TRANSFORMING SCIENCE INTO PRACTICE

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Abstract

The space for action that might move agricultural systems toward sustainability is narrowing. In so far as increasing dis-order in agroecosystems and food systems is caused by human agency, then remedial action must take account of cognition. This article argues that an understanding of cognitive processes is essential, as the foundation for participatory R, D & E that builds platforms of cooperation, binding actors into communities of learning that are trasnforming both science and practice.

Keywords: Interactive R, D & E; cognitive processes

A new framework of understanding

As I write this, I am considering some sobering facts:

- for the first time in around 50 million years, the Arctic ice cap is melting, and a sea passage opened up in the summer of 2000. Some already are hailing the possibility of cutting the time and cost, and increasing the volume, of trade over the north polar sea route. That is, the effects of the production and consumption that are triggering profound changes in global ecosystem structures and functions, are seen by some simply as opportunities for further expansion of the drivers of ecological change.
- The global agrochemical market was valued at US $ 30 billion in 1995 (Ragnarsdottir, 2000). Competitive restructuring has since reduced the main players to a handful of corporations (Jiggins et al. 2000). Approximately 100,000 chemicals are marketed for use within the European Union alone. For 2000 to 3000 of the large volume chemicals on the EU market, insufficient toxicity and eco-toxicity data are available for 75 % of them for 'minimal' risk assessment under OECD guidelines (EEA/UNEP 1998). Organophosphates comprise a large part of this market; they have been sold as safe for use on crops and animals due to their relatively fast degradation rates. But the evidence is that they can and do persist in the environment years after their application, when conditions are unavailable for microbial metabolism, and that they are preserved and transferred to humans through food (Ragnarsdottir, *op.cit*). OPs are highly toxic and human exposure is undesirable (ibid). A volume estimated as at least one billion litres a year of a chemical cocktail comprising OPs, solvents, bactericides, and emulsifiers, are poured onto UK farmland alone from sheep dips. And yet, the agrochemcial corporations, repositioned as 'life science' companies, have attempt to launch genetically engineered crops and pasture plants onto the market on the back of herbicide and pesticide resistance.

There are many more examples of this 'business as usual' and 'more of the same' mentality, and of the failure of market signals to guide people toward behaviour that is ecologically rational. The latest compilation of the consequences can be found in *World*

Resources 2000-2001: People and Ecosystems, the Fraying Web of Life (UNDP, UNEP, World Bank, World Resources Institute, 2000).

Science does not stand apart from this collective failure. Jane Lubchenco, as President of the American Academy of Science, recognised in 1998 that science had to enter a new contract with society in order to deal with what she called the 'eco-challenge'. Yet her description of how this challenge was to be met was curiously weak: more scientific knowledge, more data, better communication of the results of science to the public. Just as economic theory, effectuated through the creation of economic institutions, has been elaborated to deal with scarcity (though patently failing to do so for the majority of the world's population), the generation of modern scientific knowledge has received funding and institutional support in order to increase our instrumental control over the causal relations of the biophysical world (though by patently failing to perceive the systemicity of living systems, control is just what we are losing).

In my view, both economic and scientific practice are leading us greatly astray, and will continue to do so, in so far as they both fail to recognise the centrality of people as cognitive agents. Cognitive theory today draws on empirical investigation in the biological and the neurosciences rather than purely philosophical study. It offers a new way of thinking about our role in changing our domain of existence, and how we might escape from the predicament we ourselves have created.

The Santiago School of Cognition, developed by two Chilean biologists, Humberto Maturana and Francesco Varela, offers a description of cognitive systems that I have found helpful. It can can be presented as in Figure 1.

Their starting point was the question: how do organisms perceive ? They researched the frog looking at a fly. They found that the image of the fly can not be projected onto the nervous system of the frog; the physical processes governing the image of the fly (light waves) are different to the neurological processes that produce the image created in the central nervous system of the frog. They came to understand that in all living organisms, the central nervous system is informationally closed with respect to its environment. All perceptions of reality are perceptions constructed by the perceiver. But perceptions are not arbitrary creations. The presence of the fly *triggers* change in the perceiving organism (the frog tries to catch the fly), just as the action of the frog *triggers* changes in its domain of existence (the fly tries to escape). Organisms and their environment are structurally coupled, maintaining their relationships through mutual perturbation.

They further specify that 'emotion' is not the same as 'intentionality', nor does intentionality imply some *a priori* setting of an objective to be attained, that motivates action. Emotion is understood as the outwardly directed and public reaction to an inducer, that serves in ensemble with the endocrine, immune and nervous sytems, to coordinate and largely automate the physiological reactions required to maintain steady internal states in a living organism (Damassio, 2000). In brief, emotion contributes to homeostasis in living organisms and as such, is integral to the processes of reasoning and decision-making (ibid: 41). (Note that this is not to say that emotions determine reasoning, rather that reasoning is clearly impaired when an organism's ability to be conscious of its own emotions is broken, and that "certain levels of emotion processing point to the decision-making space where our reason can operate most efficiently" (ibid:41).

The maintainance of structural invariance (the singular individual bounded by a body over changing time and circumstance), and the continuity of reference that the autobiographical self perceives, occur despite the constant death and renewal of all bodily tissues except neurons (which none the less are modifiable by experience and learning), the lens, and the heart muscle. Maturana and Varela name the capacity of living organisms to self-organise, 'autopoesis'. A living organism survives by continuously regulating and renewing its internal processes such that structural coupling is maintained between the organism and its environment, at the same time as preserving continuity and stability of structure and function in the face of perturbation.

Homeostasis (or better, perhaps, to use Steven Rose's term, homeodynamics), in living organisms thus requires :

- *sensors*, a capacity to perceive imbalance between the perceiving organism and its environment, and in the internal state of its own embodied systems;
- a *capacity to act,* the means to perform pre-emptive or corrective actions; and
- *a disposition for action*, including memory, emotion, experience, learning, as well as innate genetic dispositions.

In simple organisms, these capacities are pre-set. In complex organisms , there is in addition selection among numerous available responses, the construction of novel combinations of response, the ability to plan ahead to avoid disadvantageous situations and propitiate favourable ones, and learning from experience. In human beings, we extend these capabilities further, by:

- Building additional sensors to monitor internal states and external signals from our environment. (Note that even if we draw from memory, memories necessarily incorporate triggers from both internal and external perturbations because these are co-registered in memory formation);
- Generating images that are capable of depicting internal states, as well as images of entities, actions, and relationships in our environment;
- Languaging, or processes of communicating through conversations .

Together, these extensions allow us to share meanings and hence create collective understanding.

This is all the more remarkable since triggered response is necessarily something that occurs 'in the moment'. The brain reconstructs a sense of self, and perceptions of self in relation to an environment, moment by moment, and always necessarily from the point of view of the perceiver. We cannot therefore share a common experience although we may enjoy an experience in common. The experiential perspective (which is the only one we have available to us), as Damassio notes (op.cit:145), helps us to situate real objects. It also helps us to situate ideas, regardless of whether they are concrete or abstract , and is " a rich source of metaphor in organisms endowed with such rich cognitive capacities as abundant conventional memory, working memory, language, and the manipulative capacities we subsume by the term intelligence" (ibid: 145).

Similarly, learning occurs in the continuous present and is necessarily adaptive. What is learned may be stored in memory, but also in cultural norms, and in institutions, both shaping and being shaped by further mutual triggering. These extensions of memory into social interactions also embody co-registered perceptions of internal states and external relationships. They cannot be reduced to the individual agent: "For better or for worse, individuals really do share their thoughts and they do to some extent harmonise their preferences, and they have no other way to make the big decisions except within the scope of the institutions they build" (Douglas, 1986: 128). Just as there is no human being that exists outside of social institutions, and thus no one can escape the shaping that each person's social 'domain of existence' gives rise to, so too is a society's system of knowledge, made visible in social relations and institutions, the foundation of social order (Douglas 1996; Jiggins and Roling 2000).

In summary of this dicussion, I draw attention to Maturana's and Varela's startling and powerful definition of knowledge as *effective action in the domain of existence*. But what is knowledge, what is effective action, in a domain of existence characteristed by anthropogenic destruction of the very conditions necessary for our own existence ?

We have come full circle. If the institutions we build, if the social and economic relations we privilege, and the science practice that we follow set up a strucural relationship between ourselves and our environment that makes it 'normal' to perceive, act, and behave in ways that bring into being an environment in which we cannot survive, that makes autopoesis impossible, that damages and then destroys structural coupling with our domain of existence, then we shall perish.

For me, *transforming science into practice* offers a chance to make a modest contribution toward survival. It means that Research , Development and Extension (R,D&E) must evolve knowledge and actions defined as (Roling, 2000):

- *Knowledge that allows us to reflexively manage the cognitive system itself*: When structural coupling can no longer easily be sustained, people as cognitive agents (and perhaps other cognitive agents to some degree) have a capacity through languaging and metaphor, cultural expression, and their institutions, to re-configure the relationship, by changing the meaning of their domain of existence and how to understand and act in it.
- *Action that allows our perceptions and behavioural dispositions to maintain structural coupling.*

Examples

*Case 1: Dairy Farmers in the Netherlands in Transition to More Efficient Nutrient Use (*van Bruchem et al., 1999a, 1999b*).*

Key features: inter-active R&D with approx. 90 Friesian dairy farmers, organised in two cooperatives, based on premise that techanical research alone, carreid out under controlled conditions, cannot provide integral solutions for sustainability in managed pastures and dairying. Specifically, the reseachers and famers initially sought to improve manure quality and reduce nutrient emissions to the environment.

A prototype farm was selected for each cooperative, providing contrasting ecological and farming system profiles. Quantitative and qualitative data were recorded for each prototype farm, and successively monitored as successive adjustements were introduced, with the results shared at periodic within-co-op and between-co-op member meetings. The adjustments were based on joint nutrient flow and transport analysis; the researchers then proposed possible actions; the experimental designs were selected through dialogue, and the assessment of the results was conducted through systematic participatory interaction.

An important learning that is emerging from the research is a focus on the concept of regenerative capacity, linked to increases in enthalpy (order) and self-regulation at the system levels important for sustaining agro-ecosystems (see also Defoer and Budelman, 2000). Recent advances in biophysics and the measurement of energy flows, suggests that it might soon be possible to connect organic farmers' intuitive understanding of the regenerative healthy ecosystems with hitherto neglected biological regulation mechanisms.

Case 2: Ranch Improvement Clubs, Montana (Matheson, N. 1995. Research by Farm and Ranch Improvement Clubs, Sidebar 10.1, in Bird, E. A. R. et al. Eds. 1995.*Planting the Future. Developing an agriculture that sustains land and community*Ames, Iowa. Iowa Unviersity Press, pp 183-185).

Key features of the Clubs**:**

- Producer groups, common practical problem

- Local technical adviser
- Small grants (up to $1000, from an NGO, AERO)

An example: Lower People's Creek Cooperative (Fort Beiknap Reservation):

Objectives: to reduce use by the Bureau of Indian Affairs of herbicide to control leafy spurge on grassland, and to try a biocontrol (sheep). The Cooeprative members were concerned both with the sustainability of their community and with what they perceived as 'poisoning' of their land and water. The proposed experiment, of intensive grazing by 1,500 sheep on 70,000 acres (winter 1992), was jointly defined by the members and researchers at Montan State University.

The results were monitored, and the effects jointly evaluated, by Club members and Montana State University researcher). Specific results included :

- herd increased to 2,3000, to control spurge on more land;
  a lamb enterprise started
- sheep biocontrol recognised as effecvive; BIA reduced herbicide use; money saved by BIA used on fencing for tribal members who wanted to control spurge with sheep.

Case 3: Group Farm Monitoring, New Zealand

(Sheath, G.W. and R.W. Webby, 2000.The results and success factors of a farm monitoring and study group approach to collective learning, in LEARN@Paris, eds. *Cow Up a Tree*, Paris, INRA Editions. In press).

Key features of the Group Farm Monitoring programme were:

- Groups of farmers (15-30 members)
- Participation of consultants, scientists, vets, service sector specialists (including banks)
- Selection of a central monitor farm, monitoring over 3-5 years
- Intensive biological and financial monitoring, presented and discussed at group meetings every 3 months
- Simulation modelling to investigate alternative outcomes
- Adoption of action decisions, the monitor farmer retaining the right to accept or reject group recommendations.

Roll-on effects:

- Other members began own monitoring
- Transformation of the groups to 'study groups' focussing on topics (e.g. pasture quality, young animal growth rates, family survival etc)

Performance outcomes (one study club):

- All farms increased income (from 13 % to 31 %)
- All but two experienced a 30% increase in kg. of meat produced per cattle stock unit
- Farm expenditure remained level
- Farm profit improved, all farms
- Monitor farms adopted key innovations to farming system
- All farms made strategy and practice changes, typically following sequence of: improving effective usage of feed already grown; correcting soil nutrient deficiency/tactical use of nitrogen; improving pasture composition and quality.

Analysis and Discussion

We may note the following commonalities (King, 2000):

- An emphasis on monitoring, by members of " communities of practice" (LEARN@Paris, 2000),
- Facilitated through action researching, action learning (Roling and Wagemakers, 1997),
- That enables the members to become "communities of learning" (LEARN@Paris, 2000),
- Through critical enquiry into the assumptions informing their language and interpretations (McClintock et al., 1997),
- And the use of systematic, participatory methods and techniques (Collinson, 2000).

Second order R&D is a label developed by Ray Ison and David Russell (2000) to formulate science and science practice as a human activity that is aware of its own assumptions and the relationships it forms in its domain of existence. Second order R&D has the following features:

As science, it is:

- Grounded in the explanation of what is experienced
- Bringing forth a reality on the understanding that what is perceived, and the cognitive agent, are a *duality* operating at different logical levels, such that one emerges from and complements the other, and together forming a unity (such as a predator/prey relationship)
- Involving the nature and study of relationships.

As professional practice, it is:

- Motivated by *invitation* and *enthusiasm*
- With all participants sharing responsibility for outcomes
- Oriented to collective and individual *learning*
- Using systematic methods and creating relationships that maintain *dialogue* or *the unfolding of meaning through conversation.*

As a way of organising research, it is:

- Building systemic interaction
- Creating new affilitations.

The examples sketched in section 2, and indeed in Ison's and Russell's own account, all draw attention to the *energy* that is sparked among participants in second order processes, energy perhaps sufficient to change the direction we are otherwise heading. I emphasise this point, for the evidence that things getting worse is accumulating, can be overwhelming, and often is de-motivating (see, for example, UNDP,UNEP, World Bank, WRI 2000). As I have noted, the trend data often lead simply to calls for 'better communication of the results of science to the public' (Lubchenco,1999) and more efficient ways of doing the wrong thing.

The literature recognises the personal acts of courage that are demanded as the pioneers set out on a new track (Meyerson and Scully, 1995). Four strategies that occur at the interface of the individual and the organisation of second order R&D, and that seem to be helpful are:

A. pushing change within the system as it is, through :

- small wins, by action that is considered credible and relevant by the system,
- local spontaneous authentic actions that extend the threshold of what is tolerated and rewarded within the system

B. creating systemic change through:

- languaging - redefining metaphor and concepts that express a new purpose, a new meaning for who we are as researchers, and what we are about in communities of practice and communities of learning,
- maintaining meaningful affiliations and creating new affiliations, that sustain and nurture - and may eventually lead to new organisational relationships and new institutions.

Conclusions

I argue for, and analyses case material that supports, the emerging practice of interactive R,D&E. The weight of the evidence is that interactive R,D & E will emerge more and more strongly as a mainstream practice, in the face of changing markets, institutional arrangements and actors, and agro-ecological trends. Specifically, the evidence is that while reductionist science remains important, it will increasingly be complemented by 'second order R & D' that involves wider networks of actors, at a range of sysem levels, in interactive relationships that are trasnforming both science and farming practice.

References

Van Bruchem, J., Verstegen M.W.A. and Tamminga S. (1999a). From Nutrietn Fluxes in animals to nutrient dynamics and health in animal production systems. *Proceedings* 5th. Internaitonal Livestock Farming Systems Symposium. August 19-20, Fribourg, Switzerland, pp 1-21.

Van Bruchem, J., Schiere B. and van Keulen H. (1999b). Dairy Farming in the Nethelrands in transition towards more efficient nutrient use. *Livestock Production Science* **61:** 145-153.

Capra, F. (1996). *The Web of Life. A new synthesis of Mind and Matter*. London. Harper Collins Publishers/Flamingo.

Collinson, M. ed. (2000). *A History of Farming Systems Research.* Wallingford, CABI Publishers, and Rome, FAO.

Damasio, A. (1999). *The Feeling of What Happens. Body and Emotion in the Making of Consciousness.*London. William Heinemann.

Defoer, T. and Budelman A. (2000). *Managing Soil Fertility in the Tropics.*Vols. 1,2,3,4,5. Amsterdam. KIT.

Douglas, M. (1986). *How Institutions Think*. Syracuse (NY). University of Syracuse Press.

EEA/UNEP. (1998). *Chemicals in the European Environment. Low Doses, High Stakes*. The European Environment Agency and United Nations Environment Programme Annual Message 2 on the State of Europe's Environment. Copenhagen. European Environment Agency.

Ison, R.L. and Russell D. (2000).*Agricultural Extension and Rural Development. Breaking out of traditions.* Cambridge. CUP.

Jiggins, J. and Röling N. (2000). A Critical Reflection on Farming Systems as Adaptive, Evolutionary, and Learning Systems: A Theoretical Exploration. Paper presented to workshop on Learning Proceses in Research and Extension at the Fourth European Symposium on European Farming and Rural Systems Research and Extension, Volos, Greece, April 3-7 2000.

King, C. (2000). *Systems Approaches to Facilitating Social Learning. Case studies from Australia and India.* Agraria 233. Published PhD. Thesis. Uppsala. Swedish Unviersity of Agricultural Sciences.

LEARN@Paris. Eds.(2000). *Cow Up a Tree. Knowing and Learning Processes for Change in Agriculture. Case Studies from Industrialised Countries*. Paris. INRA Editions.In press.

Matheson, N (1995). Research by Farm and Ranch Improvement Clubs, Sidebar 10.1, in Bird, E. A. R. et al. Eds. 1995.*Planting the Future. Developing an agriculture that sustains land and community*Ames, Iowa. Iowa Unviersity Press, pp 183-185

Maturana, H. and F. Varela (1992). *The Tree of Knowledge. The Biological Roots of Human Understanding.* Revised edition. Boston. Shambhala Press.

McClintock, D., Kersten S. and Ison R. (1997). Emergent practice in agricultural research using metaphors and dialogue to create a space for understandings. In F.A. Stowell et al. Eds. *Systems for Sustainability*: *People, Organisations and Environments* , New York, Plenum, pp 79-84.

Pearson, C.J. and Ison R.L. (1997). *Agronomy of Grassland Systems*. 2nd. Edition. Cambridge. CUP.

Ragnarsdottir, K. Vala. (2000). Environmental fate and toxicology of organophosphate pesticides. *The Journal of the Geological Society.* London, **157:** 859-876.

Röling, N.G. and Wagemakers M.A.E. eds. (1997). *Facilitating Sustainable Agriculture. Participatory Learning and Adaptive Management in Times of Environmental Uncertainty.* Cambridge. Cambridge University Press.

Roling, N.G. (2000). Gateway to the Global Garden. Agricultural Science for a Reflexive Major Force of Nature. Eighth Annual Hopper Lecture. October 24 2000. University of Guelph, Ontario. Wageningen, Wageningen University.

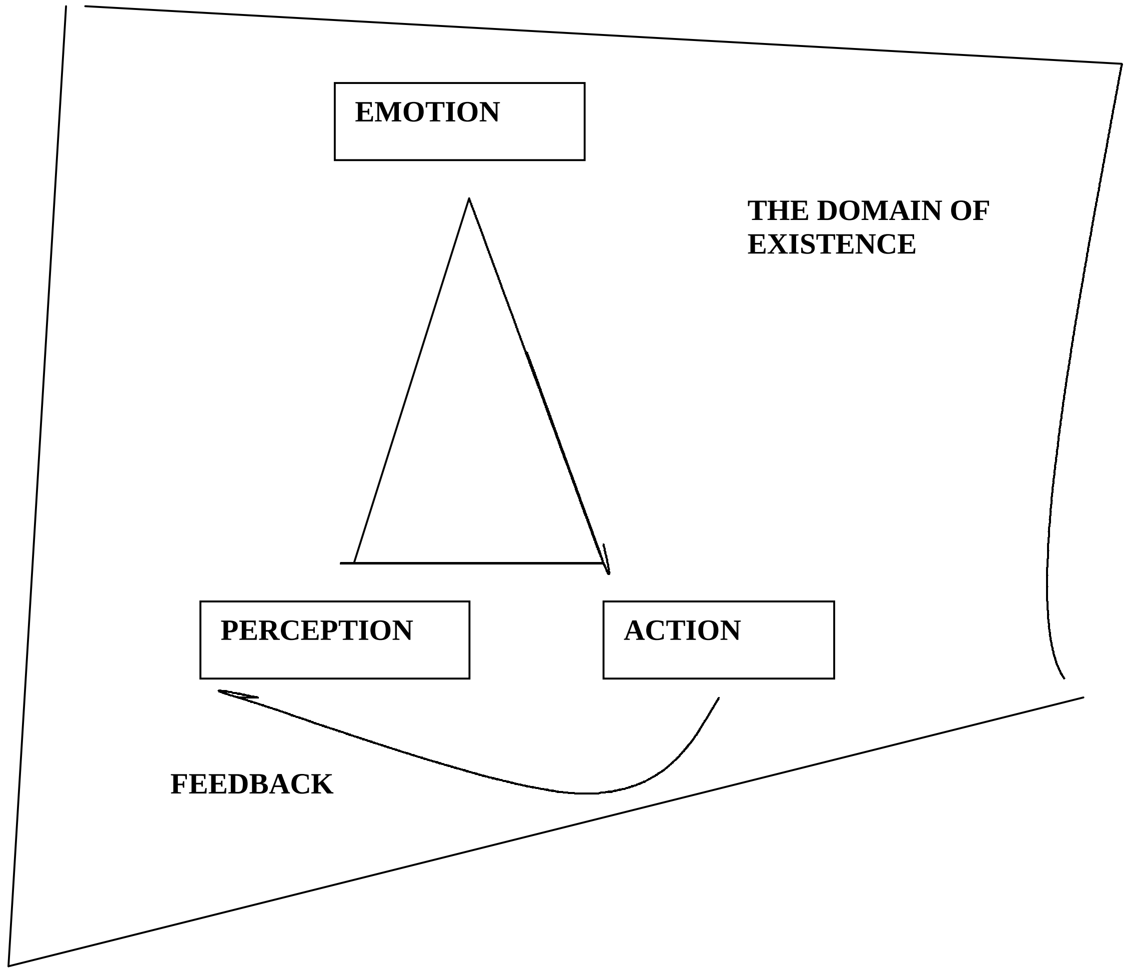

Figure 1 - The Cognitive Triangle (after Maturana and Varela, 1992; Capra 1996)