Chapter 12
Agency, Networks, Past and Future

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Abstract In this contribution, I will first draw upon the other chapters of this book to summarise what are in my opinion the essential elements of their discussion on the concept of agency and on Actor Network Theory. Then I will argue the need to come to understand the process of invention and innovation and present some ideas about why this topic has not generally been given the importance that, in my eyes, it merits. Finally, I will try and develop a perspective that might indeed help us understand the process of intention and innovation, based on some of the ideas about agency presented in this book.

Introduction

While I was working on my PhD thesis "*Studies in the Technology of Ancient Pottery*" (1976), I had the good fortune to do much of it in dialogue with an experienced potter, Jan Kalsbeek, who had himself used the foot-driven wheel to manufacture a wide range of ceramic artefacts in a semi-industrial context before being appointed to the University of Leyden as a specialist in ancient ceramic technology.

At the time (1969–1976), the approach to ceramic analysis that we were working on was quite novel and demanded the development of new ways of thinking about ancient technology, about pottery manufacture and about ceramic analysis in archaeology. Our discussions were wide-ranging and often heated as they confronted two very different perspectives.

Jan Kalsbeek's perspective was that of the practitioner who tried to 'get into the mind of the ancient potters', to find out what they did to create the pots that we studied the broken remains of and why they did it. For that purpose, he used his own inimitable mixture of acute observational and analytical skills, knowledge about the potter's craft, extensive experiments in his workshop and

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descriptions of ceramic manufacture from the ethnographic and historical literature. I, on the other hand, was charged with presenting the results in such a way that they were understandable and acceptable to a scientific audience.

I realised quite a few years later that the heated nature of our discussions was in part due to the fact that we did not understand the inherent difference between our two perspectives. Whereas I, a freshly trained (positivist) scientist at the time, tried to write a coherent discourse about the how and why of the procedures used by ancient potters to shape and fire their wares in terms of chains of cause-and-effect and conscious choices, Jan verbalised the process of pottery making not in terms of cause-and-effect but in terms of possibilities and probabilities. Choices, in his view, were not necessarily conscious but often inherent in 'the way things were done' – in culturally determined 'know-how' anchored in they ways potters had learned their craft.

In other words, while Jan Kalsbeek looked at pottery making as a creative activity, in which the potter was faced with certain opportunities and challenges and used his skills to 'manage' both, I looked at the result of the potter's work and tried to explain how it came into existence. His perspective was directed towards understanding what enabled the future existence of the pots, whereas mine was focused on understanding the origins of the pottery I had in front of me. The potter in Jan phrased his conclusions in 'a priori' terms – positioning himself at a time before the pottery was created and looking forward towards its creation. I worded my conclusions in 'a posteriori' terms, positioning myself as the observer of the – already made and broken – pots and trying to explain how they were made and broken. Jan was thinking in terms of *prediction of what might have happened, what did happen and what did not happen* whereas I was working towards an *explanation of what did happen*. His language was that of uncertainty, probability and scenarios of possible future events, whereas mine was that of certainties, cause-and-effect and models of past events. Needless to say that his objection to my writings was, time and again, that I oversimplified and distorted the essence of what he was trying to express.

Human History and 'Natural History'

The implications of this difference in perspective are an important source of confusion in much interdisciplinary research that combines, as we often do in our discipline, approaches from the sciences on the one hand, and perspectives from the humanities on the other. Whereas the life sciences, in what used to be called 'natural history', tend to construct their vision of the past by referring to their understanding of the present, the historical sciences, dealing with human events, tend to explain their vision of the present by referring to the past. Among other things, this is reflected in the respective disciplines' perspective

Table 12.1 Contrasting 'human history' and 'natural history'

Human history ('a priori') approach	Natural history ('a posteriori') approach
Main interest in past	Main interest in present
The present understood in terms of the past	The past understood in terms of the present
Time and process irreversible	Time and process reversible, cyclical or reproducible
Accentuates differences	Accentuates similarities
Case studies	Generalisations
Language of probabilities	Language of certainties
Open-ended categories	Closed categories
Contingency	Causality
Focus on inter-scale interaction	Focus on intra-scale interaction
Scenarios	Models

on time. Whereas historians studying the actions of people have never really wavered in their vision of time as an irreversible 'arrow', natural and life scientists have for a long time approached the study of their domain by assuming the absence, the reversibility or the cyclicality of the temporal dimension in which processes occurred. This has only changed recently, when the complex adaptive (self-organising) systems paradigm was introduced. Table 12.1 summarises some of the implications of this difference in approach.

Archaeology is indeed profoundly affected by this opposition. Whereas the more distant pre-historic past is studied according to the canons of the natural and life sciences, the last five thousand years (the historic past) are studied with approaches coming from the humanities. The period in between (proto-history) is from this perspective a kind of confused 'no man's land', in which both approaches are being used. But, of course, one also finds 'historical' interpretations of pre-history and 'scientific' interpretations of more recent archaeology. Indeed, very often, authors are unaware of this aspect of their perspective, especially when socio-environmental dynamics are discussed.

The reader will have understood that this opposition has, in my opinion, also important ramifications for the discussions in this book, and in particular where they touch on the interaction between human and non-human agency, on action and re-action, and therefore on the debate around agency that is the subject of the preceding chapters.

In reading these chapters as a relative outsider to the domain, I was inspired by the many possibilities offered by the convergence of approaches presented in this volume to anyone interested in improving our understanding of the role of material culture in society, of human cognition but also of the dynamics of invention and innovation. In the next few pages, I will summarise some of the new strategies I see emerging.

What is New?

As mentioned, I am a newcomer to the discussions presented in these pages and when I ask 'what is new?', that is not meant as a starting point for a detailed discussion of what exactly in this inspiring volume has been said before and what has not. I think one of the most interesting aspects of the book is that it mingles and combines a number of different domains and approaches that have a history of their own but do not have a history in common. This section is merely intended to summarise what in my eyes are some of the main characteristics and implications of the shift in perspective proposed by the authors of the foregoing chapters.

At the core of the book is a perspective on the relationship between people and material culture that accords a more active role to the latter. The initial move towards this perspective goes back some twenty years or so but "has been more a case of acknowledging the active [. . .] use of material culture by humans, rather than ascribing much dynamism to the artifacts themselves" (Knappett & Malafouris, this volume). The various authors in this volume go a step further, and open the 'Pandora's box' of *assigning an active role to the artefacts themselves*, in particular in the context of human *cognition* (Clark, this volume, Chapter 1). Artefacts thus become 'agents' in the cognitive process just like human beings. This also changes the presumed role of the human brain, fuzzing the distinction between perception, cognition and action and emphasising action as the core focus of the brain. In Clark's words (infra, p.10):

> Perception is itself tangled up with possibilities for action and is continuously influenced by cognitive contextual and motor factors. It need not yield a rich, detailed and action-neutral inner model awaiting the services of 'central cognition' so as to deduce appropriate actions. In fact, these old distinctions (between perception, cognition and action) may sometimes obscure, rather than illuminate, the true flow of effect. In a certain sense, the brain is revealed not as (primarily) the engine of reason or quiet deliberation, but as the organ of *environmentally-situated control*. Action, not truth and deductive inference, are the key organizing concepts.

However important it may be, the cognitive process is only one of the loci of interaction between humans and artefacts. Another is that of *material engagement*, the interactive process by which human beings create or transform artefacts. Malafouris (this volume, Chapter 2) makes this point and in the process highlights another very important aspect of the overall shift in perspective: agency and intentionality are *distributed, emergent* and *interactive* phenomena in which materials, tools and brains each have their own roles, locating the neural contribution as just one (important) element in a complex causal web spanning brains, bodies and world, a perspective that is closely (and not accidentally) linked to the 'a priori perspective' of active creators such as Jan Kalsbeek. The role of the brain thus resembles that of a mediator who attempts to negotiate between the opportunities and challenges of aims (e.g., the characteristics of the end product), materials and tools to achieve the end product. In that process, the interaction between *prior intention* (what one sets out to do) and *intention in action* (what one

does in the material world) is crucial (Searle, 1983), but not always clear: "[a]ll intentional actions have intentions in action, but not all intentional actions have prior intentions", and "[i]n both cases, the intention – as an internal representational state – causes the agent's movement – as an external physical state in the world. The difference is that in the case of "intention in action" the internal intentional state and the external movement become indistinguishable". According to Malafouris, such "*intention in action*" is not an internal property [of human beings] but a component of extended cognition which is part of the action rather than preceding it. I will return to this point a little further down when making the distinction between *knowledge* and *know-how*.

In Chapter 3, Sutton discusses Malafouris' (2004) perspective on Material Agency in the cognitive context and positions himself somewhat differently concerning the relation between people and artefacts in the acquisition of knowledge and know-how and in the transition between them. But he also adds an important concept, that of '*cognitive biography'*. Following Appadurai (1986) and Kopytoff (1986), his core assertion is that "the outcome of any action is also determined by the diachronic trajectories of things [and, I would add, ideas and people] through time and space". This seems to imply that there are certain continuities in conception and realisation of artefacts through time and that the distributed actor-artefact network has what amounts to a 'memory'. But for our purposes, it may even be more important that it therefore does not seem possible to invent literally 'anything, at any time'. Existing material culture (and the concepts and relations it represents and instantiates) seems to constrain the range of inventions and innovations that may emerge.

The concept 'artefact' that is traditionally used in such discussions also needs to be *extended, to all observable non-human entities*, including sheep and trees (Law and Mol, this volume, Chapter 4; Jones and Cloke, this volume, Chapter 5), but in effect extended to all of the atmosphere, hydrosphere, geosphere and biosphere. In certain instances, in my opinion, it may also be extended to human beings, that is, wherever humans are the object of other human beings' actions. Artefacts, moreover, play many different roles, related to the different perspectives from which active humans are considering them. Law and Mol point out that in the 2001 foot-and-mouth disease crisis in Cumbria, for example, sheep played roles in a veterinary, an epidemiological, an economic and a farming perspective. *Artefacts have more than one significance in the distributed network of agents*, depending on their partners in interaction and in particular on the functions they fulfill (the roles they play) in the network. Each significance comes with its own markers, its own characteristics and its own place in the human actors' worldview, etc.

Chapters 4, 5 and 9 also introduce an extant approach in social science – Actor Network Theory (ANT) – that aims to come to grips with the multiple interactions between different agents playing out in any cognitive or material engagement process. Introduced by Callon (1986), Latour (1993) and others, this approach has championed non-human agency whilst at the same time rejecting the non-human/human distinction. The agency of non-humans is

seen as an essential element in the relationship between the natural and the social and *nature is framed as both a real material actor and a socially constructed object*. This leads one to assume and describe partnerships between human and non-human actors in mutual constructions of an artefactual nature (Latour's 'hybrids'), in which agency is viewed as located among different actors (human or not), decoupled from subject-object distinctions and representing the collective capacity for action by humans and non-humans. As a consequence, particular attention is paid to: (1) the *investigation of the nature and dynamics of the hybrid network itself* and (2) the *semiotic connections between the diverse elements in socio-technical ensembles* rather than to the entities that interact.

In such a network, agency is not located in any one place and it is multi-temporal (the result is determined by the interaction of many temporal rhythms occurring simultaneously in the network). The temporal and the spatial dynamics are, of course closely related. "*The [. . .] comings and goings in the production of place can be seen as processes of [temporal] patterning"* (Jones and Cloke, this volume, Chapter 5). Or, in the words of Harrison, Pyle and Thrift (2004): "All kinds of things can come together in the world and, in that process of encounter and settling down into at least a short-term equilibrium, they can creatively produce new kinds of organizations that are greater than the sum of their parts". "[. . .] all places are not merely processes and narratives but whole ecologies of interrelating trajectories that settle into temporary local forms but which also have threads that weave through the local to the global in scale" (cited by Jones and Cloke, this volume, Chapter 5).

Of the last two chapters of this volume that I wish to briefly include in the discussion, Yarrow (this volume, Chapter 8) focuses on aspects of *the semiotic relationship, in cognition and engagement between the material world and the world of ideas*. He shows how the administrative 'capture' of material archaeological data impoverishes the information inherent in those data by reducing the material world to its symbolic and meaningful content in the process of 'fitting' them in formal categories. Conversely, different meanings may be derived from what is manifestly the same text as it enters different contexts. To summarise this in my own terms (to which I will return): *moving from the material world to the world of ideas reduces the number of dimensions in the hyperspace associated with each artefact, whereas implementing ideas increases the number of dimensions in the hyperspace*.

Knappett's (this volume, Chapter 9) starting point is the distinction between 'things' and 'objects'. Whereas the former exist in the material world, the latter exist in the world of ideas. Things, according to Brown (2003) are ambiguous, undefined and have a metaphysical presence, whereas objects are named, understood and transparent, materialising out of the amorphousness of things. Gosden (2004) adds that objects are alienable, quantifiable and dis-embedded from social relations, whereas things are inalienable, possess unquantifiable qualities and are embedded in social relations as part of artefact communities from which they are difficult to extract without making them lose much of their meaning. The question is: how do 'things' become 'objects' or vice versa?

Found, nondescript 'things' may be transformed into artworks and then become objects. Naming something with a word can make an object out of a material thing and the same is true of imaging: the image of a thing can transform it into an object. In other words, *things in the material world are carriers of potential information and it is their link with concepts in the world of ideas (knowledge) that transforms them into objects that do carry significant information*. Evidently, the relationship is complex but one aspect of it is that 'thing-ness' is beyond representation, poly-interpretable and therefore nullified by naming or imagining – by creating a direct relationship with the world of ideas. Conversely, once something is brought out of 'thing-ness', it requires an interpretive framework (a world view), sometimes backed up by a scaffolding structure, to keep it suspended in 'object-hood'.

Depending on the relationship which is studied, *intermediates* (such as images, pictographs, ideographs, spoken or written words), can be both objects and things – they *are objects relative to the artefacts they represent, and they are things with respect to the imagery, writing system or language that is their context*. However, the nature of the representation is different. Images and pictographs are direct representations of things (or indirect representations of concepts), whereas spoken or written words are indirect representations of things (or direct representations of concepts). In the evolution of writing, the evolution from indirect to direct representation of concepts can be seen as a gradual dispelling of the 'shadow' of the objects.

I would like to conclude this section by emphasising that it would be too easy to conclude from the distributed, networked nature of action and agency that artefacts have their own kind of intelligence. Harper, Taylor and Molloy (this volume, Chapter 7) argue (rightly, in my opinion) that that is a step too far. In their terms, even modern information *technology is not offering intelligence, it is only offering people [. . .] resources to act and think*. While that may be simplifying things (as it does not take the distribution of cognition and action in networks of human and non-human actors into account), it does point to a very real danger of the cognitive and communication revolution and provides the necessary counter-arguments.

The Need for a New Kind of Innovation Studies

We live in a world that is driven by invention and innovation but that has not always been so. In the 17th century, innovation was a 'dirty word'. The world order was deemed to be immutable; people behaved as their ancestors had done (or at least they believed they did and they often strived hard to meet that ideal) (Girard 1990).

Little by little, though, over the last three centuries, 'history' and 'tradition' ceded place to 'nature' as the concept invoked to explain the world order. We still speak in many instances of 'it is natural' when we wish to express the fact that we think that a kind of behaviour is in harmony with the world order. In the

process, in the first part of the 19th century, history has become a discipline rather than the omnipresent way to explain what happened or what happens.

Simultaneously, we observe a growing *emphasis on the new rather than the old* – particularly during, and as a result of, the Enlightenment and the Industrial Revolution (Girard 1990). As science and technology gained in importance, the conceptual and instrumental toolkit of the (western) world grew exponentially, and in doing so enabled humanity to identify and tackle more and more challenges. But solutions always leave unexpected challenges in their wake and they require more problem-solving. Hence, since the Neolithic but particularly during the last three or four centuries, the following feedback loop has been accelerating (van der Leeuw 2007):

> Problem-solving structures knowledge —> more knowledge increases the information processing capacity —> that in turn allows the cognition of new problems —> creates new knowledge —> knowledge creation involves more and more people in processing information —> that increases the size of the group involved and its degree of aggregation –> creates more problems —> increases the need for problem-solving —> problem-solving structures more knowledge . . . etc.

As a result, the number of inventions and innovations around us is increasing almost exponentially. This is clearly visible if one looks at the number of inventions that are patented in the industrial countries (cf. Fig. 12.1).

After the industrial and nuclear revolutions, we are now witnessing the silicon, information technology and communications revolutions, and the nanotechnology, biotechnology and cognitive revolutions are on the horizon, each of which is opening another whole new domain of knowledge, know-how and innovation. For the moment at least, there does not seem an end in sight to this acceleration of change in our world.

Can the world sustain this? The social divide, the information divide, the health divide and so many other divides are growing, mainly because a smaller and smaller portion of the world population controls these innovations and the fruits thereof. Although many inventions are at least potentially beneficial, their sheer number increases the chance of unhappy surprises (misuse, but also accidents and unexpected long-term consequences of innovations) at a similarly exponential rate.

In that context, it is in my opinion surprising that the scientific community has so little understanding of the process of invention and innovation itself. Generally, the world reacts a posteriori to innovations once they have been introduced. Could we not attempt to shift our stance from a re-active to a pro-active one and come to understand and guide the process of invention and innovation itself? That would put us in control rather than dealing with things after they have got out of hand and it would potentially allow us to accelerate the innovative process in those domains in which that is most needed and maybe slow it in others . . .

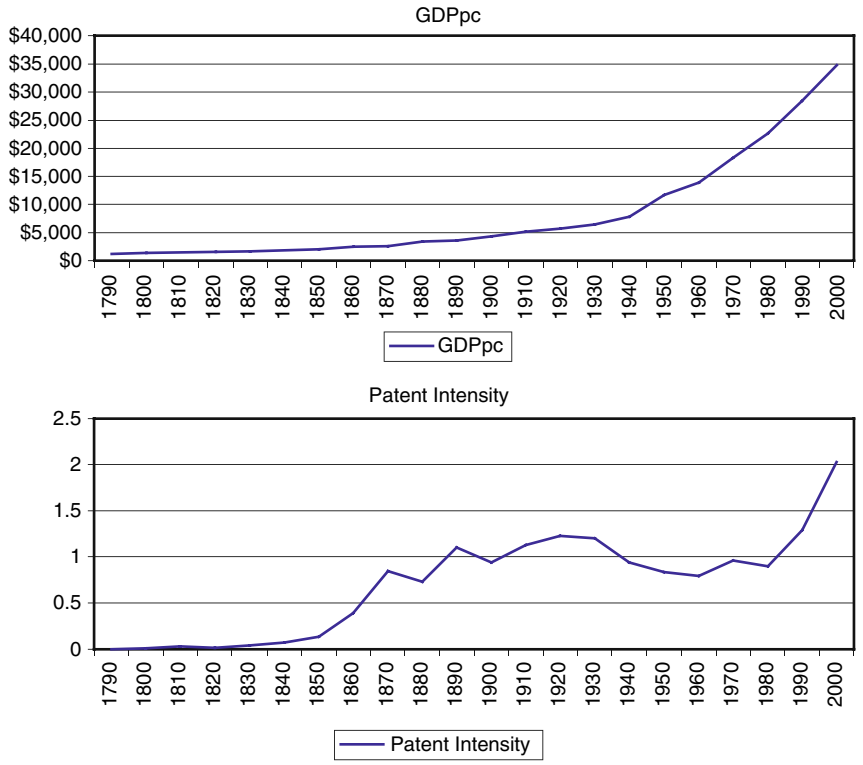

Fig. 12.1 Since around 1840, the number of patents accorded per capita in the US has increased substantively, the last two decades exponentially. The figure shows this increase, as well as the concomitant increase in GDP (reproduced with permission from the author, J. Lobo)

I have therefore been asking myself what has thus far held back our understanding of the process of invention and innovation, and that has been one of the main drivers for the ISCOM project that Carl Knappett refers to in his contribution. My tentative working hypothesis for the moment is that this lack of understanding is directly related to the fact that the majority of the scientific community has looked at invention and innovation using a positivist, scientific perspective such as the one I applied to ceramic studies. In essence, invention and innovation have mainly been studied 'a posteriori'. In the introduction, I tried to make clear that from such a perspective, creation cannot be described or understood. Hence, we have left 'invention' completely to one side in innovation studies, relegating it to the domain of 'personal creativity' and we have focused uniquely on innovation, that is, on the ways in which an invention is adopted and spreads throughout a population.

What I would like to do in the remainder of this chapter is to apply the perspective of the creator – as represented in the introduction by Jan Kalsbeek – to

the process of invention. The reason for this is that I think that this book has unwittingly lifted the tip of the veil by introducing a relational perspective that includes people, ideas, artefacts and resources in an interactive network.

From 'Being' to 'Becoming' and from Entities to Relations

At its core, this book proposes the (partial?) substitution of a relational perspective for the current emphasis on entities. In itself, that is not a new idea. In "*Tlön, Uqbar, Orbis Tertius*", for example, Jorge Luis Borges (1981) outlines what the consequences are of a perspective that excludes entities. One of the imagined languages of Tlön lacks nouns. Its central units are "impersonal verbs qualified by monosyllabic suffixes or prefixes which have the force of adverbs". In a world where there are no nouns — or where nouns are composites of other parts of speech, created and discarded according to a whim — and no *things*, most of Western philosophy becomes impossible. Without nouns about which to state propositions, there can be no a priori deductive reasoning from first principles. Without history, there can be no teleology. If there can be no such thing as observing the same object at different times [because change is omnipresent and permanent], there is no possibility of a posteriori inductive reasoning (generalising from experience). Ontology — the philosophy of what it means to *be* — is an alien concept.

The implications of such a shift in perspective, from a static to a dynamic world view, are taken up at considerable length in Ilya Prigogine's "*From Being to Becoming*" (1980). In such a perspective, we do not study 'what is' but 'what happens', we do not study 'entities' but 'processes', where change is assumed and stability needs to be explained, rather than vice versa. Some of its implications for archaeology have been described by McGlade and van der Leeuw (*Archaeology and nonlinear dynamics: new approaches to long-term change*, 1997). I ask the reader's indulgence for a brief summary of the most relevant ones.

One could compare the archaeologist to a prophet standing with his back to the future and looking into the past predicting the origin of known phenomena from a perspective diametrically opposite to that within which humans in the past made decisions about their future. That, of course, does not allow the archaeologist to understand the process of creation. To do so, he should, as it were, *travel back* in time and *look forward* with those whom s/he studies.

The success of the non-linear dynamic systems approach in representing hitherto inexplicable behaviour in a wide range of systems sheds a different light on one of the fundamental assumptions underlying most scientific explanation, the concept of causality. Unexpected system behaviour, which does not fit the usual idea of cause-and-effect, can 'suddenly' occur in an otherwise regular process. Moreover, from this perspective, similar causes can have widely divergent effects, but very different causes can, under certain circumstances, also have convergent effects.

The theoretical and methodological tools provided by this approach allow us to re–conceptualise the evolutionary behaviour of complex human systems from a non-linear dynamic perspective – one in which discontinuity and bifurcation are seen as intrinsic properties of open, dissipative systems. Such systems depend for their resilience and continued existence as much on innovative behaviour as they do on replication.

The focus on system resilience that is currently emerging in ecology, archaeology and other disciplines, attaches great importance to the capacity of a system to survive by changing 'in tune' with its environment. In doing so, it not only draws attention to the importance of innovative behaviour, but also to the fact that from this perspective, it is change which is assumed and stability which is questioned, rather than vice versa. As change is assumed to occur non-linearly in many cases, it is often important to have an idea of the change of change before change itself can be qualified and/or quantified at any point of the system's trajectory. Although very long-term models of the change of change often are virtually impossible to formalise in a testable manner, they ought to be present in the back of our mind when we formulate ideas concerning shorter-term developments. It probably serves an important purpose that such models are made explicit and subjected to scrutiny.

The focus on non-linear dynamics has also changed our perspective on space and time. Our awareness of non-linear phenomena puts density-dependent spatial phenomena in a new light and our conception of time is also changed, replacing a universal, external, analytical time dimension (radiometric dating in calendar years) by a highly individual non-linear phenomenon which is dependent on experiential and highly contextual attributes. The range of temporal rhythms occurring in any dynamic system are to a considerable degree, if not entirely, responsible for unexpected occurrences in the human/environmental co-evolution.

The Dynamics of Invention

Invention, and all creations, is a paradox. *Creation is at once the substantiation of form and the information of substance*. It occurs simultaneously and indivisibly in mind and in matter. On the one hand it is the creation of new ideas, which is instantaneous and implies change and uniqueness. But on the other, it is the introduction of a new process, a new form that fixes the transience of creation and thus implies control over matter and energy, and stability. The creation is subsequently imitated, making use of the dimensions 'discovered'. These two aspects of innovation are antithetical and define the relationship between 'innovation' and 'tradition' as a duality of perception.

Argueably, the set of solutions perceived *necessary* to the creation of a material object is structurally represented in memory as the set of relationships between a number of dimensions. But because that set is a post-facto construct,

it is never *sufficient* to create another artefact, even one which is as closely similar as is theoretically conceivable. In the time elapsed since the first artefact materialised, both the observed context and its perception have inevitably changed, so that some more creation is needed: material culture is not replicated, it is re-created.[1] *In this sense, invention only exists as a 'special case' of change, from an a-posteriori perspective such as the archaeologist's*. From an a-priori perspective such as the artisan's, the distinction between innovation and repetition is only a quantitative one: every time, a jump needs to be made. *All* decision-making is invention as well as recognition.

In the last part of this chapter, I will try to show how the perspective on agency presented in this book might contribute to our understanding of the dynamics of invention. My point of departure is the basic distinction that Knappett (this volume, Chapter 8) makes between 'things' and 'objects':

> Evidently, the relationship is complex, but one aspect of it is that 'thing-ness' is beyond representation, poly-interpretable and therefore nullified by naming or imagining – by creating a direct relationship with the world of ideas. Conversely, once something is brought out of 'thing-ness', it requires an interpretive framework (a world view), sometimes backed up by a scaffolding structure, to keep it suspended in 'object-hood'.

In other words,

> [. . .] things in the material world are carriers of potential information, and it is their link with concepts in the world of ideas (knowledge) that transforms them into objects that do carry significant information.

The so-called 'scaffolding structure' (here used in the 'narrow' sense),[2] which enables the retention of the 'object-ness' of 'things', is always a distributed one, involving a network of associative relationships between different elements, both 'objects' and 'things' (including people and other living beings, other artefacts, tools, resources, etc.). That network can either reside entirely in the realm of ideas (and thus in the human mind), or it can have material components that 'activate' the human memory when the individual encounters them. These material components may be 'things' to which humans have 'delegated' certain marker functions (trees, rocks and the like, as in the case of animist belief systems), patterns, events or sensations associated with the 'object' that is being retained or recalled, or even artefacts such as uniforms, religious symbols, etc., (man-made things to which marker function have been delegated), and which therefore have a degree of 'object-ness' themselves. The total scaffolding structure, that is, the total configuration of relationships among all elements in the network is important in determining the outcome: the actual 'objects' thus defined.

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[1] I am not referring to modern industrial means, where tools create objects (Ingold 1988).

[2] In my view, the sense in which Lane uses 'scaffolding structure' is a direct extension of the way in which I use it here and refers to its social and material instantiations.

That configuration can be represented, in the language of Actor Network Theory (this volume, Chapters 4, 5, 8), as a network of different actors (human or not), provided one acknowledges that the relationships between human actors and non-human ones are not symmetrical. Humans create the link between 'things' and knowledge that transforms these 'things' into 'objects'. The 'things' or the 'objects' themselves do not do that. Hence, whereas an artefactual 'object' that is (even temporarily) separated from the carrier of its interpretive framework reverts to 'thing-ness', the human being that has created the link can retain a memory of it – the 'object' remains present in memory as 'object', not as 'thing'. Similarly, the different significances that individual 'things' (as 'non-objects') may have in the distributed network of agents are latent and activated by linking these 'things' to knowledge and ideas present in the human mind. Indeed, the links between non-human agents in the network are themselves latent and can only be activated in the human mind.

Next, it is important to underline that the 'mind' in this relationship is itself not an entity. Maybe it is better to speak of 'mindsets'. Individuals have many different cognitive maps in their minds, composed of different 'objects' and relations between them, which are activated differentially according to context and in particular according to the need the individual is attempting to fill at any particular moment. An easy way to see that is by thinking in terms of geographical maps. An individual will have a very different mental map of a particular area, depending on whether he or she is fishing, hiking, driving a car, looking for a site to implant an industrial complex, etc. Each of those maps will include different 'objects' – lakes and waterways in the first case, footpaths, flowers and forests in the second, highways and other drivable roads in the third, and economic conditions, logistics, etc. in the fourth. But one also 'thinks of different things' when eating, repairing a watch, making a pot, etc., in effect possibly associating the same 'thing' with different 'objects'.

The relationship between the different actors in the network (including the relationships between 'things' and the 'objects' that are associated with them in the mind) is a dynamic one. In this dynamic network, association and disassociation between different agents and between different 'things' and 'objects', occurs depending on the person, the mindset, the moment, the context and a range of other variables.

Different 'objects' can therefore be associated with the same 'thing' – as in the case of the sheep in chapter 4 – again, dependent on the function that is being fulfilled, on the purpose of the person involved, on the context, etc. Hence, one can regularly observe mental shifts from one 'object' to another while dealing with the same 'thing', including the creation of associations based on more than one object or of completely new 'objects' related to the same 'thing'.

The core of my argument in this chapter is that invention can profitably be conceived as enabled and constrained by the structure and dynamics of the scaffolding structure that maintains the link between 'things' and 'objects', and that in order to understand the process of invention one has to understand both that structure and the dynamics that maintain it. In other words, to gain an

understanding of the process of invention in different instances, we need to investigate the complete network involved, as well as the nature of the dynamic relationships between things and objects and between human and non-human agents.

Of course, the configuration of the network is different in each case and needs to be mapped and studied in terms of network theory, but we can make some assumptions about the general nature of the dynamic relationships involved.

Hypothesis 1: Our ideas ('objects') are under–determined by our observations (and over–determined by our preconceptions).

Our first assumption is that our ideas ('objects') are generally under-determined by our observations, and therefore over–determined by our preconceptions (other 'objects' generated earlier). Atlan (1992) presents an interesting argument to this effect: take five traffic lights, each with three known states (red, orange, green). There are then 243 (3^5) different combinations of the three different colors possible. But there are 25 connections between the traffic lights. That means that there are 3^{25} (about a thousand billion) possible structures (interpretations, theories) that could link the different states of the five traffic lights. Although sequential observations provide more information than random ones, deducing the single correct structure or theory from observations is therefore well–nigh impossible during a lifetime.

That in turn suggests that (1) in observing the same 'thing', different people create somewhat different 'objects', (2) there is a degree of flexibility in the way 'things' are linked with ideas, (3) the context in which the link is made is to some extent determinant for the nature of the resultant 'object' and (4) the ideas to which one links a 'thing' to some extent over-determine the interpretation of that 'thing' as an 'object' in the mind.

If that is so, in many cases our capacity to quickly recognise structure in complex situations must depend on prior knowledge, ways of linking observations and ideas that have been acquired at an earlier time, and proven helpful in such situations. Hence my statement that if ideas are under-determined by observations, we must assume that they are over–determined by earlier ideas.

This hypothesis therefore also links our argument directly to Sutton's in Chapter 3, about the importance of the historical trajectory, and the work of Appadurai and Kopytoff that it is based on. In particular, the historical trajectory of ideas and 'objects' is important, insofar as 'things' are, and remain, poly-interpretable and assume different roles as they are associated with different 'objects'.

Hypothesis 2: The relation between 'things' and 'objects' is determined by the direction of observation

The reduction in dimensions from 'thing' to 'object' is achieved by searching for apparent symmetries (similarities, regularities) between different observations. Our cognitive apparatus allows us to 'fix' instantly certain symmetries in

space that disappear the next moment. Repetition of the process also permits us to find and retain temporal symmetries in complex processes with non-harmonic rhythms.

Two different steps can be distinguished in the cognitive process: (a) searching for a perspective that includes a sufficient number of symmetries (defining the problem) and (b) defining the dimensions (finding the solution). Of these, the former takes time and is non-linear because it deals with change, with the uncertainties and risks of the unknown.[3] The latter is instantaneous and linear, fixing as it does a dynamic process into a static perception at the moment at which the future becomes the past. That moment is experienced as the intuitive 'jump' or 'click' of discovery or invention. As soon as a dimension has been defined, it can serve as a (new) "point of view" from which to make observations, providing a new perspective and thus prompting further searches for symmetries. The process is as endless as it is continuous.

Because symmetries need to be distinguished from asymmetries in order to be cognised, the former are continuously compared with the latter and vice versa. Such comparisons can either take asymmetry as subject and symmetry as referent or vice versa. Experimental research on heuristics done by Kahnemann, Tversky and others indicates that the outcome of the comparison is related to the 'direction' of the comparison (e.g., Tversky & Gati, 1978). Comparing a subject with a referent stresses similarities, while comparing a referent with a subject emphasises dissimilarities.

If we apply that idea, which is well-anchored in observational data, to the relationship between 'things' and 'objects', it implies that when 'things' are compared (in the absence of an 'object' to which they are related), that comparison emphasises similarities between the 'things' and identifies the dimensions of similarity. Those dimensions are then stored as an 'object'. Later, when new 'things' are observed and evaluated against that 'object' in order to determine whether they instantiate it, however, this comparison (in the opposite direction) emphasises differences between the 'object' and the 'thing' concerned. As a result, we can identify two phases in the relationship between things and objects: a first one in which the 'object' is as yet 'open-ended', in the sense that it is known which observations might relate to it, but not yet which observations eventually do not, and a second phase, in which the object is 'closed' in the sense that it is known which observations do relate to it, and which do not (Selby & El Guindi, 1976).

If we now relate this to the difference in perspective introduced in the introduction, it is easy to see that cognition of an observed difference between two states of a system at times t_o and t_1 depends on whether the referent is t_1 (the *result* of a presumed process, i.e., when the perception is 'a posteriori') or t_o (the *starting point* of the presumed process as in the case of an 'a priori' perception).

[3] The non-linear nature of the search for a perspective is explained by the fact that in order to cognise change, it is necessary to perceive change in the rate of change.

In my case, the a-posteriori comparison between two states of the system stressed similarity (continuity), produced a scheme of thought or construct ('object') and was formulated in terms of certainties and linear causalities. In Jan Kalsbeek's case, the a-priori comparison was interpreted in terms of a personal experience of time, tended to stress dissimilarity (change) and was cognised in much fuzzier terms, based on concepts such as possibility, risk and uncertainty. Hence our conclusion that *(re-)creating the past from the vantage point of the present is a paradox*. If archaeologists, therefore, wish to reconstruct past decision-making they will have to re-create innovation rather than study it.

Hypothesis 3: The relationship between the world of ideas and the material world is also asymmetric

Another aspect of the asymmetry between the human and the non-human actors in the network manifests itself in the interaction between the world of ideas and the real world. That process is, of course, a two-way street, linking 'things' to 'objects' and 'objects' to 'things'. The former involves a process of *selection* of attributes from among those observed in the real world – the 'object' always has fewer than the (infinite) number of attributes of the 'thing'. In the other direction, *intervention* of humans in the material realm is based on these (simplified, symbolic) 'objects' (ideas), but in connecting them with the material world of 'things', un-cognised attributes of the real world are being involved. This concerns all and any attributes that are connected to the part of the system that is being impacted by human beings. Not only must we therefore conclude that the vast majority of attributes of the outside world remains unknown to us, but also that the instantiation of any human invention in the material realm in due time creates more unknowns. In the domain of sustainability science, these are well-known and called 'unintended consequences'.

Invention in Pottery Making

How does this work out in the 'real world? ' I will try to illustrate that with reference to a network model of the kinds of relations that impact on the capability of a potter to create a set of objects by mediating effectively between the functions of the pottery to be made, the tools and materials at his or her disposal and his or her own know-how, thus relating this part to Malafouris' Chapter 2 of this volume.

The core of this model (Figs 12.2–12.8[4]) is here presented in seven graphs, which together constitute a (rough and incomplete) model of the network of different 'objects' of the pottery making system that the potter has to keep in mind if the pottery is in effect to be realised. These 'objects', in turn, are associated in multiple ways with different phenomena ('things') in the real world. The exact nature of the relationships between these 'objects', or between

[4] Figures 2.8 and table 2 have been adapted from van der Leeuw 1980.

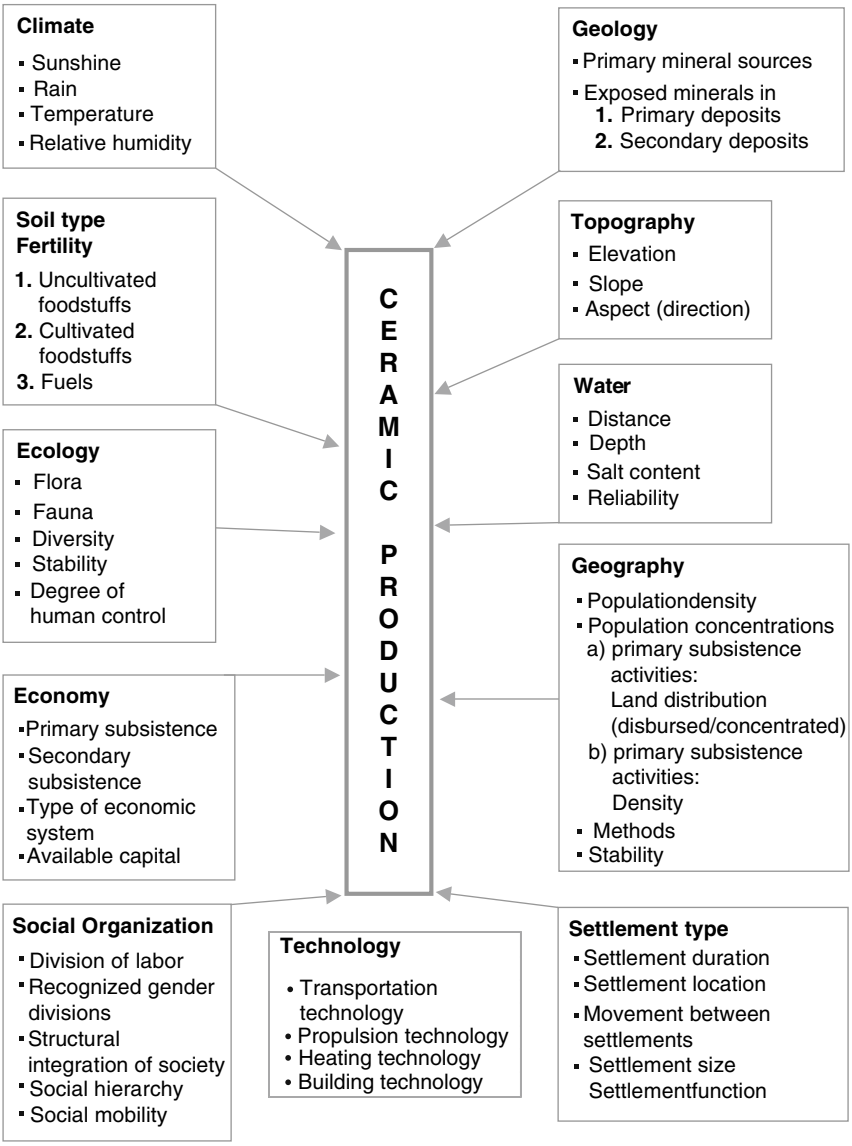

Fig. 12.2 When making pottery, the potter needs to take a wide range of aspects of the context of production into account, including environmental conditions, geography, aspects of the society, etc.

the 'things' and the 'objects', has not been elaborated in these figures, as it differs from case to case. To complicate matters, each of these 'objects' can be in different states: the clay can be dry or wet, too plastic or not plastic enough, the firing can be insufficiently hot, or too hot, etc. Each of the seven figures (Figs. 12.2–12.8) highlights a different perspective on the network that governs

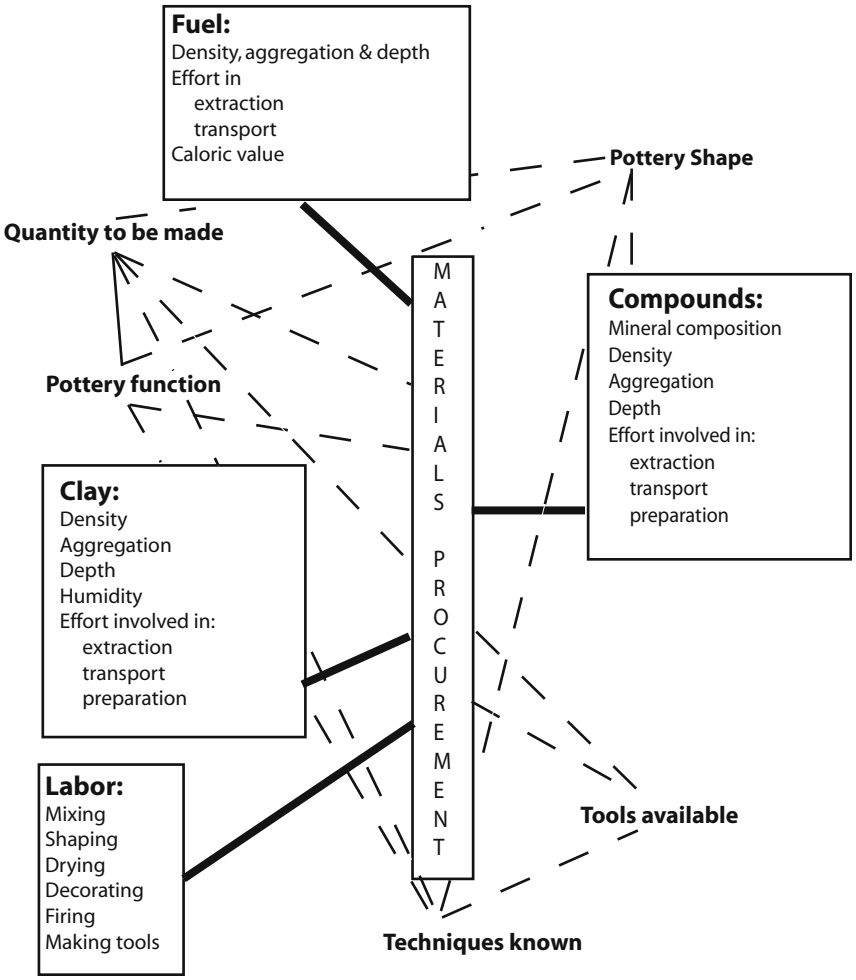

Fig. 12.3 Network representation emphasising certain aspects ('objects') impacting on raw material procurement (in boxes in the figure) that the potter has to keep in mind in order to obtain suitable raw materials for his work at a convenient cost

pottery making: the first figure, Fig. 12.2 presents some of the elements of the context of pottery making which every potter has to take into account. Figures 12.3–12.4 deal with some of the variables important for raw materials procurement and preparation, Figs. 12.5 and 12.6 with some of the elements factored in by the potter when conceptualising and shaping the pottery, Fig. 12.7 with some of the factors determinant for marketing and pricing, and Fig. 12.8 with aspects of the organisation of the workshop.

Of course, each figure presents a partial perspective on the total network of 'things' and 'objects' and when making pots, the potter has to keep the content of all these figures (and a mass of others) in mind. The 'objects' are elaborated in

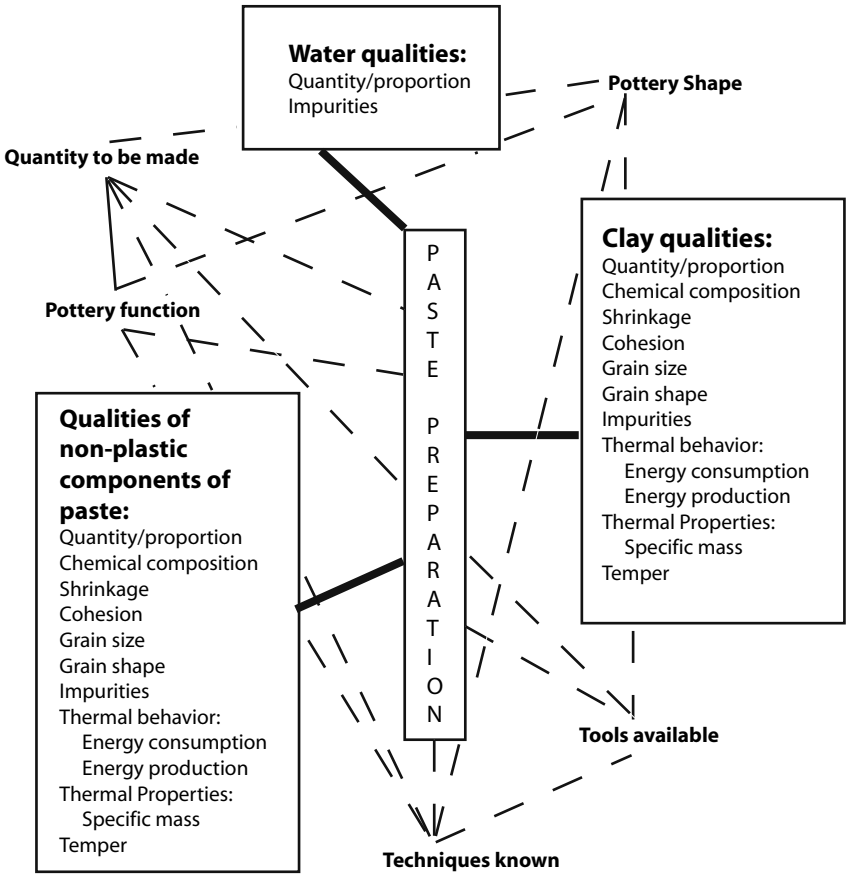

Fig. 12.4 Network representation emphasising the 'objects' (in boxes in the figure) impacting on the potter's transformation of raw materials into a suitable paste to use in pottery making

the kind of asymmetrical interactions of the mind with the real world that we have discussed above, and all of them (as well as others) figure in the network that governs pottery making together with the 'things' with which they have (often multiple) relations of perception and instantiation.

Complex though the network is, interestingly *the number and nature of the relationships in it is limited by the nature of the real world*, which does validate certain relations, but does not tolerate others: dry clay cannot be molded or otherwise shaped; certain shapes cannot be realised due to the laws of physics; each clay requires a minimum amount of heat to be fired, but cannot be fired beyond a certain temperature, etc.

Other limitations derive from the economic context in which the production occurs. This is represented in Table 12.2, which describes pottery making in terms of a series of system states constrained by the size of the production, and thus by the market conditions in which the work is done.

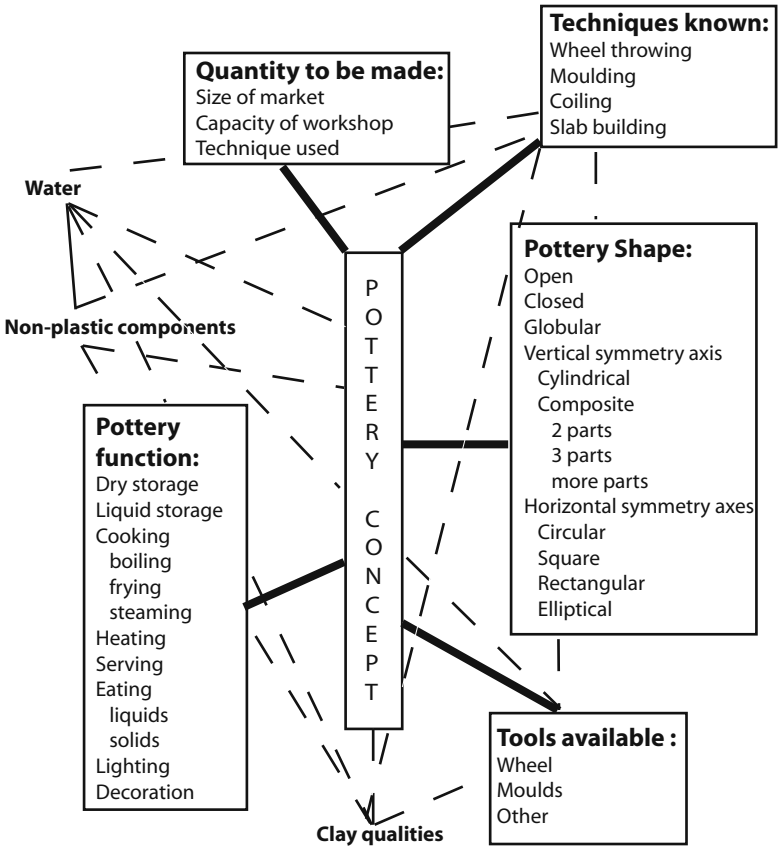

Fig. 12.5 Network representation emphasising some of the technical 'objects' the potter keeps in mind while conceptualising the pots to be shaped (in boxes in the figure)

Even then, these limits to the total size and structure of the network, however, far exceed the actual part of the network that is activated in routine production within any one manufacturing tradition. *The third limitation is inherent in the history of the tradition (the network)*. Once certain solutions have been found (i.e., once certain 'things' have been transformed into 'objects', and once it has subsequently been proven that these 'objects' can successfully be instantiated into more 'things'), the sheer complexity of the network and of the instantiation procedures favours the continued use of these 'solutions' over the invention of new ones as long as the context is the same. As we will see below, for example, once it became a habit on Negros to begin the vessels by shaping the rim, this was maintained throughout a range of ulterior modifications of the manufacturing procedure, such as the introduction of more and more sophisticated rotation devices. But ultimately, that same choice to begin with the rim was not compatible with the use of the modern, western, potter's wheel, and that was therefore difficult to introduce.

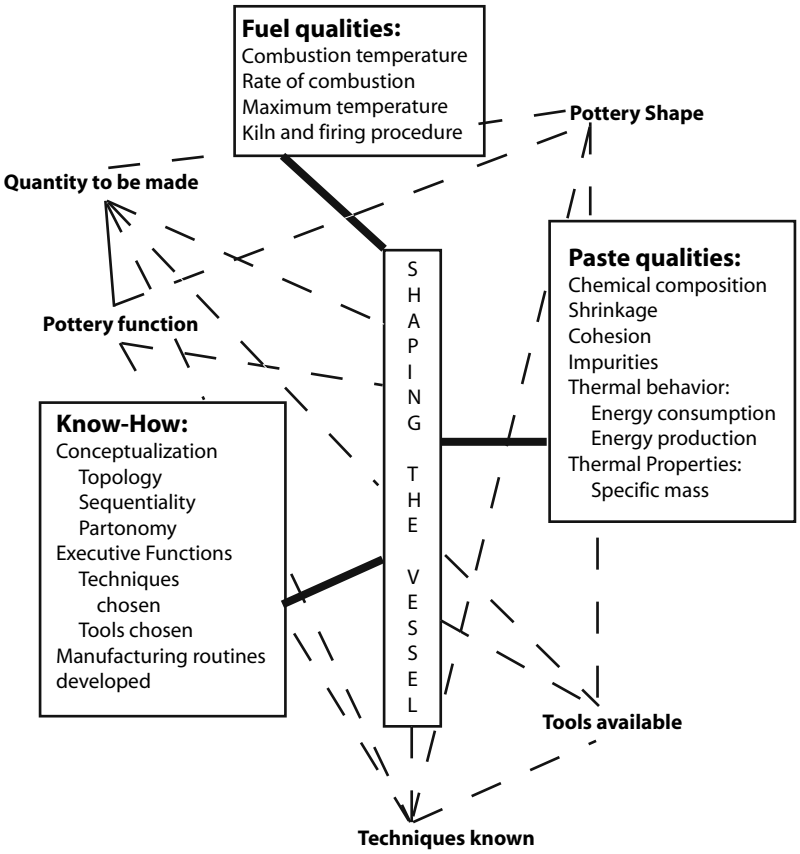

Fig. 12.6 Network representation emphasising some of the technical 'objects' the potter has to keep in mind while shaping the vessels (in boxes in the figure)

Suppose the potter has in mind to make a jar to pour water from. That imposes certain minimal constraints both on the shape of the vessel (a high centre of gravity, a handle, a spout) and on the characteristics of the vessel wall (it has to be waterproof). The tools he or she uses impose other constraints: on a potter's wheel, *ceteris paribus*, there is more potential variation in shape than when the potter is using a mould, for example. Other constraints derive from the nature of the kiln and fuel: if the kiln can be fired above 1050 C, the potter can usually ensure impermeability of the vessel wall by vitrification, but if that is not the case, the vessel either has to be glazed or impregnated with another substance to make it impermeable. Yet other constraints derive from the availability of raw materials: if the clay is fine and plastic, and the potter is working on a wheel, the clay may be used as is, but if it is found with larger non-plastic admixtures, it will have to be purified. On the other hand, if the potter is working in a mould, the 'rougher' paste may be used, and a fine clay will have to be mixed with some form of temper, etc.

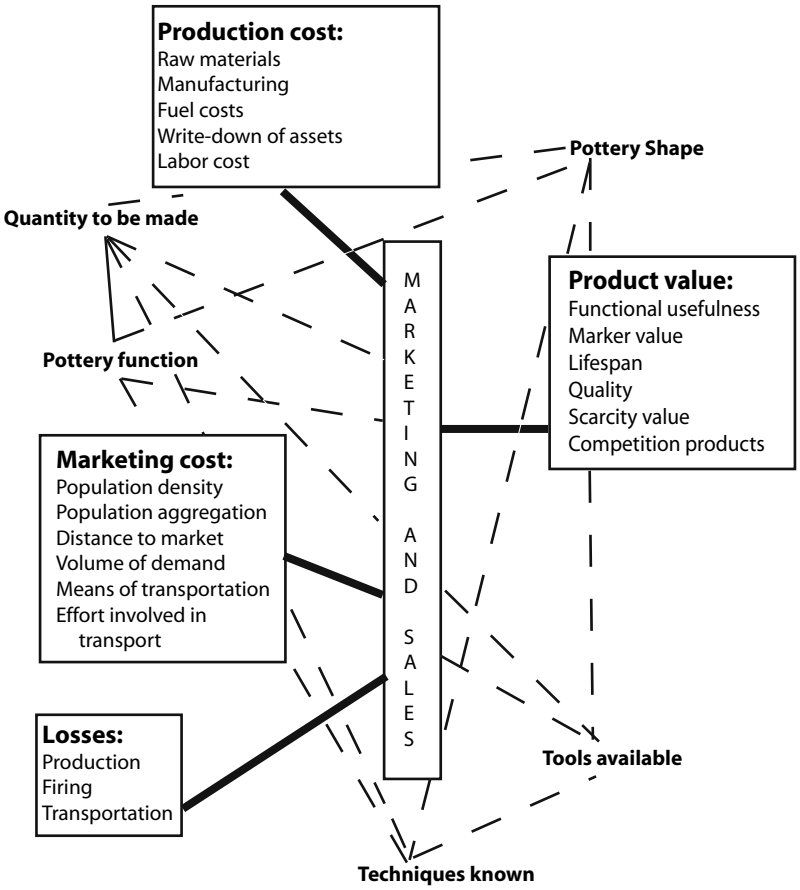

Fig. 12.7 Network representation of some of the aspects ('objects') of the market and the marketing organisation that impact on the marketing of the vessels (in boxes in the figure)

These are but some examples to illustrate the nature and complexity of the process by which the potter articulates all the different elements to be taken into account to successfully produce the desired vessel. In reality, many more such elements and considerations come into play, some of which are referred to in the illustrations. But the main points to make here are (1) that this process is subject to the three asymmetries that we have outlined earlier, (2) there are always multiple 'solutions' in the general model to realise one's aim and (3) the historical trajectory of a particular 'tradition' generally has limited the choice of potential 'solutions' of which the potter is aware by circumscription of the set of 'objects' which constitutes the 'know-how' of the artisan.

At the level of the individual relations between people, 'things' and 'objects', the dynamics are subject to the three working hypotheses outlined above: the asymmetries between cognition and action, the asymmetry between 'things' and

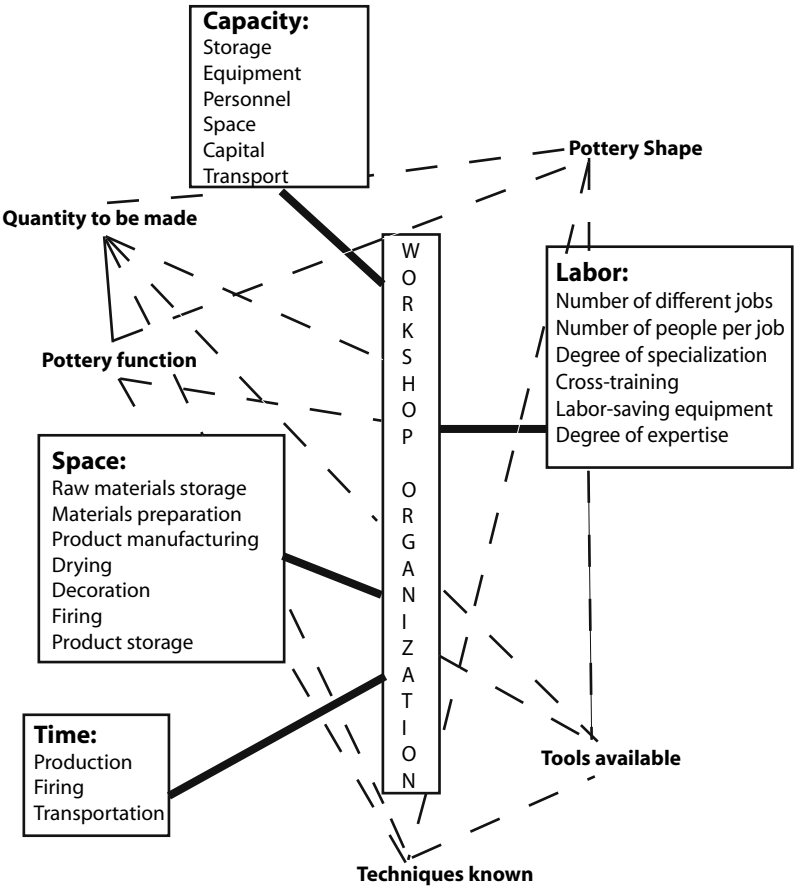

Fig. 12.8 Network representation of aspects of the organisation of the work and the workshop ('objects' in boxes in the figure) that impact on a potter's decisions in planning and implementing production

'objects' and the under–determination of our ideas by observations (and the concomitant over-determination by understanding or know-how acquired earlier).

As a result of all these asymmetries, the network that connects the nodes is to some extent 'flexible'. There is flexibility in the connections between 'things' and 'objects' in the sense that certain things do not always have completely the same associations in the mind – because those associations are in part dependent on the context, as well as on the direction in which the different nodes are connected. But it is important to emphasise that this does not mean that the network is 'unstructured'. Rather, the asymmetries of the cognitive relations create a kind of 'structure of biases' which over time impact on the trajectory of invention in a society.

Table 12.2 Relationship between the economics and the technology of pottery making. The table presents a number of 'system states' of the overall pottery making system in order to show how production (and sales) volume relate to the organisation of pottery making, to the techniques used, and to the raw materials selected for use

	variables	household production	household industry	individual industry	workshop industry	village industry	large-scale industry
Economy	Time involved	Occasional	Part-time	Full-time	Full-time	Part-time/Full-time	full-time
	Number involved	One	Several	One	Several	several	Many
	Organization	None	None	None	(Guild)	Certain	Certain
	Locality	Sedentary or itinerant	Sedentary or itinerant	Itinerant	Sedentary	Sedentary	Sedentary
	Hired hands	None	None	None	Some	Some	Labour force
	Market	Own use	Group use	Regional	Village/town	Region (wide)	Regional and export
	Raw materials						
	Clay	Local	Local	Local	Neighbourbood	Neighbourhood	Neighbourbood/ distant
	Temper	Local	Local	Local	Neighbourhood	Neighbourhood	Neighbourhood/ distant
	Water	Local	Local	Local	Local	Local	Local
	Fuel	Local	Local	Local	Neighbourhood	Neighbourhood	Neighbourhood/ distant
	Investments	None	None	Few	Some	Some	Capital
	Seasonality	Production as needed	Season w/o other work	All year except winter	All year/good weather	All year/good weather	All year
	Labour division	None	None	None	Some-considerable	Some-considerable	Detailed
	Time involved per Pot	High	High	Medium	Medium-low	Medium-low	Low
	Status	Amateur	semispecailist	Specialist	specialist	Specialist	Specialist(few techniques)

Table 12.2 (continued)

	variables	household production	household industry	individual industry	workshop industry	village industry	large-scale industry
Technology	Manuf. techniques tools	Hand/small tools	Hand/small tools	Hand/small tools	Mould/wheel	Mould/wheel	Wheel/cast/press
	Sed. Basin	None	None	None	When needed	When needed	Needed
	Wheel	None	None; rotary support	Turntable	Various kinds	Various kinds	Kickwheel or similar
	Drying shed	None	None	None	Needed	Needed	Needed
	Kiln	Open firing	Open	Impermanent	(semi-) permanent	(semi-) permanent	Permanent
	Raw materials		firing/ impermanent				
	Clay	Wide range	Wide range	Wide range	Narrower range	Narrower range	Narrow range
	Temper	Wide range	Wide range	Wide range	Narrower range	Narrower range	Narrow range
	Water	Any	Any	Any	Any	Any	Any
	Fuel	Wide range	Wide range	Wide range	Narrower range	Narrower range	Narrow range
	Range of pottery	Narrow	Narrow	Wide	Narrow or wide	Narrow or wide	Narrow or wide
	Range of functions per pot	wide	wide	wide	narrower	narrower	Narrower
Examples					Bergen-op-Zoom	Tzintzuntzan	Wedgwood
		Kabyles, N Africa	Cameroon, Tanzania	Tibet	Farnham	Temascalcingo	Delft
					Haarlem	Djerba	

There are two sets of circumstances under which the artisan has to adapt by making changes in the mediation process that underpins production. The first of these is when unintended consequences of certain choices made in the production process lead to problems or incompatibilities within the specific model underlying manufacture so that that model cannot satisfactorily be applied and the other is when any of the parameters governing a particular way of making a category of artefacts changes (new economic conditions, new materials, new shape (or other) requirements, etc.).

When either set of circumstances occurs, the artisan has to re-evaluate all the elements of the specific conceptual model on which production is based and the relations between them. That process takes place from the 'a priori' perspective that is the artisan-creator's and is subject to the above-mentioned biases inherent in the cognitive articulation of the world of ideas with the material world. Depending on the situation, and in particular on the nature and extent of the problems that emerge, this will lead to either incremental improvement or to drastic change such as the invention of completely new techniques. But in either case, the 'new' emerges from the pre-existing network of 'agents' by looking at that network 'anew', devising new conceptualisations, new ways to mediate between the different materials, tools, ideas and know-how that enable the creation of artefacts. And over the longer term, the 'structure of biases' mentioned above therefore inevitably has an impact on the evolution of invention in the system, creating a 'tradition'.

Innovation

The core of my argument in this chapter is that invention and innovation play out in a dynamic network relating agents, things, 'objects' and contexts. In such a network, invention is a local process, involving few nodes and few edges. Only those agents that are immediately connected to the inventor(s) are involved and the process is therefore one that plays out in a relatively limited number of dimensions comprising the immediate articulation of the know-how of the inventor(s) with the other agents in their material world.

Innovation however, the process by which an invention spreads and is taken up – and may even generate an 'innovation cascade' – plays out in a much larger network of agents. The network dynamics involved are of several different kinds. First of all, there is variability in the extent of, and the parts of, the scaffolding structure that are activated at any one time, so that new associations can be made, or old ones 'lost'. This variability is related to the topology of the network itself – that is, to the nature and configuration of the nodes in it and the edges between them. But it is also related to the context(s) of activation and to the accumulated understanding that the human actors in it have gained in the past as part of the activation of (partially) different networks. But that accumulated understanding is not activated in its entirety: it is activated in the form

of associations that the human agents make between a current activation and anterior ones.

This may be illustrated by contrasting two ceramic traditions, pottery making in a mould in Michoacan (Mexico; van der Leeuw, Papousek & Coudart, 1992; van der Leeuw & Papousek, 1992), which I have studied in the early 1990s and pottery making on different forms of rotating devices, such as I have studied on Negros (Philippines) in the early 1980s (van der Leeuw, 1984a, b). As limitations of space do not permit me here to work these examples out in great detail, or even to map the networks completely, all I can do here is to present the differences between the two systems in tabular form and add some explanation. A more elaborate presentation is in preparation.

The two examples essentially represent workshop industries in which many potters in the same location compete in making a range of pots in considerable numbers for sale in a market economy.[5]

What immediately strikes one in Table 12.3 is that the *social context* of pottery making in the two locations is very different, and does indeed seem much more conducive to invention and innovation in the Philippines than in Mexico because it favours information exchange in the former but works against it in the latter. But although that may explain *why* innovation was more manifest in the former than in the latter society, it does not explain *how* it occurred in either society.

Following on from the social context, the *organisation of production* is more flexible on Negros. In both cases, men and women make pots, although on Negros men and women can both own property and are economically more independent and equal than in Michoacan, where the society is strongly dominated by men. In Michoacan, the family unit is essentially the basis of the organisation of pottery making, whereas in the Philippines, it is a commercial unit that may include (paid) workers that do not belong to the family. This does not make any important difference in the organisation of the work itself but it does enable the workshops on Negros to adapt their organisation more quickly to new needs.

Let us then look at the *toolkits*. The tools used in the original traditions are the paddle-and-anvil and the mold respectively. But in the Negros tradition, the use of the mold as well as of a rotating device has been introduced, whereas in Michoacan, the mold has remained the principal tool, with very few exceptions. On Negros, it is common to mount a half horizontal mould (an upside-down

[5] Although this is the case for the vast majority of workshops on Negros, the full range of organisational forms is represented, from the single potter who only makes pottery every once in a while via the single individual who makes pottery full time, all the way to the workshop industry and the full industrial factory. Indeed, it is a characteristic of the Negros case that the potters have been able to adapt their toolkit, know-how and organisation in a relatively short period to mass production by inventing new technical and organisational solutions to the challenges posed by the original pottery making tradition. The Michoacan potters have not done so.

Table 12.3 Some of the principal differences between pottery making traditions on Negros and in Michoacan

Negros	Michoacan
Natural environment	
Tropical	Mediterranean
Social context	
Very interactive society	Closed, fragmented society
Pottery making in open air, visible to all	Walls around workshops or pots made inside
Individuals can undertake change	Change requires collaboration of many people
Everyone has all know-how to effect change	Only moldero has know-how to effect change
No visible social means to limit change	Numerous social means to limit change
Makers' conceptualisation	
Makers' topology does not distinguish inside and outside of vessels	Makers' topology fundamentally distinguishes inside and outside of vessels
Makers' partonomy distinguishes shapes made as wholes or shapes made in horizontal segments	Makers' partonomy distinguishes horizontally molded open shapes or closed shapes molded in vertical segments
Makers' sequence is lip to base	Makers' sequence is in vertical segments
Neither shapes nor decoration prescribed	Shapes prescribed, decoration partially proscribed
Tools and executive functions	
Basic tradition is hammer and anvil shaping	Basic tradition is mold-shaping
Molds used as aids for certain shapes	Molds essential for all shapes
Rotating devices used as aids in many workshops	Rotating devices used only in two a-typical workshops, for unusual reasons
Firing principally in open air, exceptionally in kiln	Firing in controlled environment (kilns)
Organisation of production	
Wide range, from 5-6 to thousands of pots per month per workshop	Thousands of pots per month per workshop
Varies with size of production; full range from individuals via family workshops to industrial workshops and cooperatives	(Extended) Family – based workshops
Division of labour in larger workshops	Only informal, temporary division of labour within the family
Raw materials	
Clays and temper from different locations, mixed at the workshop	Clay deposits generally contain enough non-plastic materials to avoid using separate temper

pot) on a stick and to allow it to rotate in an upright bamboo tube, while in Michoacan, very occasionally, a similar device is being used to support the heavy horizontal mold on which one shapes plates, bowls and other 'open' objects. Although in both places there are people who have attempted to make the potters aware of the European kickwheel, their attempts have not been

successful in either region. Finally, kilns are known in both places, but while they are commonly used in Michoacan (where fuel is scarce), they are only rarely used in Negros (where fuel is plentiful). In view of all that, contrary to habitual interpretations in archaeology, the difference in toolkit itself can therefore not be held responsible for the different ways in which innovation has manifested itself in the two traditions.

As for the *raw materials*, these are pretty much the same in both regions – whether the clay is dug up mixed with sandy temper or whether that temper is added. The main difference is that in Michoacan the clay is dug dry almost all year around, then ground and reconstituted into a plastic mass by adding water, whereas on Negros, a large part of the year, the clay is dug wet, so that grinding is avoided. In the industrial workshops on the island, sand is then added.

We conclude that none of the above categories of attributes of the pottery making system seem individually to explain the difference in direction of inventiveness and innovation that we observe when comparing the two regions. However, brought together into an interactive triangle between people, ideas and material 'things', they may provide part of the story. The clue to all that is found in the interaction between ideas ('objects' in the terms of this chapter) and the 'things' in the material world, in the context of the social-organisational systems in the two areas.

Let us therefore turn to the makers' *conceptualisations*. In the case of Negros, pots are conceived in horizontally joined parts. In most cases, the rim is shaped first and the body next. Whether the shaping of the body is by hammer-and-anvil out of a single lump of paste or by shaping the base and the shoulder separately and joining them together, the conception of the pot is based on a horizontal partonomy and a sequence that begins with the rim. Such a conception has facilitated the introduction of a vertical rotary device. In Michoacan, on the other hand, the more complex pots are conceived of in terms of a vertical partonomy – the pots are shaped in molds that consist of two or more vertical sections. Such a vertical partonomy evidently does not facilitate the use of a rotary device turning around a vertical axle.

As in every tradition, ultimately ideas, tools and know-how become closely aligned and intertwined into a system in which changes in one domain immediately require changes in many others. Thus anchored, the two traditions developed in very different ways – on Negros, a rapid increase in production was facilitated by better and better turning devices, but the range of shapes that could be made on them remained limited. The fact that pots are conceived from the rim down blocked the introduction of a western-style potter's wheel. In Michoacan, increasing production could not be achieved by increasing productivity and the vertical conception of the vessels completely excluded the introduction of a western-style wheel. Mold-making is in effect relatively efficient, but increased production required more people and more moulds. On the other hand, the vertical partonomy enabled the making of a very wide range of shapes, including annular pots, pots in the shape of birds, and asymmetric pots, which would never have been 'invented' on Negros.

The need for mold-makers and potters to agree on the creation of new shapes, and the fierce inter-village competition, coupled with the 'closed' social structure, hampered innovation in shaping techniques in Michoacan. Creativity was much more evident in decoration, where many traditional motifs were in the process of being exchanged against much more innovative ones, because in this domain there were no physical constraints against change, and the social rules were less stringently formulated.

Conclusion

In this very preliminary study, I have argued that we urgently need to understand the process of invention and innovation so as to avoid always re-acting to innovations, instead of harnessing innovation to our needs. Thus far, such understanding has been hampered by what I have here called an 'a posteriori', scientific, approach to the topic. Instead, we need to develop an 'a priori' one, which looks at the logic of creation in terms of choices made and choices not made. In developing such an approach, the 'distributed' network approach to agency developed in this book is very helpful, provided one does not forget that humans are the medium through which action occurs and that, therefore, the inherent asymmetries of human interaction with the material world play an important role. These asymmetries are over time responsible for a 'structure of biases' in each and every technological tradition which impact on choices made and ultimately, on which kinds of inventions and innovations are affordable in a tradition.

To gain this kind of understanding of invention and innovation, it is important to consider – from a network perspective – all the factors that may play a role in the decision-making process, including social and environmental ones.

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