Technological Memories[1]

Dino Borri*

Introduction

The technological concept of techniques linearly and positively evolving through time is increasingly challenged by social, economic, and environmental failures of numerous techniques (Mignolo, 2000). In industrial or civil production activities many technologies have been abandoned because of their risks for people and the environment. It has been argued that technological change is largely self propelled, under the push of the powerful, complex, and integrated systems that are evoked by growth and development of technical abilities (Severino, 1998).

Satisfaction of people basic needs (water, food, houses, mobility, culture, energy, waste disposal, etc., in a continuously growing list) is now conceived as a complex, evolutionary, probabilistic, and chaotic human survival ecology and not anymore as a deterministic process (Newman, Jennings, 2008).

Dialectics and transition between tradition and innovation in technology, at the heart of which in the course of time a standard dominant technology comes to be fixed, are now seen in a critical perspective, extending the Kuhnian paradigm of scientific revolution to the technical domain (Kuhn, 1962; Dosi, 1988). This brings to revaluate – often in terms of rediscovering – technologies which derive from times and places very distant from the dominant technological cultures and from their operational systems (Brodt, 2001).

These developments call for widening the reflection on technological change from the social and aggregate levels of a recent past towards new microorganizational levels, from the small nomadic or village communities to their individuals, that is just where presumably techniques originate through a sort of

* Technical University of Bari (Italy)
borri@poliba.it

ecology of technological microobservations and microconstructions, microdecisions and microplans, implementation successes and failures (Borri, Camarda, De Liddo, 2005).

This emerging cognitive approach to the analysis of technological change aims at pushing social anthropology and history and philosophy of science and technique to a new consideration of molecular and distributed events and at integrating them into a new frame oriented to the individual agents as original springs of technological change processes (van de Kerkhof, Wieczorek, 2005; Weick, 2001).

Water technologies offer an exceptional stance in the above cited perspective, because of their centrality in the ecology of living beings. The centralized big hydraulics produced by standard technical expertises is critically reviewed, for example, in favour of a small and distributed hydraulics, bioregional, ecologically more resilient, produced by local common knowledge well adapted to the local environment (Borri, Grassini, Starkl, 2009).

Our work starts from a research on local hybridization of the traditional technologies and the innovative ones that replace them (often, admittedly, standard technologies lacking of whatever innovation or of doubtful success for certain aspects, exported from dominant technological environments towards dominated technological peripheries) to introduce and discuss the neglected concept of technological memory (TM).

TM, for us, is essential to understand technological change (TC) in the above cited cognitive and microorganizational perspective. Our concept of TM in a way recalls the concept of ontology as this is currently used in computer science for distributed multiagent systems or in regional science for cognition-based and spatial-based analysis of human capitals (Sechi, Borri, De Lucia, 2010).

Piaget and his followers have paved the way to the understanding of the development of knowledges and abilities of the individuals starting from the fast and essential stages of the development of human conceptual and practical abilities from childhood to maturity (Piaget, 1950). Newell and Simon have showed that human problem solving ability links to a cognition-action rule based memory gradually framed through interaction with the real world and education and accessible via an innate program (Newell, Simon, 1972). Anderson has supported the idea of a modular architecture of cognition having at its centre a long term memory (dualistically oriented towards facts and procedures) and a working memory (Anderson, 1983).

If technique, as organization of cognition-action abilities of individuals and societies aiming at reproducing their life and incorporating resources available to external to them, is reviewed in the light of our TM concept some major questions emerge. Should the TM concept be definitely sound: (i) is TM a particular form of memory or does it comply with the dominant model of generic memory currently postulated? (ii) does the TM structure vary with the variation of its objects? (iii) what is the relation between social and individual learning in TM?

In the following pages the analysis of some case studies of persistence or disappearance of traditional water technologies still in use in Mexico provides interesting tentative answers to the above cited questions. The paper in its first section discusses peculiarities of water technologies when these are applied to fundamental common goods – basic environmental resources – whose ontological conceptualization is partly innate, in the second section the dilemma relating to individual *vs* social form of technological learning, in the third section the concept of TM with some of its theoretic and experimental implications, in the final section some Mexican case studies.

Technological Memory

The concept of TM refers to a specific qualification of the agents' generic memory that cannot be merely postulated and requires adequate theoretical and experimental argumentation.

I hypothesize that a plurality of task specific memories as specific memory (sub-)organizations coexist within the generic and cumulative memory of an agent, depending on the finalities for which the various chunks of the memory progressively constitute themselves, a problem already analyzed in neurophysiology (Damasio, 1995).

Here I evoke the concept starting from some evidences presented by some case studies of water technology in environments in which traditions and memories still resist to innovations and standardizations. The case of the water technology of the *jagueyes* in Mexico, small artificial basins used by villagers in the pre-Hispanic Mexico to satisfy their needs, today persistent or interrupted in relation respectively to absence or presence of technical innovations introduced by the *conquistadores*, is meaningful.

Since ancient ages, in arid climate countries, water technology presents extraordinary examples of specific organizations devoted to designing, constructing, and managing complex and ambitious works. The frequently big dimensions of these works and the evidence we have about the impressive quali-quantity and the collective organization of the human work needed for them should not obscure individual brilliances and contributions. The gradual minor adjustments that have been brought to the original forms of these works through the infinite repetitions of them in different places and times suggest that social forms of cognitions and actions interacted with individual contributions, granting a blend of mutual learning and transfer of memory and creativity.

With the gradual disappearance, due to many reasons, of the productive and market organizations on which certain techniques are based technological memories referring to these suffer transformations and become unusable.

An interesting example of disappearance of a given TM due to the destruction of the socio- political organization on which that technique with its materials, markets, and professional abilities was based is presented by the construction of large roofings.

Covering large spaces without intermediate supports (see the solution used in Rome during the Empire age for the Pantheon's dome, a semisphere of more than forty metres of diameter, built in a very sophisticated way with extremely light prefabricated clay pieces settled in concentric circles and linked by high resistance and extremely light mortar) will be impossible for fifteen hundred years, until the reinvention of a different building solution (by the way strongly less sophisticated: heavy

masonry, made of bricks reinforced by big ribs) with the Gothic dome designed by Filippo Brunelleschi for the cathedral of Saint Mary in Florence. In this case, the disappearance of the Roman political and productive organization operationally annihilated a technological memory: building history and techniques in exceptionally wide perspective were presumably perfectly known to Filippo Brunelleschi in Florence or to Andrea Palladio in Venice, the two giants of architecture presumably shared the sectoral TM which was needed for emulating the Roman technique of covering large spaces but they did not have anymore the ability of making it operational.
Thinking on one side to the Newell's and Simon's memory model (abilities as gradually formed by series of condition-action rules and on the other to the Anderson's one (factual memory plus procedural memory), in the light of the simple above cited considerations, the hypothesis comes that TM is labelled in relation to facts, procedures, and judgments as essential attributes on them. In this way it becomes clear how parts of TM learnt through experience within a tradition or description from others can be gradually abandoned till the eventual cancellation or more probably qualified with obsolescence and impracticability attributes.
Coming back again to the difference in TM between the big Roman constructions and the constructions built in the ages to come, it can be that Brunelleschi or Palladio – to cite only some giants of technique and creativity in the field in the Western world – ignored some operational details of those constructions, for example preparation of special pieces and mortars, and therefore they could not design them even if hypothetically they belonged to a still practicable.
Individual memories make sense not per se but within social chains of context-based practicability, they are made by transmission rings cut and interrupted by disappearance of individuals, organizations, resources, and examples (Howells, 2002).
TMs are constituted in the agents through direct or indirect – the latter as they can be diffused outside from local origins – experience and can (i) *be limited to simple passive cognition of facts and*

procedures ("I know that a certain technique exists" or I saw that technical device while functioning", or "Somebody described me that technical device but I never had a chance to use it ") or (ii) *become part of an active inclination of the agent as a direction given by him/her to other agents* (political agents can say to other agents – should these already know it or not know it so that they have to learn it immediately – to adopt that technique), or, further, (iii) *become part of a life that uses that technique* ("I am a user of that technical devices, should they have functionality problems maybe I would be able to repair them" or "I saw that technical device while functioning, while giving me water availability for long time"), or, in the end, (iv) *become active ability* ("I know very well that technical device as I had the chance of realizing it" or "I was present when this technical device was realized and started its functioning" or "I know how to create this type of technical device here", or "I am a user of this technical device", or "I am not a user of this technical device but I could be a user of it in the future") (Gorman, 2002).

In a process of technical imitation, consisting in introducing an exogenous technique in a place, the whole set of cognitions and resources on which the technique at hand founds is present so that what results is a – no matter how much relevant – technical change, an ecological variant of the technique at hand whose inspiring principle (the ontology) remains substantially fixed, obviously in the terms in which the imitator conceptualized that technique or that technique was represented to the imitator (the latter through a technique description to this by a protagonist – primary – or informed – secondary – agent). Therefore in technological transfer and use of TM it is important to distinguish general principles from local applications.

Influential theories of architecture of cognition postulated memory as organization of sets of atomic condition-action rules (Newell, Simon, 1972) or, alternatively, *frames* (Schank, Colby, 1973), while more recently the two alternative forms of memory organization have been assumed as not incompatible, by postulating memory (and cognition) as metaorganizations (organizations of organizations): it is plausible the hypothesis of having memory based on condition-action rules plus *frames*, with contingent precedence of each form on the other, in compliance with circumstances and needs. Causal frames as models deriving from immediate representation-conceptualization could have (hierarchical?) precedence of use on atomic rules constituted more gradually, as presumably effective interaction with reality requires the most immediate and powerful from of cognition and memory.

Another hypothesis is that TM cannot be effectively constituted when the principle of functioning and applicability of its components (techniques) is not enough clear in detail: in this case, technique is not memorized or is destined only to passive action memories and commonsense warns us against its possible superficiality and also that a political orientation it ("Use that technique, it has a lot of positive credentials!") sometimes can prove to be a disaster because of a knowledge about it too much shallow.

So an answer to the first question comes: operational TM is constituted by facts and explanation about facts from which actions come down, it is not mere *if-then* type memory of events and of phenomena in which causal relations are relaxed.

TM – like any other operational and specific memory – postulates the existence of memories with or without incorporated explanations (in fact, a technique can also function as a *black box* for us: we can see it while functioning without understanding why it is functioning).

The last assertion, anyway, drives to wonder whether a difference exists between TMs, oriented to implementation but not necessarily located at the top of the hierarchy of the agent's intelligence in his/her relation with the world, and other memories that can relate to and deal with events and natural phenomena the reason of which we do not understand.

A further interesting hypothesis, coming down from the TM concept, is that a difference exists and comes from the intuitive perception that in front of natural phenomena whose reasons are unclear all the human agents are in a same knowledge condition while we perceive by intuition that in front of human phenomena whose reasons are unclear (for example, take those generated by applying techniques unfamiliar to us) the human agents are in asymmetric knowledge condition (being or not familiar with those techniques).

From here the impossibility or the senseless feature – a part from possible intentional learning aimed at entering a circle of technical scholars – of the cultivation of memories of techniques that go out of the operational boundaries and contents of a TM.

We look at techniques assumed by us as impracticable and pass beyond or to deal with them – when needed – we place our trust in specialists (see the Nozick's hypothesis about the emergence of a technical rationality more an more inaccessible for non-specialists) (Nozick, 1993).

Therefore TM is selectively constituted according to the following framing hypotheses: (i) selection has large stitches when human agents perceive by intuition that a large filter is essential for them, because by capturing more technical memories it increases their survival abilities in the future inevitable solitary confrontations with those technical problems; (ii) selection has narrow stitches when human agents perceive by intuition that even if they do not understand those technical problems they could delegate the problem solving to others (Bathelt, Malmberg, Maskell, 2004).

In this reasoning the following question is nested: In a water technology like the one of the *jagueyes*, which presents a problem of TM drama in a village community under the push of exogenous innovations (water engineering of the Spanish *conquistadores vs* water engineering of the Mexican natives), is the *jagueyes* TM diffuse in the whole village community or confined in specialists?

The case study reports a TM diffuse in the whole set of community agents because of its simplicity that makes that it can be easily memorized and reproduced by all and preserve it from becoming exclusive patrimony of specialists. The whole society of the individuals of the village has had to contribute to maintain the *jagueyes,* so that they became active protagonists of that technique and agents of the related TM (it would be confirmed, here, the concept of cognitive difference between passive or active participation in practising a technique).

Conclusions

The case study allows to argue in favour of the existence of a TM which has selective nature, is rich of causal relations, not identically distributed within the whole set of agents who practise the technique at hand, is transformed by specific utility functions based on ecological rationality, is linked to resources and organizations more than individuals as technical applications – differently from what happens for *if-then* rules related to manipulation or recognition of biotic or abiotic entities – are part of complex social chains and hardly can be implemented in isolation.

Therefore TMs have high social connotation, are not basic as they do not pertain to fundamental facts and processes, and like in the other social domains accept division of work ("You have that memory which differs from mine …"). In practice, just because of this sociality, TMs essentially function in interactive ways and cannot be understood, constituted, and experienced in isolation: as they have not basic contents, TMs can be cleaned or anyway confined into sleeping memories that can be found and activated only in particular conditions of intentionality or need.

The case study shows that communities that are affected by organizational breakings in water technologies suffer from a destruction of their TMs and are forced to start from scratch through the adoption of new techniques, often exogenous and worse than the traditional ones passed on by those disrupted technological memories.

Notes[1]

This paper is part of a paper presented at the Conference of the Organizational Learning Society, Boston, June 2010, by D. Borri, D. Camarda, and L. Grassini, Technical University of Bari, and M. L. Torregrosa, University of Mexico, as a result of the European Union scientific project ANTINOMOS (Global Vs Local Knowledge for Water Technologies) coordinated by Dino Borri.

References

Anderson J. R. (1983), *The Architecture of Cognition*, Cambridge, MA, Harvard University Press.

Bathelt H., Malmberg A., Maskell P. (2004), Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation, *Progress in Human Geography*, 28, 1, pp. 31-6.

Borri D., Camarda D., Deliddo A., (2005), Mobility in environmental planning: An integrated multiagent approach, *Lecture Notes in Computer Science*, 3675, pp. 119-129.

Borri D., Grassini L., Starkl M. (2010), Technological innovations and decision making changes in the water sector: Experiences from India, paper presented at *The II International Conference on Water Values and Rights*, Palestine Academy for Science and Technology, April 13-15, 2009, Ramallah, Palestine.

Brodt S. B., (2001), A systems perspective on the conservation and erosion of indigenous agricultural knowledge in central India, *Human Ecology*, 29, 1, pp. 99 – 120.

Damasio A. R. (1995), *Descartes' Error*, New York, Avon Books.

Dosi G. (1988), Sources, procedures and microeconomic effects of innovation, *Journal of Economic Literature*, 26, 2, pp. 1120-1171.

Gorman M. E., (2002), Types of knowledge and their role in technology transfer, Journal of Technology Transfer, 27, pp. 219-231.

Howells J. R. L. (2002), Tacit knowledge, innovation and economic geography, *Urban Studies*, 39, 5-6, 871-884.

Kuhn T. S. (1962), *The Structure of Scientific Revolution*, Chicago, University of Chicago Press.

Mignolo W. (2000), *Local Histories/Global Designs: Coloniality, Subaltern Knowledges, and Border Thinking*, Princeton University Press, Princeton, NJ.

Newell A., Simon H. A. (1972), *Human Problem Solving*, Englewood Cliffs, NJ, Prentice-Hall.

Newman P., Jennings J., (2008), *Cities as Sustainable Ecosystems*, Melbourne.

Nozick R., (1993), *The Nature of Rationality*, Princeton, Princeton University Press.

Piaget J. (1950), *The Psychology of Intelligence*, London, Routledge and Kegan Paul.

Schank R. C., Colby K. M. (1973), Eds., *Computer Models of Thought and Language*, W. H. Freeman, San Francisco.

Sechi G., Borri D., De Lucia C., (2010), Social capital as knowledge facilitator: Evidence from Latvia

Severino E. (1998), *Il Destino della Tecnica* (*Technique and Destiny*), Milan, Rizzoli.

van de Kerkhof M., Wieczorek A. (2005), Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations, *Technological Forecasting & Social Change*, 72, 733-747

Weick K. E. (2001), *Making Sense of the Organisations,* Blackwell, Oxford.