides they look insubstantial and hollow. This is an apparent fault of the observer's perceptual apparatus and must be compensated for: "Hence, we must counteract the ocular deception by an adjustment of proportions."[12] The visual world is subject to deviations that deny perfection, and requires the introduction of curvature (entasis) to the profile of a column.[13]

The necessity for adjustment is also explicit in the construction of war machines, such as catapults. That machines for destroying buildings are described in such a matter-of-fact manner in a treatise on architecture is also indicative of the recognition of a breach in the fabric of orderliness. In any case, Vitruvius describes a catapult in terms similar to the stringing and tuning of a musical instrument:

> Next, the loops of the strings are put through the holes in the capitals, and passed through to the other side; next, they are put upon the windlasses, and wound round them in order that the strings, stretched out taut on them by means of the handspikes, on being struck by the hand, may respond with the same sound on both sides. Then they are wedged tightly into the holes so that they cannot slacken. So, in the same manner, they are passed through to the other side, and stretched taut on the windlasses by means of the handspikes until they give the same sound. Thus with tight wedging, catapults are tuned to the proper pitch by musical sense of hearing.[14]

Among the various components that are named, Vitruvius makes explicit reference to the wedge, which he considers important in the process of adjustment. Circles and squares belong to the language of

platonic perfection, but if you are looking for a shape that corresponds most to the existence of discrepancy then the wedge is the best candidate.[15] The wedge is the operative device for adjustment and tuning; it is perhaps the archetype of pervasive media. Wedges are bits of wood with a triangular profile, one side narrower than the other, which can be jammed into place with a mallet. In the case of Vitruvius's catapult, a rope passed through a hole at the top of a thick rod is wedged in place after being tightened by a rolling mechanism. The harder you hit a wedge, the further in it goes, but a wedge also pushes out to make a gap bigger or to fill it. Mumford references the wedge indirectly in his praise of wood, which has the capacity to be "split and split again with the simplest tools—the wedge and the mallet."[16] A wedge also increases traction and makes it harder for wheels and barrels to roll down hill, or for taut rolls of rope around axles and pulleys to unwind. The constructional and structural advantages of the wedge are apparent in the case of the stone arch,[17] formed by a series of wedge-shaped stones that gravity jams one against the other in succession, with the sharper end of the wedges pointing downward. The top of the arch often is completed with a keystone, a bigger wedge of stone that closes off the top. The keystone is an element that accommodates discrepancies.

The wedge is a means of adjustment and serves to hold things in place. Carpenters may deploy several wedges to keep a wooden frame aligned and in position. Two pieces of wood can be joined together by a mortise-and-tenon joint, which involves shaping the edge of one piece of wood into a series of wedges, which lock into the spaces between corresponding wedges in the piece to which it is joined.

Wedges were also used in the calibration of water clocks, according to Vitruvius: "The hours are marked in these clocks on a column or a pilaster, and a figure emerging from the bottom points to them with a rod throughout the whole day. Their decrease or increase in length with the different days and months, must be adjusted by inserting or withdrawing wedges."[18] Similarly, he says of pumps: "Over the vessel a cowl is adjusted, like an inverted funnel, and fastened to the vessel by means of a wedge thrust through a staple, to prevent it from being lifted off by the pressure of the water that is forced in."[19]

If astute observers of the manufactured and built environment allow their imaginations to run with the wedge, they will then see wedges every-

where. Teeth are in fact wedges. The axe, the most primitive of tools, is a form of wedge, as is a pick, a knife, an adze, a sewing needle or acupuncture needle, a nail, a skewer, a spike, and a rapier, all of which are instruments of reduced thickness in the direction of the force applied. The operations of the wedge apply to both swords and ploughs. An adze, which is a flat-edged pick for chipping at a surface, is "self-jigging," which means that its form acts as a template for the shape it produces and works.[20] The narrow side of the wedge goes in first and works the gap, translating a longitudinal force into an approximately lateral one, which is also the effect of a lever, or a ramp. The British idiom "the thin edge of the wedge" refers to the start of something of greater consequence. Once the point enters the material its splitting can be achieved with greater ease: a wedge-shaped military formation of tanks apparently achieves something similar, as a task force that is able to advance while simultaneously attending to its flanks. The wedge has evolved into more complicated apparatuses. For example, the screw is a twisted wedge that provides greater control and firmness of fit. Cogwheels, used in clocks and other machines, are made up of regularly spaced wedges that engage with the gaps between the wedges of an adjacent wheel. A ratchet deploys a rack with wedge-shaped teeth that engage with a pawl, a hinged and wedge-shaped component, to restrict mechanical rotation to a single direction. Wedges imply engagement, locking, and keying.

As for the keystone, significance is attached to the capping stone and ceremony is attached to the completion of a dome, and the accompanying capping-off ceremony. Capping off implies culmination, but also the final cover-up, the apparent gathering and occluding of all discrepancies, though in some cases this makes them all the more obvious, or at least draws attention to a disregard for precision. The wedge as keystone or inverted as a pyramidal capping element fulfills this role. It is an imprecise device for achieving an impression of accuracy, order, and neatness. There is more tolerance in the specification of a wedge than a wheel. The angles of the sides of the wedge do not need to be exact. Gaps are managed by the depth at which you drive the wedge. The workings of the wedge are apparent to anyone who has had to improvise a wedge of folded paper to slip under a table leg to stabilize a table in a restaurant.

Can we also build an understanding of idealized ordering on the tenuous foundation of the wedge? When formalized, the wedge gives birth to the

triangle, a primary platonic form. Surfaces bounded by straight lines can be broken into triangles. Complex meshes and networks are shown as so many overlapping triangular shapes. Triangles are planar and stable. In buildings, triangles come into their own in elevation, in the distribution of gravitational loads, the shedding of water, and in buttresses and ramps.

There is psychological evidence for the primacy of the wedge in human cognition. Rudolf Arnheim demonstrates the obvious importance of the approximate circle in the drawings of young children. A circle delineates an object of as yet unspecified shape. Everything is drawn as a circle, but when the infant starts to introduce other shapes, then she starts to represent objects that she actually thinks of as round: faces, the sun, flowers. According to Arnheim, "A circle is a circle only when triangles are available as an alternative."[21] Wedges and angles are the medium of discrimination, including the appearance of scribbled "saw teeth" to represent hair drawn around the circle of a face.

According to this trajectory of investigation, the archetypal pervasive device is a wedge, not a wheel. The wedge is local and interstitial, compensatory, and apologetic. What is the relationship between the wedge and contemporary pervasive media? Designers and users deploy various words for a technological component or machine, such as *mechanism*, *apparatus*, *instrument*, *tool*, *device*, and *gizmo*. A common diminutive term for a machine component is *gadget*, which the *OED* suggests might derive from French *engager*, to engage one thing with another. A wedge facilitates engagement, and therefore is a kind of gadget.

Widget also is a common term denoting a trivially simple but perhaps essential apparatus whose name one may have momentarily forgotten. The *OED* suggests its origin in the term *gadget*. Widget seems to be a twentieth-century portmanteau (a word formed by joining two others, merging their meanings) and several dictionaries suggest it is a combination of *window* and *gadget*. The Online Etymology Dictionary suggests widget might be derived from "which it." Irrespective of a word's etymology its usage can persist due to connotations. The sound of "widget" is suggestive of fidget and digit, and indirectly of a key. It is also suggestive of wedge, though I know of no source as yet that refers to widget as "wedge it."

A discussion of wedges, cogs, ratchets, gears, and mechanical composites is perhaps apposite when we reflect on the history of computing (the Jacquard loom, Charles Babbage's Difference Engine, the Enigma

cipher machine, old office adding machines[22]), and the popular romance with machinery in science fiction, fantasy, computer gaming, and steampunk culture. The differences between the idea of a wedge and a sophisticated item of pervasive computing such as a mobile phone are obvious. A wedge operates within the mechanics of adjustment, and is a long way from precision electronics, which is dependent on complex technological infrastructure. But diminutive terms are often deployed to account for the most complex and sophisticated organization: *plastic* for credit card, *hardware* for computer, *handy* (in German) for mobile phone, *widget* for a self-contained computer program. A simple characteristic is deployed to stand in for the whole complex apparatus—like the thin end of an ontological wedge, a metonym that stands for the whole, the tip of the iceberg connected to an invisible, uncharted, and unfathomable mass. Pervasive devices are often placed at the "cutting edge," and Internet blog addicts are on a slippery slope. Thus the alignment of sophisticated electronics with the wedge that works, fills, and creates the gap participates in familiar linguistic practice.

Colleague Dermott McMeel has examined the use of mobile phones on building construction sites in this context. Regulators often forbid mobile phones on building sites for reasons of health and safety, but where they appear they frequently are deployed as a means of stopping gaps: to make an emergency call to a supplier, for example, or get clarification of an instruction or a drawing. The contract documents (drawings, blueprints, specifications, shop drawings) and the line-managed passage of instructions provide the legally sanctioned framework for the project, but frequently it proves necessary to jump out of this framework and resort to unofficial lines of communication. Pervasive digital media provide conspicuous means of adjusting meeting times, schedules, and instructions. Of course it is not the devices in isolation that provide the adjustment, but the access, communication, and attendant social practices that they support or bring into focus on the construction site.

There are several aspects of ubiquitous devices that render them as "stop gaps," as ubiquitous, inconspicuous, portable, disposable, interchangeable, and incidental. They do not draw attention to themselves, but facilitate the operations of the network. They support something larger and more consequential. A structural wedge does not achieve much on its own, but supports the conspicuous edifice. It can also be replaced by something

more secure or long-lasting. Like many cutting-edge electronic devices, mobile phones become obsolete within a year or two, but people hold on to them or pass them on. The device often fills a provisional role until the next model comes along. They are not only transient but also support and encourage transience, drift, slackening, and looseness in social relations. Think of the emerging casualness in appointment keeping. People might think less of running late for an appointment given they know they can phone ahead to explain. The device fills the discrepant gap in the schedule. It also adjusts and transforms the concept of schedule.

Sensory Wedges

The wedged profile features prominently in early accounts of architectural acoustics. For Vitruvius, the cornice is an ornamental detail that facilitates the transmission of sound. The cornice after all has the profile of a chamfer, an interior corner blunted by an angular edge. This wedge-shaped device covers over discrepancies in the junction between wall and ceiling, has an ornamental role, and serves to modify sound reflections.[23] The function is similar to that of the deflecting board above a pulpit that assists in the transmission of speech.[24]

Triangles also relate to lines of sight. Renaissance essays on perspective in painting draw attention to the importance of the pyramid, a three-dimensional wedge shape. In his treatise *On Painting*, Alberti relates the pyramid to the eye: "The vertex of the pyramid resides within the eye, where the angles of the quantities in the various triangles meet together."[25] Rudolf Arnheim writes about the importance of non-Euclidean, "pyramidal space" in the perception of environment.[26] The human understanding of space deals in convergences, and the perspective vanishing point constitutes the tip of a wedge.

Trinitarian symbols abound and feature within classical ideas of spatial organization. The triangle speaks of perfection and ocular dominance. But as its everyday forebear, the wedge does the work, including in visual perception. Philosophers of perception draw attention to the irregular trapezoidal nature of the visual patches that make up the visual field, which the human perceptual apparatus then processes into solid shapes and objects. According to philosopher John Hospers, perception of a table-top begins with "a trapezoid with the acute angles on the nearer side,"[27]

and a succession of variants that present themselves as one moves and which one learns to form into a continuous sense experience and thus a contiguous object. As is obvious in the crude graphical representations of early 3D computer games, the visual field can be construed as a collage of irregular wedge-shaped planes on the computer screen.

Cubist painting, the art of the Russian Constructivists, and the contemporary architecture of Zaha Hadid present as a celebration of fracture, rupture, and displacement realized often in terms of wedge-shaped, shard-like forms (more recently replaced in Hadid's work by fluid forms). So many acutely angled lines intersecting irregularly and according to site contingencies produce architectures that break with centrality and classical notions of symmetry.[28] Such forms are also artifacts of exaggerated straight-line-perspective geometries, as when simulating a wide-angled lens in a computer renderer that always draws straight lines as straight rather than curved as in a wide-angled photograph. Like straight railway tracks disappearing into the distance, wedges are ubiquitous in simplified ocular geometries. Sonic and ocular sense impressions converge on the wedge. Sound designer and colleague Martin Parker inverts the romantic metaphor of architecture as "frozen music" to inflect the dynamic of live performance: "Being neither frozen architecture nor liquid music, these live encounters are fractured and shard-like."[29] Sound structures often draw on the wedge.

Sound versus Sight

Attending to the relationship between the senses also highlights the role of the gap, as if there is a wedge driven between the senses. As I have shown, the scientific models that philosopher Mary Hesse invokes to account for analogy include the propagation of light waves with the transmission of sound. Sight is compared with sound in a kind of cross mapping. Calibration across the gap has a role to play in coordination between the senses. The senses are constitutive of different perceptual models, each carrying particular entailments. For example, some claim that sound requires visual confirmation of its source. For cultural theorist Steven Connor, sound "is experienced as enigmatic or anxiously incomplete until its source can be identified, which is usually to say, visualised,"[30] a requirement that is not necessarily reciprocated in the case of the visual sense. Whereas human beings appear to be adept at visual closure—completing

an image consisting of four L-shaped marks such that the observer infers a square—human language for replacing sonic deficit seems to call for entities outside the experience of sound. In many ways sound is suggestive of incompleteness, and vision of completeness. Connor deploys the functioning of teeth to emphasize this incompleteness. After all, the voice, the major bodily sonic apparatus, involves the rolling volutes of the tongue, which are cut short by the abrupt operations of wedge-shaped teeth.

Wedges are devices for recalibrating structures and mechanisms so that they fit their environment and fit together, or interoperate. They also cleave, separate, and articulate the fissures between surfaces, rendering conspicuous the grain between devices and within networks. I have so far mainly considered calibration as a process involving two models that have to be aligned in some way under carefully controlled conditions. It only takes one wedge under the leg of a four-legged table to make it steady, but if the table surface is to be level or at a certain height then more wedges may be required. Making several interrelated adjustments is difficult. In some circumstances a complex measuring instrument similarly must deal with several interrelated variables such as temperature, air pressure, and altitude. The obvious procedure would be to isolate each variable and test them in turn. Procedures exist for *multivariate calibration*, the calibration of devices with many interrelated variables, typically involving rapid iteration through multiple readings and involving the adjustment of several variables. The readings can be handled probabilistically. Calibration therefore becomes particularly troublesome and interesting for ensembles of devices, or complexes of variables, none of which is entirely stable during the calibration process. Pervasive, ubiquitous, interconnected sensing devices might require calibration of this kind. Automated multivariate calibration is one of the elusive goals of pervasive digital media.[31] I will return to consider such calibration after a discussion of social tuning.

Social Tuning

The claim that clocks synchronize people's actions appeals to a standard, that of clock time. The clock provides a regular model against which to calibrate personal and group schedules and routines. Clock time ostensibly reduces reliance on negotiation and the subtle alignment of patterns and practices. Small, localized communities may be adept at organizing their

routines by virtue of habituation and subtly nuanced signs and cues involving diurnal cycles, bodily rhythms, and informal communications: coming together or dividing their time for meals, work, recreation, and sleep. But it seems that commerce, trade, public transportation, and large-scale organization across distances involving large numbers of people require the externality of clock time, as an independent standard that people can share and against which they calibrate their actions. But even synchronization to the demands of the clock requires proficiency in the subtle, human arts of tuning.

Tuning as a human, interpretive activity seems to take place at the boundaries, the gaps between models, where calibration, recalibration, alignment, and measurement call on interpretation, judgment, and the visceral intelligence of human bodies. Musicians and computer users calibrate equipment to human particularities, such as tuning musical instruments to scales, or training voice recognition software to respond to the sound and inflection of a person's voice. But consumers and users also tune their faltering human practices and perceptions to equipment, at least as a kind of training. The calibration of a touch screen adjusts the equipment. It also provides a simple rehearsal for the user of the touch screen. It trains the device user to regard the process of drawing on the screen with a certain degree of care. The calibration of language recognition software and voice-activated devices operate in a similar way. The speaker trains the program to recognize words, inflexions, and usage patterns to refine its pattern matching and indexing functions and so convert speech to text. Users of such programs also report that they learn to adapt their speech to the program. They learn to speak "naturally" and clearly, and by pausing in the right places. Musical training is an elaborate and extended process of tuning muscles and nerves to align with the characteristics of a musical instrument. Technological implants and prosthetics also require extended tuning and retuning of bodily functions, as well as the calibration of equipment.

Recalibration implies resetting a device, model, or program so that it operates reliably, predictably, and with stability in relation to a reference model. Recalibration is required when the models drift out of alignment. But recalibration can be a dynamic process. Calibration is a special case of a process that is ubiquitous and constant within organisms and human relations. Cyberneticians explain the relentless processes of calibration and

recalibration in terms of feedback loops. The organism moves in its environment, picks up signals that indicate some change, and responds with an appropriate action.[32] This produces further changes and responses. In walking, every step not only advances locomotion, but also provides feedback about surface, gradient, stability, and various resistances that contribute to the way the foot falls at the next step. Therefore walking on a pavement requires a different pattern of movement than does walking on a hot sandy beach. Dancing, ensemble playing, group working, sports, combat, and even conversation seem to require this two-and-fro movement that constitutes a series of complex, instantaneous, multivariate calibrations and recalibrations, tunings and retunings.[33]

Theories of embodied intelligence render such tuning processes inevitable and endemic to the way organisms are shaped and keyed to their environments (their morphology).[34] Tuning does not always equate to calculation or deliberative cognition. By virtue of muscle and nerve dynamics, and the general shape of things, creatures fall into stable patterns of movement (walk, trot, gallop) that require only minor adjustment by neural control. Neurologists Rolf Pfeifer and Josh Bongard describe such adjustments as "slight modifications." They also describe the way that an organism learns and develops as "an incremental and continuous process," by which the behavior of the organism alights on new "attractor states," stable moments of activity that are well suited to its physiology. From the perspective of embodied intelligence, tuning is less a cognitive labor than it is a process of letting things fall into or out of alignment.

It seems that similar tuning processes are in play as people interact with one another. Alfred Schutz places music at the apogee of social attunement. Music presents as a "mutual tuning-in relationship,"[35] indicative of all communication. Ensembles of musicians "tune" to one another's styles and expressive gestures: facial expressions, gestures in handling their instruments, posture. Practices that are in some way oblique to the task at hand are brought into play. Social activities seem to display something of the complex character of a multivariate calibration. Extended practice enables ensemble players to tune into and retune to each other's performances. Performers can be observed to participate in incessant retuning as they make microadjustments to their playing. A violinist makes small adjustments to finger positionings in order to compensate for a string that is slightly out of tune, or even an accompanist's slightly variant tuning.

The judicious use of glissandi (sliding notes) and vibrato enable vocal and instrumental performers to work around discrepancies in pitch, to inflect and calibrate as they go. In fact, the whole range of "expressive" musical moves, pitch, and rhythm play into the process of retuning in solo and ensemble work. As it happens, tuning is thought to have performance value in its own right, as proposed by the artist Marcel Duchamp: "Have a piano tuned on the stage . . . or make a movie of the tuner tuning and synchronize the tunings on a piano. Or rather synchronize the tuning of a hidden piano—or have a piano tuned on the stage in the dark. Do it technically and avoid all musicianship."[36]

Music also has an instrumental role in coordinating other activities. In his work on the history of technologies, Arnold Pacey notes how groups of workers use music and its rhythms to synchronize work.[37] In the Scots Gaelic traditions of textile production, women would sit around a table, grasp the sides of a length of newly woven tweed and beat it against the table in order to soften the wool fibers, all to the accompaniment of a repertoire of song, gradually increasing in tempo. These are known as "waulking songs." There are many examples where music seems integral to work processes, from cotton picking to warfare. The role of such practices in synchronizing the sociable aspects of certain activities are obvious cases of those secondary processes by which people align their practices, and tune their behaviors. Some practices apply to the short-term moment-by-moment performance of a task, but some abet longer temporal intervals, such as the ringing of bells in churches and monasteries, calls to prayer, and the observance of timetables and calendars.

People primarily think of synchronization, calibration, and tuning in terms of temporal coordination, but tuning also applies to space, being in the same place at the same time, and coordination of sensory experience: such that I see what you see, hear Mozart as others hear him, am repulsed by the scent of boiled cabbage as are my siblings, feel the touch of a guitar string as does my teacher, acquire the same taste for wine as members of my diners' club. Social calibration is temporal, spatial, and sensual and works through everyday practices.

As I have shown, commentators and designers often think of such tunings in terms of coordination and synchronization, in which machines and tools play a crucial role. Mumford's elucidation of the advent of the industrial era focuses on the central role of time keeping, through regular

observances, sundials, water clocks, and mechanical timepieces.[38] By this reading, human societies deploy technologies to coordinate and synchronize their activities. Devices calibrate and tune the actions of people, to their environment, certainly, but also tune people to one another through their environment. As social animals, human beings use technologies to bring themselves into line with each other. According to cognitive scientist Edwin Hutchins, "the real power of human cognition lies in our ability to flexibly construct functional systems that accomplish our goals by bringing bits of structure into coordination" by deploying "artifactual and social interactional resources."[39]

If Mumford presented the clock as the pivotal technology to mark major social change, and the industrial, scientific, liberal age known as the "modern period," for his protégé, Marshall McLuhan, the operative technology was print.[40] It was language and its technologies that marked the transition into the modern, industrial era: sign systems (languages), texts, tables, dictionaries, encyclopedias, and indexes. For McLuhan these are visual technologies, amplifying the sense of sight, converting the aural medium of the voice to the visual media of writing and then print, able to be stored and mass produced. Language and its technologies of dissemination and preservation are the most conspicuous means of coordination and calibration within human societies. Electronic and digital technologies extend linguistic capability, but also amplify the range of sensory modalities. Writing in the 1960s and no doubt thinking of the incessant chatter of transistor radios, for McLuhan the electronic age returns human kind to the era of the ear, but we also have our eyes wide open.[41] Pervasive digital technologies are now implicated in this social tuning. The development of social network media seems to extend the means of disseminating, regulating, and monitoring shared practices.

Does this social tuning have as its end a process of harmonization, bringing social relations into a uniform, homogeneous, hierarchized whole? Social misalignment is commonly described in terms of a "culture gap," to be bridged by education, coming into contact with others, and exposure to the mass media, commerce, global capital, and the apparatus of the state. Contrary to such normative controls, liberal concepts of social tolerance imply looseness of fit, providing room to move, to disagree, on religious and other issues, as explored by the libertarian philosopher John Stuart Mill (1806–1873).[42] Liberalism implies openness to processes of

alignment and misalignment, tuning and detuning. It is one thing to think of technical processes as working in concert in finely coordinated harmony, but human relations are more complex than machines, and benefit from friction and instability. To think otherwise is usually to appeal to some variant of utopian romanticism, idealism, or, worse, a return to feudal, bureaucratic, or dictatorial social organization. It is as well to attend to the gap as a palliative to social control. Tuning is a dynamic process that works the gap, at times amplifying, distorting, exaggerating, or diminishing difference, in order to bring two or more models into alignment with one another and see what interference patterns might emerge. As a dynamic process it implies restless change and adjustment in concert with, or in contrast to, moments of stasis.

If designers and social commentators think of the role of language in tuning human relations, then they could do worse than attend to the indeterminate operations of metaphor. If nothing else, the wedge is a suggestive and provocative metaphor for understanding the relationships between humans and their devices.

Tuning and Metaphor

As I have indicated, the most general formulation of the technical calibration problem is of the adjustment of one model with another, an adjustment necessary between two models. I have been dealing with technical models that involve interconnections and causalities. Such models concern physical objects, mechanisms, signals, and patterns. But I am also dealing with sociotechnical contexts. There has to be a context in which it makes sense to compare those particular models. Models have to be detected, identified, isolated, observed, and interpreted. What constitutes a model in any circumstance is open to interpretation, justification, and argument.

Models are created and not simply found. Calibration (and tuning) is a specific and instrumental case of the general problem of metaphor, and of language. One mode of experience is linked to another and reveals certain similarities and differences, as in the case of the water and light models of the propagation of waves. Such models are also metaphors or analogies, which Hesse describes in terms of contest, or *agon*: "Of course the description of similarities and differences between two analogues is a notoriously

inaccurate, incomplete, and inconclusive procedure. Although we often feel some confidence in asserting the existence of a similarity and that some things are more similar to each other than to other things, we cannot usually locate discrete characteristics in one object which are positively and finally identifiable with or differentiable from those in another object."[43] Hesse is here describing models in science and other domains of measurement and their interpretive and conflictual character, an observation that can apply to all metaphorical interactions.[44]

The operations of metaphor therefore embrace ethical and political considerations. One model in the comparison is generally privileged above the other: the secondary model is calibrated against a standard. So the standard takes priority. Likewise a sentence is subservient to the thing to which it refers. A reference has to be adjusted to fit the referent. Any description language submits to the authority of the thing being described, the signifier adjusts to fit the signified, and the explanation adjusts to the explanandum. Calibration, or tuning, already implies a value is being assigned to models. The touch screen has to be calibrated against the visual display, rather than the other way around. It only makes sense to calibrate with the visual display, not the keypad, and the visual display has primacy. Recall Connor's observation of the incompleteness of sound until the listener can visualize its source.[45] Visual models are generally prioritized over the sonic. Tuning is therefore value laden. Metaphor involves similar entailments of priority. Depending on social context, some metaphors assume more importance, or greater currency, than others.

I mentioned "frames of reference" in chapter 2 in relation to standards. One problem with standards in the construction industry is that there are many players, professionals, and stakeholders, and each has a different view of the world, that is, a different frame of reference, or model. Political difficulties arise where the standards favor one frame of reference over another, or enable interoperability between powerful stakeholders (planners, developers, and contractors), but marginalize others, such as consumers, resident communities, and people working in minor trades. Certain players have to struggle to get into the tuning game.

The nature of calibration and tuning as implicating value is obvious in emerging metaphors of the city. So-called smart mobs suggest urban life in which individuals are empowered to contribute to something greater than the parts, a contribution that is socially redemptive. The autonomy

of the urban crowd suggests the metaphor of the city as organism. Think of the properties of an organism: alive, self-determining, willful, growing, changing, sentient, in an environment, and in a complex relationship with other organisms. A city may suggest other entailments: a human construct, an overlay of models, historical, governed, subject to laws, which houses people, and has functions. What adjustments to these various metaphors are needed so that each is referring to the same thing? In other words, how are these concepts calibrated one with the other? How do critics, planners, and inhabitants calibrate organism with city and city with organism? This tuning is a two-way process. It is also a linguistic question, and an incremental linguistic operation. Terms are adjusted and configured to make sense of the comparison. Similarities and differences come to mind. Such tuning also raises a design question: how do you make a city more like an organism? What pervasive technologies facilitate this organic interaction, provide the variable ligatures in the complex network of human relations, and assist in the tuning and coordination of human endeavor? What technologies pull apart and reconfigure human relations?

Returning to the wedge as a particular metaphor: the wedge is emblematic of marginality in physical space. The wedge is the form of improvised constructions. The "lean-to" is an improvised structure formed by placing a less enduring construction, such as a wooden frame or a series of joists, against a solid wall to create a wedge-shaped structure, in other words, a planar frame that is neither horizontal nor vertical, but leans at an angle against a wall. Its roof sheds water as needed; its overall structure requires minimal precision. There is less of the ideal built into such structures, and less accuracy required in their construction. Such interstitial structures are themselves gaps in the order of the city. As well as emblemizing the forms of slum towns and *favelas*, there are parallels here with the way mobile phones have been adopted in poorer countries by a class of trader identified as the "microentrepreneur,"[46] who might minimize the cost of communications by adopting a hand-me-down mobile phone and using unanswered call tones as a code to signal that the milk delivery is on the way. Such interstitial practices lean on the expensive cell phone infrastructure designed for a richer clientele.

Organic metaphors of the city currently hold greater allure and currency among liberal planners than models that rely on hierarchical organization, where everything is master planned into place, a standardized, regimented

city order. Such organic constructions can be contrasted to the obsolete concept of the ideal city, against which meager urban instances (London, New York, Paris) are supposed to be measured and calibrated. The formal, obsolete metaphors propose retuning as reparation.[47] Insofar as visitors and inhabitants experience real, contemporary cities so they participate in myriad social relations and interests governed by complex tuning practices.

Support for a politics of retuning comes from social historian Michel Foucault. Under the sway of the clock, society moves toward certain alignments and realignments, configurations and reconfigurations. Foucault talks of the role of repetitive practices in the assertion of rule in institutions.[48] So marching in time, exercise drills, and the regularization of times of sleep, ablutions, cleaning, meals, and so on have had an important place in the institution of military discipline, as in schools, hospitals, and prisons. Foucault's argument refers to the progressive development of the "modern era," where society opted to regularize itself and so bring practices into ordered alignment, rather than resort to ad hoc, brutal, and autocratic processing in the exercise of power. Historians may speak of increasing democratization, regard for verification and evidence, industrialization, freedom of thought, liberty, and enlightenment, but the modern era is also marked by the introduction of techniques for regulating the human body, its movement, comportment, and surveillance, processes readily associated with social tuning, desirable or otherwise, but according to Foucault essential in order to get things done.

Metaphors of the city based on tuning return us to the incremental, which at the pen of sociologist Michel de Certeau also becomes a political process involving empowerment. According to de Certeau, the users of the city make "innumerable and infinitesimal transformation of and within the dominant cultural economy in order to adapt it to their own interests and their own rules."[49] He said of the immigrant worker: "On the same terrain, his inferior access to information, financial means, and compensations of all kinds elicits an increased deviousness, fantasy, or laughter."[50] As for the microentrepreneur, this kind of retuning celebrates small-scale opportunism: "The tactics of consumption, the ingenious ways in which the weak make use of the strong, thus lend a political dimension to everyday practices."[51] These are processes akin to bricolage and "artisan-like inventiveness."[52]

> Many everyday practices (talking, reading, moving about, shopping, cooking, etc.) are tactical in character. And so are, more generally, many "ways of operating": victories of the "weak" over the "strong" (whether the strength be that of powerful people or the violence of things or of an imposed order, etc.), clever tricks, knowing how to get away with things, "hunter's cunning," maneuvers, polymorphic simulations, joyful discoveries, poetic as well as warlike. The Greeks called these "ways of operating" *metis*. But they go much further back, to the immemorial intelligence displayed in the tricks and imitations of plants and fishes. From the depths of the ocean to the streets of modern megalopolises, there is a continuity and permanence in these tactics.[53]

De Certeau describes the resistance of certain indigenous cultures to colonization: "They metamorphized the dominant order: they made it function in another register."[54] Functioning in a different register alludes directly to processes of calibration and tuning. In his treatise on walking, *Step by Step,* the philosopher Jean-François Augoyard further celebrates the small change as perpetuated by residents of a large public-housing development:

> Altering a partition, placing a flower pot on the window sill, or daubing some paint on a façade does not broach the geometric massiveness of the habitat-object. And yet these rare blisters and swellings, these secretive transformations, these sporadic scratches manifest, in an almost derisory way, a force that is perhaps more insistent than it might at first appear; this is a force neglected by our scientific knowledge because it is not of a stable nature, thetic, "essential," but rather a capacity for alteration, a mode, a way of doing.[55]

Tuning and Design

How does tuning mesh with issues of the urban environment and its design in the digital age? According to a common view, the designer identifies a gap between a desired condition and an actual situation. To offer an example: I need nutritious and palatable food, and technologies of food preparation and cooking are developed to fill the gap between my needs and starvation. A would-be traveler needs to meet with associates in another, distant location, and so technologies of travel come into being to bridge this spatial gap. Likewise the need for shelter from the rain is met by roofs; the need for instantaneous communication across distance is met by telegraph and the telephone. According to this view, machines address human needs. Discrepancies between desires and circumstances

constitute gaps that devices fill. Of course, technologies open up further gaps or needs. Roofs need to be maintained, and cars need infrastructures. Those who can afford them fill the gaps with yet more devices. The gap features within common narratives of the insatiability of capitalist consumption. Technological development presents as a progression to finer grades of gap filling, the most recent stage of which is met by portable, personal, and customized ubiquitous devices. Concepts of pervasive digital media can perpetuate this trajectory, as if contemporary urbanites construct the need for their world to be filled with intelligent, interoperable, invisible computational devices. This model resonates with the early systems thinking of Christopher Alexander and the concept of fitness:[56] design enters to provide fit between goals and circumstances, as if there are complex structures of goals, needs, desires, subgoals, and the complex of environmental circumstances. The two models of needs versus circumstances require calibrating and recalibrating, aligning with one another, and devices do the job. A Darwinian version of this approach to design invokes concepts of the survival of the fittest. As for organisms, designs survive and thrive on the basis of how well they accommodate the exigencies of their environment, the design ecology: design as a complex adaptive system.[57] Perhaps I do not need to embark on a critique of these approaches here. Suffice it to say, needs and fitness are elusive, as contexts change.[58] It is sufficient to note that calibration and tuning provide interesting metaphors for formulating such approaches to design. In this case design, as the optimization of a fitness function, constitutes one particular take on the operations of tuning.

In summary, calibration and tuning feature as major design issues in the creation, invention, and configuration of pervasive digital media. There are several further design responses to the tuning metaphor.

First, calibration can be targeted as an undesirable characteristic of a fledgling technology that has to be eliminated during the design stage, or at least the device can be designed so that the user need not be involved in the tuning process. In this case the challenge is to make the calibration of the device invisible, as when I travel overseas and my mobile phone automatically searches and adapts to a new network provider.

Second, the challenge is to make the manual calibration task as simple as possible for the novice, or at least to ensure that the calibration consti-

tutes an event that has meaning in terms of the use of the device. Calibration assumes the ritual significance of a musician tuning her violin. Detached instrumental calibration becomes meaningful ritualized tuning. My cell phone currently announces my arrival within the orbit of a different network provider in a subtle way that makes me aware of the change, and reminds me of the complexity and intelligence behind the device that supports my roaming communications. Tapping a touch screen on a handheld device to calibrate it (a process now largely obsolete) serves as a rehearsal and an inauguration ritual that relates to the context of use of the device, in the way that opening the back cover of a mobile phone to replace the battery or SIM card perhaps does not. Celebrated experiments into the coupling of electronics and organism point to the fusion of animal and machine, brought about by cyborg implants and prosthetics. Arguably, little attention is granted in the technical literature that celebrates the concerted human labor required in tuning, to successfully connect "biological neural tissue to technology."[59] The processes of tuning and such retuning are clearly subject to design consideration.

Third, a designer might think of a device as a means to facilitate adjustment and to fill the calibration gap, as in the case of the wedge. Devices can be thought of as enhancing fit, mapping territories to one another, or re-enforcing a standard. In this light a GPS device serves to calibrate visible landmarks with map coordinates, or my understanding of where I am with the map, or to tune hill walkers' movements relative to one another as they converge on the same landmark at the same time, much as timepieces synchronize "the actions of men."[60]

Fourth, tuning also features in a methodology of design that draws on templates, the selection of an appropriate type or solution from a set of templates, which is like designing by catalogue. As a model, the template has to be adjusted to fit the contingent circumstances. And so there are templates for web designers, the precise format and content of which may be adjusted for use by the retail or institutional client. Classical buildings and speculative house construction have often been produced in this way, from stock plans. The clever part of the design is in the adjustments that have to be made. There are now standard designs, operations, and shapes for cell phones and digital cameras. The fine differences between them can be understood in terms of adaptations and adjustments to different circumstances, market niches, and local conditions, as in the case of the

Ilkone cell phone that contains a compass for indicating the direction of Mecca. Tuning applies to market differentiation.

Fifth, bringing tuning to the fore goes some way in humanizing technology, or at least recognizing it for what it is, as dependent on adjustment. There is clearly a risk in the concept of a one-off calibration without recalibration. Media theorist Sean Cubitt highlights this in remarking on how remote-sensing scientists apparently calibrate the colors of the terrain on known "training areas," after which other correlations are extrapolated, which contributes to capitalism's "dangerous and damaging administration of global resources."[61] Could devices be designed such that they require periodic retuning to remind us of their limitations? Calibration and tuning procedures can be designed into devices as conspicuous processes that engage the user.

Sixth, tuning provides potent metaphors through which to think about the design process. Design is a venturing forth from a standard condition to an unknown contingent condition, with reference back to the stable home base. Attending to tuning can engender sensitivity to context and risk taking. The metaphor also invites a consideration of the effects of interference, where one model overlays another, and a discrepant condition emerges that is suggestive of something new. The new entity is a hybrid condition to be worked and developed through a generative process. Tuning points to the idea of design as an extended and iterative play of metaphors.[62]

Seventh, the function of the device is to reveal otherwise unrecognized structures and relations, the exposure of which can inform further design. A wedge works the grain, finds lines of least resistance, exposes fault lines, divides, and differentiates. The capacity of mobile camera phones to reveal sensitivities to privacy and security is palpable, and quite specific, in the case of school-yard bullying, for example. On a slightly different tack, Henrik Ekeus, colleagues, and I experimented with different means of interfacing physical interactions with the imagery of the three-dimensional simulations of the multiuser online role playing environment Second Life. One project involves pointing a camera at a physical room, some components of which correspond to shapes in a Second Life model. When someone enters the physical room they appear on a screen as if integrated into the Second Life world, surrounded by Second Life scenography, objects, and avatars. Such melding is usually accomplished by

standing the human subject in front of a green screen. This turns out to be unnecessary. All that is needed is a means of filtering out those parts of the physical scene that are static. Humans invariably move, and so they appear visible. This is an interesting calibration issue. The computer processes are set up to detect and occlude static objects. In early trials of the process, the team noticed interesting behaviors from human subjects who entered the physical room. Once they knew the rule that static objects are invisible, they would then start pushing objects such as chairs around the space. This would make the chairs visible on the Second Life screen. To return the furniture to its original position would make it invisible again. It turns out that people are interested in threshold conditions, playing around with the border between visibility and invisibility, the calibration edge, the moments when things are in and out of alignment, and this can have startling and useful outcomes in creating and analyzing spatial experience.

Eighth, ideas about tuning contribute to public participation in design, as in various Web 2.0 developments. Usability testing is now live. Designers, publishers, and consumers take for granted that applications will be refined in time in response to user comments and reviews, as exemplified by reviews of third-party applications for the iPhone and other smartphones. The rapid rate of software release and rereleases indicates a responsive design environment involving various tradeoffs, and constitutes a kind of retuning. Design presents as a retuning to circumstances. If tuning involves adjustment of technical apparatus to context, then everyone is involved in this all the time. The processes of tuning reinforce the proposition of Castells and colleagues that "the more a technology is interactive, the more it is likely that the users become the producers of the technology in their actual practice."[63]

I hope this brief catalog provides a persuasive demonstration that the concept of tuning is helpful in explaining how people relate to pervasive technologies, and of tuning's role in shaping and defining the environment. Digital devices are complicit in tuning and potentially enable occupants to tune their environments, a means of modifying everyday experience. The tuning is the design. We are all designers, improvisers, collaborators, and calibrators.