Homes:
Meshwork or Hierarchy?

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I

Imagine having just landed a corporate job which demands that you move to a new city. In this urban environment the corporation has already found you an apartment and, following the tradition of its great corporate culture, it has had it decorated so that it embodies the aesthetic and functional values for which the firm has become famous. No doubt, when you finally move to this new place it simply won't feel like home, more like a hotel suite, despite the fact that it offers you shelter and even luxuries that you did not enjoy before. Does this lack of 'home feeling' stem from the fact that everything around you has been planned to the last detail? Would it feel homier if you shared the corporate values that informed the planning? Wouldn't you have to live for a while in this place, interacting with its walls and table surfaces by placing a souvenir here, a momento there, before something like a sense of home began to emerge?

These questions can also be raised even if we eliminate from our scenario the intrusive presence of an outside planner. Would a place feel like home if every expressive or functional detail had been exhaustively planned by yourself? No doubt all of us think about the decoration of our home environment, but do we always have an explicit reason why certain things are placed where they are? Don't we often place them in a given location because it feels like that is where they belong, as if our souvenirs and sentimental possessions arranged themselves through us?

Answering these questions in the case of human beings is rather hard because of the extreme variability of human culture and, even within a given culture, the great diversity of human personalities. Besides, I am not aware of any systematic study of these questions regarding human homes. We do have some information, however, about the creation of home territories by certain species of animals which throw some light on the question 'Are homes planned or self-organized?' In particular, I would like to begin my exploration of these issues with a brief examination of bird territories and the role that the expressive qualities of song and color play in their formation.

When the question of how birds create a home territory was first raised (by ethologists like Lorenz and Tinbergen) the answer given to these questions was ‘Homes are planned’, with the remaining controversy gravitating around the issue of ‘Who does the planning’, genes or brains. Are the planned strategies pieced together by genetic evolution or are they learned in the bird’s lifetime? In either case, the formation of a home territory was seen to derive from an internal territorial drive or instinct, with a precise central location in the brain. Out of this ‘territorial center’ commands would then be issued to other centers in the brain (a nesting center, a courtship center) and out of this hierarchical mental structure a correct set of actions would then be implemented and the borders of the territory would then be appropriately marked.

More recently, however, this line of thinking has been increasingly criticized. Philosopher Daniel Dennett, for example, has convincingly argued that to postulate ‘brain centers’ is to simply move all the original questions about an animal’s behavior to an ‘animalculus’ inside the head. Unless this animalculus is ‘stupid’ enough that it does not need to interpret representations or perform other complex cognitive functions, we are simply answering one question (How are territories organized by an animal?) with another one of equal complexity. (How are territories organized by an animalculus?). Philosophers Gilles Deleuze and Félix Guattari have raised essentially the same point, adding that home territories should be conceived not as emanating from an internal drive but as emerging from the interaction of a non-hierarchical set of brain functions and the expressive qualities of the territorial markers themselves, for instance, the color of certain leaves or stems which some birds use to attract females, or the musical properties of bird songs, or even faeces or urine scented with the excretions of special glands.

II

The recent development of theories of nonlinear dynamics and of processes of self-organization has given these critics a boost. While before the 1960’s it was virtually impossible to imagine the emergence of order without a central agency behind it, today we are familiar with a growing body of knowledge about the spontaneous generation of ordered structures in inorganic as well as organic (and even social) processes. For the purposes of understanding the issue of home territories, it will be useful to

trace the effect of these new ideas in the current confrontation between symbolic Artificial Intelligence (which retains a hierarchical organization of centers) and the new connectionist school, based on nonlinear dynamics and a decentralized conception of the mind. An 'artificial bird's brain' designed with symbolic AI would typically contain representations of the world (coded in bird mental language) forming a cognitive map of the animal's surroundings. Creating a territory would then consist in symbolic operations performed on these representations and only later implemented as actions in the real world. A connectionist approach, on the other hand, would be to generate a population of neural nets, each of which is dynamically connected to the outside world. In other words, without using mental representations each neural net in the bird's brain is in a nonlinear stable state (or attractor) which is associated with a similarly stable pattern in the animal's environment. A pattern outside (such as the expressive qualities of a territorial marker) can then be recognized by the animal without forming an explicit internal symbol to stand in for the pattern.

Neural nets have indeed supplied us with a concrete technological paradigm of how brains could function without internal homunculi. Unlike symbolic AI which has only scored successes in the modeling of evolutionarily late skills (such as playing chess or proving theorems), connectionist designs have succeeded in capturing some more basic abilities, such as face recognition. And yet, for our purposes here, not even this novel branch of cognitive science has gone far enough. The real breakthrough to understand how home territories could self-organize through brains and outside expressive qualities comes from an even younger branch of AI: behavioral-based AI (or as it is sometimes called, the animat approach). The differences between behavioral and symbolic AI have been very lucidly expressed by Pattie Maes, and we may summarize them as follows: Symbolic AI decomposes minds into relatively large functional modules (perception, execution) interfaced together by central representations (beliefs, desires, intentions). The activity of the modules and the representations form a static 'model of the world', and the effects of learning are conceived as the operation of reformulating this model. Behavioral AI, on the other hand, does not involve high level general modules (which as I said, almost always embody homunculi) but low level specific modules (such as 'collision avoidance'). High level skills emerge out of the interactions of these micro-modules, none of which can be said to possess the skill. More importantly for our present purposes, behavioral AI does not aim at the

internal generation of a world model, but rather, it situates its robotic animals in the real world so that the objective features of the environment can be used as a form of external memory. This modeling strategy is sometimes expressed with the phrase: 'The world is its own best model'.

One useful way of explaining this rather cryptic phrase is by using some insights from the ecological theory of perception developed by James Gibson in the 1960's. Gibson elaborated the crucial idea that the environment provides an animal with meaningful constraints which he called 'affordances'. For instance, solid ground supplies animals with (or 'affords' them) a surface to walk on. On reaching the edge of a swamp an animal's 'muscular intelligence' tells it automatically that the ground there does not afford suitable support, and the animal reaches this 'conclusion' without the need for an internal 'world model' which includes representations of dry and wet land. Similarly, a hole in the ground of suitable size affords an escaping animal a place to hide, and twigs afford the bird nest-construction materials. An open environment affords locomotion in all directions, while a cluttered one affords it only at certain openings. And, of course, what a given part of the world affords depends on the animal: water, due to surface tension, affords a walking surface to a small insect but not to a large bird, to whom it affords at most a gliding surface. The point of all this is that the world possesses a kind of intrinsic 'proto-semantics', which are meaningful to animal minds in a functional way.

In terms of behavioral AI this means that, a simple module for collision-avoidance (so simple it does not contain a homunculus) together with the obstacles afforded by a room's walls can generate the complex behaviour of 'wall following' without an internal representation of the room. But the layout of surfaces in the environment is only one source of affordances, the behavior of other animals is too. Prey afford predators nutrition, while a territorial bird affords another competition. Animals may also afford one another opportunities for co-operation. This idea has also been exploited by behavioral AI in designs where novel intelligent behaviors emerge not only from the interaction animal-environment, but also from the interactions between the animals themselves. Hence the idea of building not expensive single robots, but teams of relatively inexpensive ones. This has the advantage that the solution to a given problem emerges out of the interactions of the whole team, with no single member being essential to the task. In this way, the inevitable breakdowns and

malfunctions that plague any real life applications do not cripple the entire enterprise, as would be the case with the single robot approach.

By now it should be clear what I am getting at. Home territories self-organize through a complex interplay between male and female birds and the expressive affordances of their environment. For example, the male satin bowerbird builds a stage decorated with bright blue objects of different kinds with which he tempts a female to stop by. Then, as the courtship begins, he will grab a yellow flower in his beak and alternately display it and hide it in a species-specific ritual. The home territory of the couple may be seen as emerging from simple in-the-head components (which are partly learned, partly inherited) and the optical affordances of the blue and yellow objects. Now, is it possible to extend these remarks to human beings? Is it possible that our own homes self-organize in this way, with the expressive affordances of our cherished possessions playing an active role too?

Although I would like to answer this question affirmatively, there are other aspects of the problem that we must consider first. In particular, unlike birds we possess also linguistic abilities, and hence a greater propensity to form representations and plans inside our heads. It may be, as philosopher Andy Clark has suggested, that our minds are a kludge (or bricollage) of different kinds of intelligence: some intelligent abilities arise out of decentralized and parallel processes, others from centralized and sequential ones. One useful way to think about this is to view the evolution of the human mind as involving a similar process as symbolic AI, only in reverse. Let me explain. When the first AI programs were written, programming languages and computer hardware were very hierarchical and sequential. In the 1970's when symbolic AI switched to the creation of expert-systems, the need for flexibility forced them to create programming languages which simulated parallel processing even while running in sequential hardware. Andy Clark's idea is that our evolution may have involved a similar, though opposite, solution: we began with a highly parallel and non-hierarchical hardware (like birds) and at some point our brains began to simulate a sequential and centralized mind: the stream of linguistic consciousness with which we are familiar through introspection.

If our minds are thus hybrids of two or more computer-types then we should expect our homes to be also complex mixtures of self-organized and planned components, or to use the technical terms, of hierarchies and meshworks. Hierarchies are structures in which components have been sorted out into homogenous groups, then articulated together. Meshworks,

on the other hand, articulate heterogeneous components as such, without homogenizing. A bird's territory is more meshwork than hierarchy, while the hypothetical pre-furnished corporate apartment I mentioned at the beginning of this paper, has more hierarchy than meshwork elements in it. Our homes can then be seen as mixtures of self-organized and planned components: certain objects will occupy a space and fulfill a function which we deliberately assigned to them while others will be located where they meshed well with their surroundings. And in these terms, the feeling of home could be derived from how well we mesh with the objects and expressive affordances of this private environment.

The concepts of meshwork and hierarchy have become one of the cornerstones for the application of nonlinear dynamical simulations to social and economic questions. Hence they are very useful in analyzing not only the structure of our private spaces, but also that of public spaces. That is, they help us thinking not only about our homes but also about the home of our homes: the city. From this point of view our individual homes become households, one of several types of institutions housed by our home towns. These institutional populations are also complex mixtures of meshworks and hierarchies, of markets and bureaucracies, for example. Pre-capitalist markets, like those which existed in medieval Europe, in China or India, or indeed in many small towns even today, are structures that emerge out of a decentralized decision-making process which brings heterogeneous needs and offerings together. In modern nonlinear models, markets have very little to do with the 'invisible hand', involving complex processes of self-organization and not just demand and supply. Behavioral AI (as well as other forms of nonlinear cognitive science) sometimes use market-like structures (such as bidding schemes) to replace centralized decision-making in the robot's mind.

III

On the other hand, cities are also the home of governmental, commercial, religious and other hierarchies, in which decision-making is centralized, and the effects of decisions travel through well defined chains of command. At every level of this chain, that is, at every rank, the human components are very homogenous: the very process of rising through the ranks performs a sorting operation which results in more or less uniform behavior within each level. Indeed, the correct functioning of a command

chain assumes this uniformity and predictability. And yet, here as elsewhere, when we actually study a given hierarchical structure we are bound to find mixtures of meshwork elements, even if only in small proportions.

Moreover, as markets grow in complexity they can generate hierarchies and vice versa. Take for example, the big fairs that existed in Europe form the 13th century on: at the top they had the money markets, followed by luxury goods markets, while at the bottom we find food and other elementary goods. Hence these fairs were veritable hierarchies of meshworks. Similarly, when we analyze the interactions between governments, large commercial monopolies and oligopolies, ecclesiastical, medical and military authorities we find that they usually interlock in varying ways, complementing one another without losing their individual differences. Since no 'super-hierarchy' is controlling this process of mutual accommodation, the overall process suggests a meshwork of hierarchies.

Drawing some analogies with biological processes may be as useful in analyzing home towns as it was in exploring individual homes. Some evolutionary biologists have suggested, for example, that any entity that replicates itself, regardless of the nature of the process, can evolve in the exact same way as creatures with genes do. The first candidate for a non-genetic replicator was, of course, Richard Dawkin's 'memes': patterns of behavior that replicate themselves across a given animal population through imitation. The best studied example of memes is bird song. Although the basic structure of the song, an impoverished skeleton, is genetically hard-wired, the full song with all its flourishes, harmonies and counterpoints is not. Individual birds must be exposed to actual full songs by other birds of their species in order to develop their own. Since bird songs form local dialects and change over generations, they are indeed a replicator as much as genes are.

Human beings, on the other hand, are the home of other replicators. While we house memes just like birds do, for example most fashions and fads are propagated by imitation, we also speak languages and these do not replicate by imitation but by enforced repetition. When people learn the sounds (or phonemes) of English, for example, they do not imitate them: they shoot for a norm, they attempt to repeat a standard sound, and they must do so if they want to be intelligible to the rest of the English speaking community. A similar point applies to both vocabulary and syntactical rules. They are replicators but not memes. It is thanks to this

flow of norms through human populations that all our languages have evolved.

Now, to return to our main subject, economists Nelson and Winter, authors of the very influential theory of evolutionary economics, have suggested that the institutional inhabitants of cities are replicators too. They claim that the daily routines of a given institution, together with whatever formalized regulations the institution may have, form a kind of ‘organizational memory’. When a commercial organization, for example, opens a new branch outside of its home town, and sends some staff there to preserve continuity, informal routines as well as formalized procedures become replicated, and in an important sense, the institution itself has given birth to an offspring. A similar process occurs when a given city colonizes foreign land and replicates its governmental and religious institutions there. Since the copying of routines (and even rules) is subject to alterations and local adaptations, there is here enough variation that some sorting process equivalent to natural selection can use as raw materials for evolution. Since our private homes are part of this population of institutions, some of the details of their architecture as well as the daily routines that make up our lives may have evolved in a process like this. So considering the two lines of my argument, the self-organization of expressive affordances as well as the evolution of institutions via routine and rule replication, our homes are like bird territories in more than a metaphorical sense.

The main problem with what I have said so far is that I have concentrated exclusively on the informational aspects of the problem. That is, I discussed expressive affordances and genetic, memetic and normative patterns and pretended for a while that that is all that mattered. But, of course, bird territories and human homes involve more that just information. In particular, they need a constant supply of matter and energy in order to work. The function of territories is, indeed, that of creating a protected source of food supplies. Urban homes too, have always been connected to local markets where they draw their supplies. Perhaps the best illustration of the crucial role played by matter-energy is provided by the action of genetic replicators. As is well known, all individual genes do is to code for enzymes (and other proteins) which are large molecules capable of accelerating or decelerating chemical reactions, and thus, of being used as control agents for metabolic functions. This catalytic function of enzymes may be described as the ability to force systems of molecules to switch from one stable state (called an attractor)

to another. But as is well known in contemporary thermodynamics, it is the flow of energy through a system that creates the stable states in the first place.

Catalysts without a flow of matter-energy are powerless. In order to perform their magic, genes and their control products depend on the flow of biomass through the food webs that characterize ecosystems. A birds territory is as much a genetic and memetic structure, as it is an energetic and material one, and so are our homes. Not only were they always connected to food webs via markets, the first other public connection that they established was with sewers, that is, the same nutritional flow from the other side. True, it was later traversed mostly by informational flows, telephone, radio, t.v., and networked computers, but as before, these flows of catalysts can only perform their magic on energetic materials capable of self-organization. We tend to forget not only the flow of food but also the flow of electricity into our homes, as well as the electric and hormonal flows in our bodies which play such crucial role in the ‘feeling of home’. And we tend to talk of the ‘information age’ without realizing that the future is as much about energy and materials as it is about information. The common dependency on matter-energy between territories and homes is, I believe, another respect in which they are alike beyond metaphor.

Biological metaphors have been used in the past, many times with terrible results. For example, positivist philosophers in the 19th. century compared cities and organisms and concluded that both have homeostatic mechanisms to keep them in internal harmony. This embodied a very romantic view of both nature and society, which disregarded friction, conflict and other nonlinearities that make simple self-regulation impossible. Today, nonlinear models are more sophisticated than that, and more importantly, have revealed that the friction exorcised from those romanticized views is essential to the self-organization of meshworks. A similar point applies to ‘invisible hand’ economics, where perfect rationality and perfect competition are supposed to benefit society automatically. Nonlinear simulations of market formation include not only bounded rationality, that is, a realistic limited degree of problem-solving skills, but also delays, bottlenecks and other sources of friction which are also key to their self-organization.

Thus, we have learned to draw better analogies and to discover more realistic metaphors. But the question now is, are they still mere metaphors? The answer to this is that some are and some are not and the ones that are not give us a good idea of how to get rid of metaphors

altogether. For example, when we compare genes, memes, norms and routines we are not, I believe, thinking metaphorically any longer. What we are saying is that, any replicator which is coupled to a sorting device (a selection pressure of any kind) results in a kind of ‘probing head’ capable of exploring a virtual space of possible forms. These forms may be animal bodies, bird songs, human languages or urban institutions, but all are evolved through a blind probing and groping in the space of possibilities. In a way, coupling a replicator and a sorting device results in a ‘virtual searching device’ which may be incarnated in different material and energetic physical supports. This abstract ‘probing head’ has in fact been incarnated in computer software: the famous ‘genetic algorithm’, which can be used to breed other software programs. Genetic algorithms, for example, are used to implement some of the non-homunculi modules of behavioral AI.

Let me use another example to illustrate this crucial point. When we say, as Marxists used to say, that ‘class struggle is the motor of history’ we are using the word ‘motor’ in a metaphorical sense. But when we say that a hurricane is a steam motor we are not: we are saying that it embodies the same engineering diagram as a steam motor, that is, that it runs on a reservoir of heat, that it operates through thermal differences, and that it runs matter and energy through a Carnot cycle. Thus, the difference between metaphorical and literal uses of a term consists sometimes in the difference between embodying a purely linguistic analogy and an engineering working diagram. The comparison of genes and memes or norms is clearly a diagrammatic (not a linguistic) one: all three embody an abstract searching device. What about comparing human homes and bird territories? Are there abstract machines behind the formation of meshworks and hierarchies that would allow us to make the comparison in a diagrammatic way?

As a matter of fact I believe there are, although a discussion of them would take me into areas hardly related to our theme here. All I can say now is that it is one and the same process (or rather different processes embodying the same abstract machine) which results in entities as different as human hierarchies, the bodies of animal species and even sedimentary rocks, all of which are structures in which homogenous elements are articulated together.

Similarly, markets, ecosystems and even igneous rocks are all structures where heterogeneous elements are linked together without imposing uniformity over them. As it is clear from the history of AI, that

is, from the domination of hierarchical symbolic thinking and the obstacles which connectionism found to become a legitimate branch of cognitive science, humanity finds it much easier to think in terms of articulated homogeneities rather than articulated heterogeneities. But it is the latter, I believe, that hold the secret for a better future. Perhaps we can learn from birds, and why not even rocks, the secrets of non-homogenous thinking.

Note

[1] *Editor's note*: This paper was first delivered at the *Doors of Perception 2 @HOME* Conference, 4-6 November 1994.