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New Thinking About Farmer Decision Makers

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> *"People (and not only managers) trust only their own understanding of their world as the basis for their actions."*
>
> de Geus (1994)

> *"It would appear then that as long as we conceptualize the issues of knowledge processes in terms of information transfer without giving sufficient attention to the creation and transformation of meaning at the point of intersection between different actors' life-worlds, [ ] we shall have missed the significance of knowledge itself.*
>
> Long and Long (1992)

In the late 1970s, agricultural scientists embarked on the exciting new adventure to make decision support systems for farmers. Two decades later, with my colleagues, Peter Carberry and Zvi Hochman, I set out to understand why farmers have not valued these products more. We began by visiting developers of some of the major decision support systems (DSSs) in the USA and Australia and hearing their stories of development and delivery. This effort led to the publication by some of these key players of their experiences and learnings in a Special Issue of Agricultural Systems (Vol. 74, No. 1, 2002), entitled 'Probing the Enigma of the Decision Support System for Farmers.' Beyond our interest in documenting significant DSS projects while key participants were still accessible, we felt that stimulation of critical reflection on the DSS experience could be valuable to a research community that by and large interpreted any past DSS 'failure' as a good idea being 'ahead of its time'—ahead of farmers' readiness for this technology. Controversially, the Special Issue openly confronted the possibility that the DSS for farming may be an idea 'whose future is past' (Ackoff, 1979; McCown, 2002b).

McCown (2002b) highlighted differences between objective knowledge embedded in a DSS and the subjective knowledge which normally guides the actions of farmers in familiar situations – local, personal, social environments. None of the fourteen DSSs had become a routine tool that farmers used in their management year in, year out. But in some cases it was evident that computer models had provided significant value to farmers in other ways. The most important of these was as an aid to learning. That simulation might lead to learning seems unsurprising. But what makes this significant to those interested in intervention to support better farm decision making, is the nature of this learning and how it takes place. This learning is not often the result of 'knowledge transfer' from researchers to farm decision makers via computer software. It is rather the use of research products (including software) by intermediaries in situations of farming practice using processes that generate experiences in which farmers construct personal, subjective knowledge that is relevant to practical action.

Acceptance by our profession of this interpretation of DSS history could have profound importance for the future of scientific intervention in farming practice using computers and telecommunication. But there is little indication that our profession is about to abandon the good-idea-ahead-of-its-time interpretation of our predicament. My aim in this essay is to provide evidence and argument that the success for decision support intervention that has been so elusive lies in using our scientific models to facilitate farmers in constructing new knowledge.

Facilitation of knowledge construction is a different intervention *paradigm* for information systems (IS) intervention to that of objective information/knowledge transfer, characteristic of the DSS and expert system. As such, I am sobered by the observation by Kuhn (1962) of what "scientists never do when confronted by even severe and prolonged anomalies. Though they may begin to lose faith and then to consider alternatives, they do not renounce the paradigm that has led them into crisis." Recognition of this justifies the lack of any attempt in what follows to provide evidence of DSS failure. On the other hand, I am somewhat encouraged in this undertaking by Kuhn's further observations that "The decision to reject one paradigm is always simultaneously the decision to accept another, and the judgment leading to that decision involves a comparison of both paradigms with nature *and* with each other." Hence, in advocating a new paradigm in this essay, my strategy includes analysis of the current paradigm as well.

This essay is also made challenging because so much of the evidence and argument is external to our familiar science domain, as are many of the concepts and terms. But this is problematic, I believe, not because the material is difficult to understand, but rather that considerable complexity results as elements are woven together. If this conjecture is true, my greatest risk is creating a picture that gets progressively confusing. I will attempt to avoid this by sketching a 'map' of the journey at a coarse scale before starting and at a finer scale for each section at the beginning of that section, and pausing, periodically, to consult the map to see where we are and where we are headed.

The first section traces the history of our traditional DSS paradigm in a distant past in which scientific principles for management came to be viewed as superior to customary managerial expertise. Major developments in thinking are traced with the aid of a typology of 'systems' traditions and a simple model of behavior in which behavior is determined by 'factors' of environmental and personal structure. Much of the history of the DSS can be seen as a periodic shift from preoccupation with one of these categories of structure to the other in response to failure to influence practical managers. The case is made that this failure was due to a normative theory of decision making in which intuitive judgment was seen as a problem to be overcome whenever possible by replacing it formal analysis providing a recommendation of what a rational person ought to do in such a situation.

The second section deals with an alternative theory for understanding decision making in which managers are purposeful persons who make subjective sense of their situations and use their knowledge and agency to 'cause' meaningful and satisfactory actions. With such a view, instead of a *normative* role, intervention assumes a *facilitative* role in which scientific models are used to support farmers' *sensemaking* in conditions of uncertainty and ambiguity. This section attempts to tease out both the characteristics of this paradigm and some logical reasons for scientists to embrace it. *Characteristics* are found in phenomenology, the philosophy of subjective experience in the life-world. *Justification* is found, surprisingly, in the philosophy of science of Karl Popper.

In the third section, answers to three questions about implications for decision support in this alternative paradigm are sought: (1) Under what conditions can the decision maker be expected to welcome support? (2) Just what is being supported? and (3) What does such decision support look like? Answers are synthesized from contributions from three fields of social theory (phenomenology; cognitive science, that is the science of subjective knowing and reasoning; and thirdly, the field of 'sensemaking', whose home is in social psychology). The successful practice of 'systems dynamics' modelling to facilitate learning contributes significantly to answering the third question.

A final section briefly explores the implications of a new respect for natural decision processes and of facilitative rather than normative intervention in farmers' management of natural resources.

Whether the manager of a farm is the owner of the family farm or is employed by the owner of the farm to manage it may be crucial to the use of a DSS (McCown, 2002b). A similar distinction is whether the family farmer is his/her 'own boss' or is contract farming for a vertically-integrated agribusiness. The underlying issue here concerns the farmer's degree of *discretion* and *agency* – his/her freedom to decide what to do and power to do it. History confirms the simple logic that when discretion and agency are low, farmers can more readily find it in their interests to use management aids that are advocated by those to whom they are accountable. The DSS began as a little chunk of corporate bureaucracy in this sort of relationship (McCown, 2002a). Of far more interest is the DSS adoption behavior of farmers with a *high* degree of agency. Since the family farm looks to remain the dominant structure in most forms of agricultural production for the foreseeable future, my focus in this paper is on the family farm with the considerable, although diminishing (Mooney, 1988), management agency normally found there.

1. Critical reflections on our traditional decision support paradigm

This section traces the evolution of ideas and tools that has shaped the DSS intervention paradigm. Helpful 'maps' are provided from two sources. The first is from the systems movement, which Jackson (2000) differentiated into three traditions. The first two have influenced agricultural research and intervention at different times over the past half century in ways indicated in Figure 1.

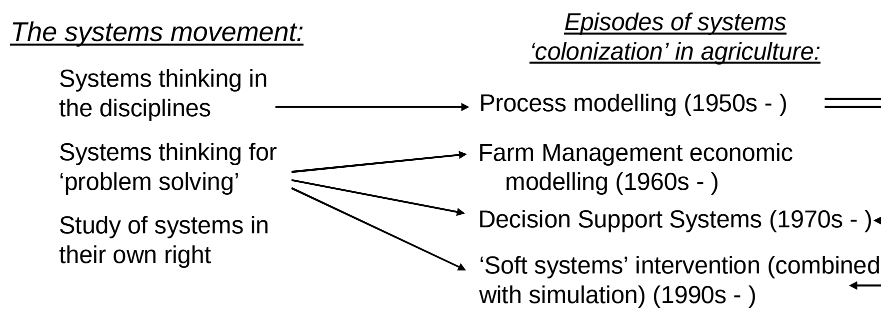


Figure 1. Three traditions of the systems movement (Jackson, 2000) and their respective influences on agricultural research and intervention.

In this section I will attempt to account for our agricultural DSS tradition as a direct product of the 'problem solving' systems tradition, but significantly influenced by an earlier systems tradition *via* process modelling in agricultural science disciplines. A further 'map' is used to elucidate various changes in direction prior to and leading up to the DSS. This is an abstract model of problem solving behavior, provided by Kurt Lewin, a social psychologist, who pioneered psychological research in the social world outside the laboratory. Lewin (1951) formalized 'the obvious' as B = f (P, E), where B is individual behavior, P represents personal determining factors, and E, environmental factors. The history of intervention to influence behavior in production practices can be seen as a sort of oscillation between emphasis on E and on P, driven by disappointment in the outcomes of the previous phase. It is significant that irrespective of the focus, intervention was normative, in that it aimed at providing substitutes for natural human mental processes that were deemed to provide superior outcomes.

Serious scientific study of 'work' behavior began with the 'time and motion' studies by Frederick Taylor of customary manufacturing activity. His principles of how labor activity can be analysed and redesigned by experts for increased efficiency, were being "applied wholesale in U.S. industry" late in the 18th century (Anon, 2000). While originally centered on more efficient returns to manual work, 'Taylorism' spread to management. A new paradigm of management emerged, which competed with the traditional paradigm. In the traditional paradigm of management behavior, the "manager is a *craftsman*, a practitioner of an art of managing that cannot be reduced to explicit rules and theories" (Schon, 1983), but rather constitutes a unified *practical* rationality centered in P, in Lewin's model of behavior, B = f (P, W). In the modern paradigm, "the manager is a *technician* whose practice consists in applying to everyday problems…the principles and methods derived from management science"—a *technical/economic* rationality rooted in theory concerning the task environment (E) (Schon, 1983) and providing a basis for rational determination of behavior (B). These changes constituted displacement in workplace cultures of *customary* management practice, based on cumulative experience, by theoretical principles of management in a 'typical' E. This rationalization of industrial culture was an important precursor to the emergence of systems thinking and practice. Management theory and principles for practical management coupled with high speed computing made possible simulation of the task environments and the solving of well structured problems in the systems fields of Operations Research and Management Science (OR/MS) following WW II (McCown, 2002a).

Although the agricultural DSS is a product of the "problem solving" systems tradition (Fig. 1), for many in the DSS community their first 'systems' experience was "in the disciplines" of agricultural science. Systems thinking became prominent in agriculture in the 1960s in agronomy and animal husbandry and the physiology and of crops and farm animals. The unambiguous 'systems' signifier was the simulation model, and the interest of the modelers was predominantly theoretical. McCown (2002a) reports an interview with the pioneer of agricultural modelling, Prof. C.T. de Wit, in which he related his 'systems thinking' history. He traced the origins of the core technology of his renowned systems group at Wageningen to the university's recruitment of a professor in 1949 from OR/MS in the petroleum refining industry who had expertise in the simulation of distillation processes. De Wit's interest was unequivocally theoretical—to use physiological simulation models to explore the limits to crop production.

A second colonization of agriculture by "systems thinking" began in the 1960s as an attempt by agricultural economists in Farm Management Research, stimulated by achievements in OR/MS in industry, to enhance their tools for economic "problem solving" in farm management by replacing static 'production functions' with dynamic production models (Dent and Anderson, 1971). The prevailing *normative* theory for Farm Management intervention is made especially clear by Hutton (1965).

> ... the model attempts to simulate the farmer's decision environment. The assumption is that the manager, without any formal analysis, is forced to use intuitive judgments in all his problem-solving activity. As a consequence his capacity to solve problems is low. Many defined problems are simply ignored. Also, the solutions he does obtain are relatively low quality since he is presumed to spread his analytical capacity, the scarce resource, over many pressing problems. Now, if formal analysis is introduced into such a situation, it has much the same effect as the introduction of a new production technique. Problems are more adequately solved and solutions are attempted over a larger number of problems. [ ]Our analytical models may be very roughly classified on a scale representing the extent to which they attempt to *substitute formal analysis for intuitive judgments…*

Such a *normative* approach features substitution for farmers' own assessment of the situation by theoretical analysis of the environment (E) and the provision of recommendations for action, i.e. decisions, that a farmer ought to follow, if he/she is rational. In the late 1970s, led by 'refugee' agricultural economists escaping the declining Farm Management enterprise, this economics activity was transformed into a production technology-oriented 'systems analysis' activity, and persisted into the early 1990s in trying (but largely failing) to be relevant to farm decision making (Malcolm, 1990).

The adoption of the DSS idea in agricultural science can be seen as a third colonization of systems thinking from OR/MS during the 1970s (Fig.1). This DSS concept was a response to the failure in business and industry of model-based normative approaches to be valued by real managers (McCown 2002a). This crisis in OR/MS coincided with the emergence of two significant developments (Keen and Stabell 1980). One of these was "a new science of management decision," based on novel theory in economics and cognitive psychology which emphasizes the control of decision behavior (B) by psychological factors (P). This shift in theoretical emphasis from E to P was accompanied by new developments in OR/MS. A second development was interactive computing which provided an alternative to the OR/MS convention of experts with models advising managers. The idea was for managers to have access to models directly—models that are "simple, robust, easy to control, adaptive, as complete as possible, and easy to communicate with" (Little 1970).

By the mid 1970s, a radically different paradigm of intervention was proposed for using models in management decision making. Looking back on the period, one of the key proponents, Peter Keen, reflected that

> in 1976, Decision Support represented a radical concept of the use of information systems and analytical tools. [ ] It meshes human judgment and the power of computer technology in ways that can improve the effectiveness of decision-makers, without intruding on their autonomy. There are better ways of applying the analytic methods of management science than to improve the normative approach of optimization science, which ignores the need to mesh decision-making process with the needs, habits and preferences of the decision maker, and *to respect rather than try to replace judgment* (Keen 1987, p253-4).

Comparison of the emphasized text with that emphasized in the quote above by Hutton indicates a 180 degree turn from normative intervention to by-pass intuitive judgment to 'facilitative' intervention that accepts preferences and judgment as integral to real human decision making, and the role of intervention is to support them. But there is little indication of this shift in the description of SIRATAC, an early DSS for cotton pest management.

> This computer program processes data on numbers of insect pests and their predators, considers the stage of development of the cotton crop, calculates probable levels of pest survival and estimates what damage could result to the crop. The program then advises whether it is really necessary to spray for insect control Peacock (1980).

This is clearly a normative approach to decision making taken by SIRATAC developers, especially so since the main aim was to achieve reduced levels of pesticides for environmental reasons. Appeal to farmers' preference for cost savings, under conditions of adequate control, was a means to an environmental end. The information generated is used to by-pass a farmer's "intuitive judgment" rather than to support it. I want to make two points. First, it is enormously significant to the making sense of subsequent low levels of *farmer* adoption of the imported DSS that agricultural innovators embraced the idea of personalized managerial computation from OR/MS *without* the accompanying learning of the failure of decades of *normative* intervention, i.e. advising what farmers *ought* to do. Yet, even today, to most of us agricultural scientists, Peacock's description of SIRATAC's approach seems eminently logical, which leads to the second point. SIRATAC's basic insect control logic proved to be sound, and at one point the system was used by some 30 % of Australian cotton growers (Hearn and Bange 2002). But in the end, routine usage was replaced by farmers' monitoring and judgments, but with standards of both raised by learning gained by using SIRATAC (Hearn and Bange 2002). An unintended function of this DSS, designed to guide routine pest management operations, was as an aid to learning about the environment and about control actions to a point where the formal DSS became superfluous. Yet, in our profession, realization of this unexpected, but successful, function of DSSs did not result in an altered strategy for intervention and software designed to aid farmer *learning*. But this history flags a possible future strategy with attractive potential.

The predisposition of scientists for normative intervention is reinforced by pointing out that although the agriculturalists pursued the normative approach in spite of its previous record of failure, the new approach, articulated above by Keen, was ignored not only by the agriculturalists, but, as it turned out, by most management scientists and interventionists in OR/MS as well. Keen later laments that the vision of the reformers for the DSS in 1976 (quote above) proved to be mainly aspirational and was never widely accepted. Instead

> …the mission of DSS attracted individuals from a wide range of backgrounds who saw it as a way of extending the practical application of tools, methods and objectives they believed in. While the definitional problem means that it has been hard to say what is not a DSS, it has also not excluded any contribution or contributor who wanted to see theory turned into practice and technology into application Keen 1987, p255).

The commitment of scientists, both in and outside of agriculture, to the normative paradigm and our interpretation of past failure in ways that preserves the paradigm are eminently understandable. It is our profession's natural approach for agricultural science to serve agricultural practice. It has a pedigree that includes endorsement by the most influential philosopher of science in the last century, Karl Popper.

> A social science oriented towards objective understanding [of E], or 'situational logic,' can be developed independently of all subjective or psychological ideas [concerns with P]. Its method consists in analyzing the social situation of acting men sufficiently to explain the action [B] with the help of the situation [E], without any further help from psychology [P]. Objective understanding consists in realizing that the action was objectively appropriate to the situation. In other words, *the situation is analyzed far enough for the elements, which initially appeared to be psychological [P],… to be transformed into elements of the situation [E]* (Popper, 1976. Bracketed interjections and emphasis added).
>
> There are good reasons, not only for the belief that social science is less complicated than physics, but also for the belief that concrete social situations are in general less complicated than concrete physical situations. For in most social situations, if not in all, there is an element of *rationality*. Admittedly, human beings hardly ever act quite rationally (i.e. as they would if they could make the optimal use of all available information for the attainment of whatever ends they may have), but they act, nonetheless, more or less rationally; and this makes it possible to construct comparatively simple models of the actions and interactions, and to use these models as the approximations. (Popper, 1964)

This philosophy featuring an objective 'situational logic' coupled with the presumption of rationality by the actor in the situation ('rationality principle') coincides with the dominant philosophy of economics that features economic rationality and optimization of economic behavior (Redman, 1991) and was the bedrock of operations research (OR) the early paradigm of management science.

The compelling case that the way forward was a shift from emphasis on E to P was provided by Herbert Simon, who won a Nobel Prize for establishing the legitimacy of the psychology of the decision maker (P) in theory about rational economic behavior (B). Simon distinguished two types of rationality.

> Behavior is *substantively rational* when it is appropriate to the achievement of given goals within the limits imposed by given conditions and constraints. Notice that, by this definition, the rationality of behavior depends upon the actor [P] in only a single respect--his goals. Given these goals, the rational behavior is determined entirely by the characteristics of the environment in which it takes place [E]. Classical economic analysis [and Popper's situational analysis] rests on two fundamental assumptions [about P]. The first assumption is that the economic actor has a particular goal, for example, utility maximization or profit maximization. The second assumption is that the economic actor is substantively rational [i.e. has perfect knowledge about E.] Thus, the assumptions of utility or profit maximization, on the one hand, and the assumptions of substantive rationality, on the other, freed economic from any dependence upon psychology.
>
> Behavior is *procedurally rational* when it is the outcome of appropriate deliberation [in P's mind]. Its procedural rationality depends upon the process that generated it. [The field of psychology] uses 'rationality' as synonymous with ' the peculiar thinking process called reasoning ' (Simon, 1979).

Elsewhere, Simon elaborates how the two rationalities operate together in 'situational logic.' Situations have an outer environment [E] and an inner environment [P], and these interact. An economic actor's adjustment to her outer environment (her *substantive rationality*) is limited by her ability, through knowledge and analysis, to discover appropriate adaptive behavior in the situation (her *procedural rationality*) (Simon, 1996). This results in a 'bounded' substantive rationality that is simply part of the human condition. The implications for situational analysis were obvious:

> It is illusory to describe a decision as 'situationally determined' [E-determined] when a part of the situation that determines it is the mind of the decision-maker [P] (Simon, 1996, p84)

Simon's rationale for focus away from E to P was pivotal in the emergence of what became known as the 'behavioral' paradigm in economics and decision research. It also spawned the academic fields of cognitive science and artificial intelligence. In management science it provided the expert system and the theory for the DSS innovation (Keen 1987; McCown 2001). Simon recognized the reality that managers could only have limited knowledge of E and that they had limited thinking power for analyzing information from E; this did not mean that managers were irrational, but they could only have 'bounded rationality.' Simon's strategy was to use computers, which, he argued, processed information in analogous fashion to brains, to provide 'intelligent machines' to compensate for managers' cognitive limitations.

Simon and his colleagues contributed immensely to better understanding of the structure of P as human cognition, but the new approaches to intervention in management decision making that this understanding spawned did little better than old-fashioned substantively normative OR/MS. It has been 'back to the drawing boards' for intelligent machines and expert systems (Clancey 1997). As it turned out, the DSS to support human cognitive processes and the expert system as a proxy for human cognition suffered the same failure to achieve a market among real managers as did the DSS for farmers, a decade later. In the most important respects, intervention to influence B conducted in the 'behavioral paradigm' was not radically different to that in which conditions in E were optimized. Both approaches treat P as an object rather than a free agent—an issue which is central the paradigm debate which is pivotal to this paper. In agriculture, the expert system appears to have been the least successful type of decision support (McCown 2002b).

While Simon led a paradigm challenge, a more profound challenge was made by Simon's arch critic, the philosopher, Hubert Dreyfus. In 'What Computers Can't Do' (1972) and 'What Computers *Still* Can't Do' (1994), Dreyfus undertook the heroic challenge to replace the 'behavioral' paradigm with an alternative way of thinking about intelligent planning and action in the world of human affairs. This alternative philosophy, *phenomenology*, is concerned with how people, as (more or less) free agents, actually interpret the world around them, carry out activities in everyday life, including work, and learn *from* and *in* action. Phenomenology is about behavior 'from the inside'—from the perspective of the person *producing* the behavior (as opposed to *observing* it). In 1972 Dreyfus lamented that:

> Such an alternative view has many hurdles to overcome. The greatest of these is that it cannot be presented as an alternative scientific explanation. We have seen that what counts as "a complete description" or an explanation is determined by the very tradition to which we are seeking an alternative. Thus Western thought has already committed itself to what would count as an explanation of human behavior. It must be a theory of practice, which treats man as a device, and object responding to the influence of other objects, according to universal laws or rules. [e.g. B = f (P, E)]
>
> But it is just this sort of theory, which after 2000 years of refinement, has become sufficiently problematic to be rejected by philosophers both in the Anglo-American tradition and on the Continent. It is just this theory which has run up against a stone wall in research in artificial intelligence. It is not some specific explanation, then that has failed, but the whole conceptual framework which assumes that explanation of human behavior can and must take the Platonic form, successful in *physical* explanation [of E]; that situations can be treated like physical states; that the human world can be treated like the physical universe. If this whole approach has failed, then in proposing an alternative account we shall have to propose a

> different sort of explanation, a different sort of answer to the question "How does man produce intelligent behavior?…"
>
> There is a kind of answer to this question which is not committed before hand to finding the precise rule like relations between precisely defined objects. It takes the form of a phenomenological description of the behavior involved. It too can give us understanding if it is able to find the general characteristics of such behavior… (Dreyfus, 1994).

A phenomenological approach brings us back to the phenomenon of ‘customary’ management practice, discussed at the beginning of this section. This is management behavior grounded in the shared knowledge of a community of practice and in individual expertise developed through experience. This type of management behavior was what OR/MS, in the tradition of Frederick Taylor’s work practice revolution, set out to replace with ‘hard,’ rationalistic, management principles. A *phenomenological* understanding of “intelligent behavior” referred to above by Dreyfus takes us outside the territory represented by Lewin’s model of behavior-determining factors, B = f (P, E). It is the key to a reconceptualization of decision making, with customary practice as the starting point.

2. Recent reconceptualization of the nature of decision making

During the 1970s, the branch of the systems movement concerned with problem solving (Fig. 1) experienced a paradigm revolution that left the field with two schools of thinking and methods—the traditional, ‘hard,’ school and a new ‘soft’ school, the differences articulated most authoritatively by Peter Checkland in ‘Systems Thinking, Systems Practice’ in 1981. Although soft systems didn’t influence agriculture until appreciably until the 1990s, it marked a significant turn from objective explanation of B in terms of attributes of P to treating behavior as action willed by P—a shift in behavioral science perspective from causal factors to intentional actors.

In keeping with this change in perspective, in this section, it is appropriate to find a replacement for Lewin’s model of behavior, B = f (P, E), that provides a similarly abstract structure for actions and the variable mental states that lead to action via decision. In this, I rely heavily on two strands of the so-called cognitive revolution in which behaviorism, with its exclusive focus on behavioral response (B) directly to environmental stimuli (E), was displaced by a psychology with emphasis on the mediation between environment and behavior by *subjective meanings* to the actor of the environment, the action, and the goal. People in situations interpret their environment and take action based on the meaning derived, based on the beliefs, values, and desires held by the actor and shared in a culture. According to Bruner (1990), the cognitive revolution "was intended to bring the mind back into the human sciences after a long cold winter of objectivism, he laments that the original focus on subjective 'meaning' was quickly displaced by a focus on the processing of information from the environment by minds and by computers simulating minds, i.e. the 'cognitive science' to which Herbert Simon contributed so much, as we saw in the previous section.

The more recent 'revolution' discussed in this section concerns the bringing together of personal, subjective, meaning and personal information processing in an *action* approach to decision making. I attempt to capture the essence of this in a simple action model, drawing on both the *meaning-making* concepts found in some schools of social psychology (e.g. Blumer 1969) and in cultural psychology (e.g. Bruner 1990) and on the *information processing* framework that developed in cognitive science (e.g. de Mey 1982). Although historically, these two fields of psychology have tended to see each other as antagonists, both of their offerings are essential to a theory of decision making that can ground a more effective approach to science-based decision support. After proposing an action model, I examine briefly the basic elements of the relatively new field of 'naturalistic decision making' to demonstrate correspondence with the action model. But I want to preface this by following the admonition of Dreyfus in the concluding quote of the previous section and look at the intelligent action (including decision making) as structured from the 'inside'—an alternative approach to 'theory'.

The structures of the life-world

. In 'The Structures of the Life-World,' Schutz (1973) attempted to provide such 'general characteristics' of the nature of normal, everyday life as experienced. The *life-world* of a subject/actor/agent is the commonsense world of everyday life and the basis of each of our experienced realities as "wide-awake and normal adults". In this work (completed and published by Thomas Luckmann following the untimely death of Schutz), Schutz explicates the elementary structures of everyday life that provide the foundation of our experience, language, and action. This is the background reality of personal decision making and, arguably, the starting point for redesign of 'soft' decision support methodology.

> The life-world, understood in its totality as the natural and social world, is the arena, as well as what sets the limits of my, and our reciprocal, action. In order to actualize our goals, we must master what is present in them and transform them. Accordingly, we act and operate not only *within* the life-world but also *upon* it. Our body movements gear into the life-world and transform its objects and their reciprocal relations. At the same time, these objects offer to our actions a resistance which we must either subdue or to which we must yield. The life-world is thus a reality which we modify through our acts and which, on the other hand, modifies our actions. We can say that our *natural attitude of daily life* is pervasively determined by a *pragmatic motive*.
>
> Nevertheless, in the natural attitude *the world is already given to me* for my explication. I must understand my life-world to the degree necessary in order to be able to act in it and operate upon it. Likewise, thinking in the attitude of the life-world is also pragmatically motivated. Each step of my explication and understanding of the world is based at any given time on a stock of previous experience, my own immediate experiences as well as such experiences as are transmitted to me from my fellow-man and above all from my parents, teachers, and so on. All of these communicated and immediate experiences are included in a certain unity having the form of my stock of knowledge, which serves me as the *reference schema* for the actual step of my explication of the world. All of my experiences in the life-world are brought into relation to this schema, so that the objects and events in the life-world confront me from the outset in their typical character -- *in general* as mountains and stones, trees and animals, more *specifically* as a ridge, as oaks, birds, fish, and so on
>
> [As an idealization], I trust that the world as it has been known to me up until now will continue further and that consequently the stock of knowledge obtained from my fellow-man informed by my own experiences will continue to preserve its fundamental validity. From this assumption follows the further and fundamental one: that I can repeat my past successful acts. So long as the structure of the world can be taken to be constant, as long as my previous experiences valid, my ability to operate upon the world in this and that manner remains, in principle, preserved. Both idealizations and the assumptions of the constancy of the world's structure which are grounded on them -- the validity of my previous experience and, on the other hand, my ability to operate upon the world -- are essential aspects of thinking within the natural attitude (Schutz and Luckmann, 1973).

By Schutz' phenomenological account, we are 'situated' in our life-world in terms of both our physical and social environments. Although these constrain our actions, it is equally the case that our actions can 'transform' our environments to suit our purposes. Knowledge acquired from our fellows and from our own past experience contributes to this latter 'mastering' of our situations. But as Polanyi (1958) argues, personal knowledge that 'subdues' and 'transforms' includes 'commitment' and 'passion.' These are all readily recognizable as part of 'pragmatic motive' in the 'natural attitude'. Regulation of knowledge and action by the 'pragmatic motive in our 'natural attitude' of everyday living means that we are inclined toward criteria for understanding and performance such as 'good enough' and 'just in time' and to repetition of behavior that has met these criteria in the past. Elsewhere , Schutz and Luckmann (1973) point out that regularization by 'conservative habits' and 'recipes' is normal and inevitable because these strategies are so often pragmatically successful. This behavior is *practical*.

Schutz sees everyday knowledge serving to provide 'typifications' and 'reference schema' that aid making sense of situations efficiently based on experience, ours and others. This conceptualization of knowledge as cognitive representations of objects and situations in the life-world that guide both perception of situations and interpretations relevant for action in particular situations is central to cognitive psychology and naturalistic decision making theory. I return to this important matter of mental representations later in this section.

More grounds for seeing decision making differently

As emphasized in Section 1, fundamental to a new theory of decision making is the shift in emphasis from decision events consisting of rational choice between alternative actions to mental assessment of situations, mental simulation of outcomes of possible actions, and resolution of the situation by committing to action that promises to be satisfactory. This 'naturalistic' decision making process tends to be one of ruling out of alternatives rather than identifying an optimum (Klein 1995, p138; (Winograd and Flores 1986, p.147). But equally fundamental, and deserving of its emphasis in this and the following section, is recognition that intelligent actions are not always preceded by this process—by conscious decision. In normal *routine* activity, commitments are made to action, and action is taken without conscious deliberation. This is implicit in the third paragraph of the above quote from Schutz and Luckman. In the natural attitude of normal, routine life, there is a taking for granted that the world and the validity of our experience will not change. This mode of automatic use of 'know how' in unproblematic situations is what Dreyfus and Dreyfus (1986) call 'intuition.' Recognition of this mode of behavior is most important for thinking about use of decision support systems: in a well functioning operation it is statistically the most prevalent mode and there is no felt need for aids to decision making. It is only when a situation becomes *problematic* (Schutz and Luckman 1973), i.e. is in a state of *irresolution* (Winograd and Flores 1986), that deliberation becomes central and intervention becomes relevant. This issue of occasions for decision support is discussed in the following section. The remainder of this section concerns the nature of deliberative decision process.

Most of the above points to *theory*. But a most convincing *practical* argument for an alternative approach to decision support is provided by Arie de Geus, a former senior executive of Shell Oil and sometime Fellow at the London School of Economics.

> I have not met a decision maker who is prepared to accept anybody else's model of his/her reality, if he knows that the purpose of the exercise is to make him, the decision maker, make decisions and engage in action for which he/she will ultimately be responsible. *People (and not only managers) trust only their own understanding of their world as the basis for their actions.* "I'll make up my own mind" is a pretty universal principle for everyone embracing the responsibility of their life, whether private or business life (de Geus 1994, p xiv. Emphasis added.)

If this is true for people who farm, what does it imply for our provision of decision support? If meaningful actions stem from subjective decisions based on the decision maker's beliefs about the world, i.e.

$$\text{action} \leftarrow \text{decision} = f\ (\text{beliefs about the world}),$$

any intervention other than the normative one of recommending the best action, must be directed at influencing a decision maker's beliefs.

Belief can be seen as linking the real and the meaningful. Much of what follows concerns the status of belief as a form of knowledge and processes of belief formulation in normal life and work, e.g. farming. This is related to differentiation of specific categories of belief in the above rudimentary 'action' model, with the intention of creating conceptual 'points' for intervention to support subjective decisions, the subject of the following section.

I submit that farmers make decisions based on their subjective beliefs about the prospects of an action that are heavily weighted by their own experience concerning the task, and on their beliefs about 'what is the case' in an uncertain environment. This can be expressed as

$$\text{action} \leftarrow \text{decision} = f\ (g, b_E, b_T).$$

Decision concerning action is a function of the agent's goals (g), his/her beliefs about the environment (b_E), and his/her beliefs about the envisioned tasks (b_T). I think the eminent psychologist, Jerome Bruner, would call this an expression of 'folk psychology.' My combining of beliefs and goals corresponds with Bruner's emphasis on the importance of processes involving information which meaning is made by actors based on both personal *knowing* and *valuing*. He argues that all psychology must be grounded on naturalistic psychology—on subjective and inter-subjective behavior in the life-world.

> Folk psychology...is a culture's account of what makes human beings tick. It includes a theory of mind, one's own and others', a theory of motivation, and the rest. I shall call it ethnopsychology to make the term parallel to such expressions as ethnobotany, ethnopharmacology and those other native disciplines that are eventually displaced by scientific knowledge. But folk psychology, though it changes, does not get displaced by scientific paradigms. For it deals with the nature, causes, and consequences of those intentional states -- beliefs, desires, intentions, commitments -- that most scientific psychology dismisses in its effort to explain human action from a point of view that is outside human subjectivity...[e.g. B = f (P, E)] So folk psychology continues to dominate the transactions of everyday life. And though it changes, it resists being tamed into objectivity. For it is rooted in language and a shared conceptual structure that are steeped in intentional states—in beliefs, desires, and commitments. And because it is a reflection of culture, it partakes in the culture's way of valuing as well as its way of knowing (Bruner, 1990).

In naturalistic decision making, decision and action originate in the subjective, intentional mental states of beliefs, desires, intentions, and commitments. This provides a starting point for a replacement of Lewin's function concerning causes of behavior. The underlying strategy for my action model is to achieve the simplest expression for decision making that 'causes' intentional action and that provides adequate 'hooks' for science-based intervention and that preserves the dimensions of knowing and valuing. Use of 'goals' is an attempt to synthesize the 'valuing' in Bruner's "desires, intentions, and commitments." From the standpoint of intervention, beliefs are key because under some conditions belief can be influenced by scientific knowledge, and there is obvious value in the differentiating these two domains of the agent's belief. Although, as indicated later, g, b_T, and b_E are not truly independent variables.

As we saw earlier, Karl Popper did his best to exclude psychological factors from analysis of behavior in situations. This was not, however, because he didn't recognize the importance of psychological determinants of behavior, but rather because he had a pragmatic motive about his goal to explicate an *objective* theory of knowledge that contributed to science achieving its aim of "increase in verisimilitude", i.e. resemblance of truth or reality (Popper, 1972). This unwavering focus tends to obscure his considerable insight into matters he claimed to have no interest, e.g. naturalistic decision making and action in the life-world. Popper fully acknowledges that our behavior is in part determined by subjective *dispositions to act* and our *expectations.*

> …we do have *expectations*, and we strongly *believe in certain regularities* (laws of nature, theories). This leads to the commonsense problem of induction. In the commonsense view it is simply taken for granted (without any problems being raised) that our belief in regularities is justified by those repeated observations which are responsible for its genesis (Popper, 1972)

Note the similarities to Schutz' description of our behavior in the natural attitude in the life-world. Elsewhere, Popper concurs with Schutz 'typifications' in perception: "… there is no observation which is not related to a set of typical situations—regularities…" . Popper recognized the *practical* importance of beliefs. Although the theoretician enjoyed the luxury of pursuing open-ended knowledge and of unhurried deliberation, it was different for the "man of practical action. For a man of practical action has always to *choose* between some more or less definite alternatives, since *even inaction is a kind of action*". He sees no escape from the dilemma that while practice depends on beliefs acquired from repetitive experience, such inductive process is *logically* indefensible as a way of producing knowledge. But beliefs differ in type, and 'beliefs' that are unconscious dispositions to act in a certain way due to past repetitions of experiences are inferior to 'beliefs' in the form of personal 'theories,' even vaguely formulated.

> I do not think that such distinctions between different ' beliefs' are of any interest for my own objectivist theory of knowledge; but they ought to be interesting for anybody who takes the psychological problems of induction [i.e. learning from repeated experience] seriously -- which I do not (Popper 1972, p26).

Systems practitioners concerned about decision support that makes a difference in the activities of 'men of practical action' are not as comfortably quarantined from the real world as was Popper, the academic. Agricultural scientists who are serious about effective support for practical decisions and actions have good reasons for interest in farmers' beliefs and the processes that influence them. But the above examination of Popper's views shows that he would not disapprove of such a turn by scientists who pragmatically 'take this seriously'. He made clear that he was *not* 'a belief philosopher', but his views provide space for a phenomenological account of beliefs in the life-world of pragmatic motive and action.

Beliefs as mental models

> In order to believe something, it must first be present in the mind; some *mental representation* must be constructed that is a candidate for [ ] acceptance or non-acceptance (Goldman 1986, p227_.

In both the phenomenology of Schutz and the science philosophy of Popper, the matching of the sensed world and stored mental representations is an important part of the processing of information process about the world which constitutes the environment a decision. The roles of subjective mental models in selective perception, interpretation, and determining action in everyday life and work is constitutive of the *cognitive* view of intelligent behavior (de Mey, 1992).

> The central point of the cognitive view is that…information processing, whether perceptual (such as a perceiving an object) or symbolic (such as understanding a sentence) is mediated by a system of categories or concepts which for the information processor constitutes a representation or a model of his world (de Mey, 1992).

We can take it that farmers, like the rest of us, carry around cognitive structures that represent their worlds to themselves. The possible implications of this for agricultural scientists with intentions to support farmers' decisions are indicated by prior projects of interventionists in non-agricultural fields, e.g. management consulting:

> When we speak of capturing and expressing a manager's mental models we are essentially saying that we want to find out how the client thinks a situation works. Our models of how things work are what enable us to make sense of the world. They allow us to add structure to everyday events. They allow us to understand why something has happened and what its ramifications are. We have such models for almost every situation that we come across. When clients use phrases like, "That's not possible," "I don't think it works like that," or "No, he wouldn't have done that," they are appealing to their mental models of a system or person. Without mental models our lives would seem capricious, random, and meaningless. Models supply structure to a stream of events. The reason mental models are important is that they are what people use to make decisions. Thus to help a manager react to a problem, it is necessary to examine their mental model of how that problem works and, if necessary, help them to change it. This requires an array of tools and we will discuss these in more detail in the section below titled "Modeling as Learning Tools" (Lane ,1992).

In the following section I will pick up on Lane's 'modelling as learning tools,' but here I want to have a closer look at the notion of mental model. Although human cognition, our subjective knowing and reasoning, is commonly explained in terms of mental models, precise description of such structures is elusive in spite of decades of research (Johnson-Laird, 1987; Gentner and Stevens, 1983 and Vennix, 1990). Frames of reference, mental models, mental maps, world views, world models, cognitive structures, scripts, paradigms and many more all have been used as term for cognitive representations.. In generalized language, these are beliefs and systems of beliefs about the environment, about ourselves (including goals), and about implications of both for action. But important structural differentiation can also be made.

De Mey (1992) distinguishes four levels of mental representation and associated levels of organization (Table 1). World models/worldviews enable actors to operate "automatically" in normal, routine situations where possibilities for actions are 'resolved' to one, or a few closely related alternatives. Information from the environment is minimal, enabling only the selection of the appropriate world model. Although this 'mindlessness' sounds undesirable, this automatic selectivity is generally adaptively advantageous because in the routine situations that prevail in our lives, it frees sensory and cognitive resources for problematic matters, and because these situations are familiar and repetitious, the risk of error through inattention is low.

When a situation becomes ‘problematic’ (Schutz and Luckman 1973), or in a state of ‘irresolution’ (Winograd and Flores 1987), the actor’s attention is required in assessing the environment and deliberating on appropriate actions. With modest disruption, this investigation is at the contextual level of action, and the restorative activity generated is ‘exploratory’. More serious disruption may force attention to the level of structure of the environment and theoretical considerations. These differences have important implications for intervention and are developed further in the following section.

Segmentation of *Self* and *Situation*	Mental Representation	Level of Organization	Attitude With Pragmatic Motive
Internal input: beliefs, desires	World model	World view	Natural
	Frame/scheme, script	Context	Exploratory
	Mental model	Structural relationship	Theoretical
External input from env't: data, context	Typification	Object, event	Communicative

Table 1 A framework of cognitive representations based on variation in scale of organization. Levels differ in the degree to which models “in the head” are augmented by information from the environment (from de Mey, 1982). ‘Attitudes’ are based on the phenomenology of Schutz and Luckman (1973).

Considerable research in cognitive science has been directed to better understanding of cognitive structure, but they remain vague entities, but valuable in making sense of human thinking, none the less. But useful, but not clear-cut, distinctions can be made between ‘models’ of situations that provide procedural guidance for action (world models, frames) and models of how the physical world works.

Referring to the definition of ‘frame’ by Minsky (1975) as "a data-structure for representing a stereotyped situation," de Mey (1982) explicates the concept.

> Frames are large complex symbolic structures which can be represented as a "network of nodes and relations". The "top level" nodes of a frame are fixed and stand for "things which are always true about the supposed situation" e.g. in a room-frame: that a room has 'walls' or vertically supporting structures of some

> sort. At the lower levels, frames "have many *terminals* or *'slots'* that must be filled by specific instances or data [‘cues’].
>
> Frames represent units of knowledge one brings to bear upon a situation. As structures which have to be completed with data, they orient the information processing system toward specific aspects of that situation. A basic point of the frame theory is that frames are neither stored nor retrieved as empty or blank forms. The open slots, frame terminals, are filled in with 'weakly bound' default assignments, i.e. *typical* examples of the kind of concrete objects one *expects* to meet when the frame turns out to be applicable (deMey 1982; emphasis added).

Inseparability of the environment and action is an important aspect of the cognitive paradigm. de Mey (1982) emphasizes that in the cognitive paradigm, frames are as much about representing the ‘self,’ i.e. the agent, as representing the world. The ‘situation’ contains both. Situations also contain goals, and frames contain “beliefs about what ought to be” (Starbuck and Milliken, 1988). They represent aspiration levels defined by expectations of the attainable (Simon, 1996)

> Goals are invoked to control the matching process which occurs to check whether or not an invoked frame is appropriate. As such, frames and frame-networks are not free-floating descriptive entities. They are always part of some procedure designed to fulfill some purpose or to solve some problem (de Mey, 1982).

This corresponds to the *pragmatic motive* of Schutz and Luckman (1973).

A somewhat different type of cognitive model is that which represents physical structure or technical function, for which the term ‘mental model’ prevails. Norman (1983) observed that such a mental model reflects a person’s beliefs about the physical system, acquired through observation, instruction, or inference. The technical model has dominated the field of mental model research because of easy availability of normative, theory-based conceptual models for comparison (Gentner and Stevens, 1983). But in the ‘natural attitude’ of practice, the ‘pragmatic motive’ means that interest in function is generally confounded with ‘action,’ and mental models combine representations of ‘how things work’ with representations of ‘how I proceed to get the outcome I want’. As part of decision process, these mental models are ‘run’ to predict the outcome of an action in a situation, i.e. the ‘mental simulation’ of Point 2 of Orasanu and Connelly (1995), later in this section (Norman, 1983 and Lipshitz, 1995).

Elaborating the action-oriented decision model

Decision and actions are about the world, and any model of action must reflect this. But instead of the deterministic relation to behavior in Lewin’s model, in this case it must be mediated by the mind of the actor, i.e. through goals, beliefs, mental models, etc. A process by which this is accomplished is described by Simon (1996).

> The distinction between the world as sensed and the world as acted upon defines the basic condition for the survival of adaptive organisms. The organism must develop correlations [b_T] between goals [g] in the sensed world and actions in the world of process. When they are made conscious and verbalized, these correlations correspond to what we usually call means-ends analysis. Given a desired state of affairs [g] and an existing state of affairs [b_E], the task of an adaptive organism is to find the difference between these two states and then to find the correlating process [action] that will erase the difference. Most problem-solving requires continual translation between the state and process descriptions of the same complex reality (Simon, 1996 interjections added).

This interaction of the organism, or from a subjective standpoint, the *self*, with the world, or *situation*, suggests an elaboration on my action-oriented model for decision making, when situations are problematic, or unresolved (Figure 2).

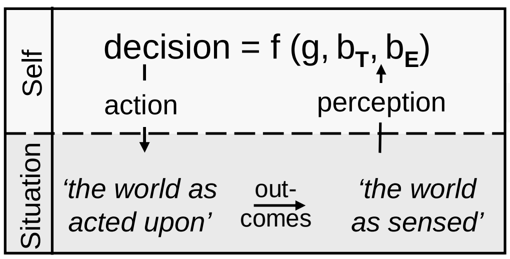


Figure 2. An action-oriented model of decision making when the situation is problematic. Deliberation centres on beliefs about the environment (b_E), beliefs about tasks (b_T) and goals (g).

(When the situation is not 'problematic,' i.e. routine, the world and outcomes are taken largely for granted and the decision expression is replaced by a 'world model' (Table 1) which enables action to follow perception 'automatically' without deliberation involving goals and beliefs.)

Perception is an active process in which what is sensed as a state of the world is influenced by what state is expected (an aspect of b_E) (de Mey 1982; Weick 1995). Interpretation of the situation is accomplished by reference to beliefs about tasks and outcomes (b_T). Evaluation of sensed states are evaluated by reference to goals (g). Goals are both underspecified actions (de Mey 1982) and are inseparable from beliefs about potential of the environment. As Shafer (1986) pointed out, "…the process of formulating and adopting goals creates a dependence of value on belief, simply because goals are more attractive when they are feasible" (quoted by

Beach and Lipshitz 1995). Through evaluation, problematic discrepancy between a goal and a state of the world as sensed can be alleviated by action to achieve the desired outcome or by downwards adjustment of the goal. But goal adjustment is not all one way. Through intervention that leads to a new learning about a task (change in b_T), farmers sometimes discover that they have been aiming too low (something that can easily go unrecognized in a variable environment) and formulate more ambitious goals (g) (Carberry, 2002).

Naturalistic decision making

The implications of this theory pertaining to subjective decision and action can be seen in recent developments in decision research. The essence is succinctly expressed by Brehmer (1990).

> The study of decision making in a dynamic, real-time context, relocates the study of decision making and makes a part of the study of action, rather than the study of choice. The problem of decision making, as seen in this framework, is a matter of directing and maintaining the continuous flow of behavior towards some set of goals rather than as a set of discrete episodes involving choice dilemmas (Brehmer 1990).

Since the mid-1980s a concerted research effort, largely funded by the US Army and the National Aeronautics and Space Agency on decision making in natural, real world conditions has stimulated a new school of decision research labeled 'naturalistic decision making.' The main features of this perspective are set out in Orasanu and Connelly (1995) and summarized below.

1. Reasoning about situations is aided by beliefs about the world and tasks to be undertaken. As frames and mental models, these greatly aid organizing problems, interpreting situations, and identifying information valuable for solution. A critical feature of the frame-driven approach is that people create causal models of the situation. They try to understand the significance of events and information by inferring causal relations.

2. In contrast to the traditional emphasis on rational selection among alternative actions, decision makers tend to conceptualize a 'best bet' solution that fits the situation and proceed to evaluate it, including using mental simulation.

3. Decision makers work toward 'satisfactory,' rather than optimal, solutions. From the naturalistic perspective this is viewed as being adaptively pragmatic when facing of ill-structured problems in uncertain, dynamic environments.

4. The major distinction between expert decision-makers and less expert decision-makers concerns their relative abilities in evaluating problematic situations rather than their reasoning processes and performance per se.

5. Reasoning and acting are interleaved. "Instead of analyzing all facets of a situation, making a decision, and then acting, it appears that in complex realistic situations people think a little, act a little, and then evaluate the outcomes and think and act some more." And in this decision cycle, actors learn.

Naturalistic decision making continues to be a very active research field, as evidenced by a recent Special issue of the Journal of Behavioral Decision Making dedicated to it (Yates, 2001), and promises to provide a valuable resource for those concerned with support for farmers' decisions.

Let's pause and assess where we are and how we got here. We have now seen that our DSS heritage is firmly rooted in long-held, and apparently logical, beliefs about farm decision making: (1) farmers suffer the 'handicap' of having to make most decisions using their 'intuition,' based on customary practice and (2) supply of information that reflects economic rationality and/or scientific 'best practice' can replace intuition, with benefit. But in the aftermath of failure of this normative school of intervention to be accepted by managers, phenomenology puts farmers' customary practice in a new light, partly by reminding scientists that habitual behavior is inevitable and fundamentally adaptive—until a problem or opportunity arises. When either such an attention-attracting event occurs, a deliberative process utilizing the manager's beliefs about the task and the situation, interprets the situation, and 'designs' appropriate action. *Agents* act in situations on the basis of their goals and beliefs, and they learn from experiences in their practical situations—theirs and those of others in their culture as communicated to them. A focus on the personal, subjective nature of decision making and action is captured in 'naturalistic' decision making. We now can address the matter of what this radical change in perspective might mean for scientists with models providing support for farmers' decisions.

3. Intervention to support farmers' naturalistic decision processes

As software produced by scientists to influence the instrumental thinking of practitioners, the decision support system is both technical and social in nature (Keen, 1987 and McCown, 2002a). Scientists' natural strategy for a decision support project is to invest in the technology and assume that rational farmers would welcome information products that are scientifically-sound, relevant to stereotypic practice and made readily accessible. This paradigm of intervention in decision making has proved to be technically impressive, but socially naïve. In this section I am arguing that greater success in science-based decision support requires intervention with a different socio-technology, one that acknowledges the social reality that good farmers—progressive farmers—behaving normally in their life-worlds, will only *occasionally* behave as expected in the traditional DSS paradigm, i.e. as eager consumers of science-based information and tools. The frequency of these occasions is too low to warrant continued production of DSSs. The big question is whether a different type of intervention would be more appropriate and successful.

This alternative socio-technology, which I am advocating, of intervention to support a manager's subjective decision making processes raises three key questions: (1) Under what conditions can the decision maker be expected to welcome support?; (2) Just what is being supported?; and (3) What does such intervention look like? In search of answers to Question 1, I look to phenomenology and management science. To answer Question 2, I look to cognitive science (the science of subjective knowing and reasoning) and to the field of 'sensemaking', whose home is in social psychology. For Question 3, I rely heavily on experience in the field of 'system dynamics' as applied to business management.

What are occasions for effective support?

Once, in response to my question, "Why are decision support systems so little used by farmers?", a very savvy and computer-literate farmer, familiar with local DSS efforts, replied, "You need a doctor when you've got problems, not when you're traveling well enough." This response indirectly exposes what is arguably the most serious flaw in the DSS paradigm, i.e. that the default rationale for expecting DSS adoption is that superior quality knowledge in, or generated from, a DSS will be preferred over existing farmer's knowledge. I am not arguing that the presumed quality differences don't often exist, but rather that this ignores the crux of the matter—farmers' existing resources for making decisions in farming practice are only *occasionally* problematic. Most of the time, a farmer feels they are "traveling well enough," and when this is the case, they can be expected to "*trust only their own understanding of their world as the basis for their actions."* These observations by managers of a farm and an oil company are congruent with the phenomenological theory of Alfred Schutz (Schutz and Luckmann, 1973).

Paraphrasing Schutz' first person account of the everyday experience, since the course of my life is a series of situations, in every moment of conscious life I find myself in a situation that requires a degree of control so that my actions will effectively achieve my goals, i.e. that I 'master the situation'. To a greater or lesser degree, a situation is imposed on me, in part this predetermination is that of the given, natural world; it is further determined, or limited, by social realities. But situations are never fully determined—they are 'open' to some degree, allowing some freedom for my personal decision, which leads to my action. But when the situation is 'familiar' and I am 'traveling well enough' in my activity, I am not actively, consciously, engaged in assessing and deciding. Rather I am mastering the 'taken for granted' situation using my stock of habitual knowledge quite automatically. As long as I believe that the situation is routine and unproblematic, it is good practice not to invest scarce resources, e.g. my time and attention, to gain more intimate knowledge of the situation or about alternative actions.

> ...I know that there are…"more precise" explanations for the events familiar to me and even that there are certain "people" who can transmit this knowledge to me: scientists...[etc]. Although I know that, I am really not interested in acquiring further knowledge about it. I'm sufficiently familiar "for my own purposes." The interest involved here is in the broadest sense a pragmatic one that determines the acquisition and interruption of knowledge. I would, or perhaps in principle be "interested" to know more about these things, but under the principle of "first things first" I have "no time," since I must "first" acquire knowledge more relevant for me. I want to keep a "place" open for more important or more urgent experience (Schutz and Luckmann, 1973).

But when the situation changes in a way that indicates that my habitual knowledge might not be adequate do deal with the new elements, the situation becomes 'problematic' and attention becomes focused. This new situation becomes the 'more important or more urgent experience.'

> If such "new" elements entered into a situation, I must "deliberate." That is, I consciously try to correlate these elements with my stock of knowledge. Let us first assume that completely new elements are also explicated with the help of interpretation schemata and typifications which are on hand, but not sufficiently for my plan-determined interest. My knowledge is not "clear" enough, "sure" enough, not sufficiently free of contradiction, for me to handle the current situation. I must thus further explicate the "open" elements of the situation until they have achieved the level of clarity, familiarity, and freedom from contradiction already given in the plan-determined interest. We will call such situations *problematic situations*. In contrast to routine situations, I must here either acquire new elements of knowledge or take old ones which are not sufficiently clarified for the present situation, and bring them to higher levels of clarity (Schutz and Luckmann, 1973).

In the first instance, my reference schemata ('types,' frames, mental models, etc.) shape my expectations of the situation and thereby largely determine what I perceive as relevant to mastery of the situation.

> In the application of habitual knowledge this happens in a completely passive synthesis of recognition; the grasp of the type is "automatic." The object of experience without a process of explication is proven to be typical: similar, the same as, resembling typical aspects of the prior experience. The more questionable the

> agreement between the type and the determining characteristics of the current experience, the less familiar it appears to me (Schutz and Luckmann, 1973).

To the degree that I experience 'surprise,' these model-based pre-perceptions fail to match the reality I perceive in the specific situation. The situation is 'problematic' and I realize a need for learning, i.e. new, more applicable, mental structures.

> If the current experience finally appears not "sufficiently typical" for determination and mastery of the situation, processes of explication are induced in which new typifications on other levels of determination are rendered familiar (Schutz and Luckmann, 1973).

But there is a very pragmatic limit to interest in acquiring new knowledge.

> We have seen that in [the circumstances of the acquisition of knowledge] the plan-determined interest motivates the determination of the situation and the explication of experiences, prescribes the level of explication, and in that way establishes when the explication should be…discontinued. In other words the expectation of a situation or experience is in general broken off when the knowledge constituted by the expectation is sufficient for the mastery of the situation. Many possibilities of explication remain irrelevant; many possible continuations of the explication prove to be unnecessary (Schutz and Luckmann, 1973).

At this point we can focus this to answer Question 1, concerning realistic expectations for farmers' receptivity to decision support intervention. The indication from phenomenology is that the windows of opportunity for support offerings to be deemed relevant by farmers are limited to the experiencing of problems, and even there, there is a risk of missing the window in the other dimension by providing a level of detail of information in excess of that needed to deal with the problem. Because the conventional DSS targets a stereotypic problem, it suffers an inability to respond to windows of receptivity. Both 'problem' and 'solution' are fixed at the time of computer programming. In the ideal intervention, what constitutes a 'problem' can be discussed and the level of intervention can be negotiated. Such flexible engagement is an important social characteristic of the alternative paradigm for the support that I am outlining.

Intervention to support what?

I now turn to Question 2, "What is supported in this paradigm of intervention?" According to the phenomenological account of Schutz, the notion of 'support' only becomes relevant when the taken-for-granted routine activity becomes interrupted by a change in the situation—a change leading to the farmer perceiving the situation to be 'problematic'. Karl Weick (1995) argues that what are brought into play in these circumstances are not problem solving or decision making processes, but *sensemaking* processes.

> …sense making begins with the basic question, is it still possible to take things for granted? [in the natural attitude in the life-world] And if the answer is no, if it has become impossible to continue with automatic information processing, then the question becomes, why is this so? And, what next? (Weick, 1995).

A problematic state concerning a taken-for-granted belief can be due to either *uncertainty*, the lack of information, or *ambiguity*, conflicting information or interpretations. The former is problematic because of *ignorance*, the latter because of *confusion* (Weick, 1995 and Weick and Meader, 1993). A farmer's situation becomes problematic when a 'comfortable' belief becomes challenged or when attention is drawn to the high degree of uncertainty or ambiguity associated with beliefs that are the basis for everyday decision and action (Figure 2), especially if there is some new prospect for relieving uncertainty or ambiguity. It may concern beliefs about the state of the environment, about relevant environmental consequences, about the action procedures or consequences, or about the appropriateness of the goal (Figure 2). In dryland farming systems in subtropical Australia, a farmer is normally hampered in decisions concerning crop selection and planting by a high degree of environmental *uncertainty*. This farmer experiences problematic *ambiguity* about decision and action when, after engaging in discussion of simulations of alternative rotations, his belief is confirmed that rotations featuring dryland cotton are by far the most profitable but also comes to believe, as the simulations indicate, that these rotations pose the greatest dryland salinity hazard because they are the most 'leaky,' i.e. they allow the greatest deep drainage because of the long bare fallows required to store soil water.

Sensemaking is an art of the possible. It is making do, coping, developing confidence when activity must continue in spite of uncertainty and ambiguity. According to Weick (1995), sensemaking processes can be driven by either tentative *beliefs* or tentative *action*.

> … even though sensemaking processes are elusive there seems to be at least four ways in which people impose frames on ongoing flows [of thinking and activity] and link frames with cues in the interest of meaning. Sensemaking can begin with beliefs and take the form of arguing and expecting. Or sensemaking can begin with actions and take the form of committing or manipulating (Weick, 1995).

One of the resources that is sometimes available is discussion with other people of one's beliefs about the situation or contemplated actions. When this takes the form of robust argument in which criticism serves to filter out weaknesses of a belief or replace a belief with a better one, more dependable understanding results.

> …when arguing is the dominant form of sensemaking, weak definitions of the situation, embedded in tentative initial proposals, gradually become elaborated and strengthened as proposers confront critics. Sensemaking occurs as this "natural dialectic" begins to produce either a synthesis or a winner (Weick, 1995).

Another way a belief can serve as a driver for sensemaking is when it is embedded in expectations that guide interpretation of the situation and decision making. In this coping process, expectations can be 'best guesses' or even 'wishful thinking;' either provides a starting point for meaning that can be reinforced by confirming action, generating what might be viewed as 'self-fulfilling prophesies.'

> The point that people keep missing is that self-fulfilling prophecies are a fundamental act of sensemaking. Prophecies, hypotheses, anticipations -- whatever one chooses to call them -- are starting points. They are minimal structures around which input can form as the result of some kind of active prodding. That prodding is often belief driven, and the beliefs that drive it are often expectations. People do not have much to start with when their goal is to "get to know" [a situation]. This means that their expectations cannot help but be a force that shapes the world they try to size up (Weick, 1995).

> …the evidence suggests that when perceivers are motivated by accuracy concerns, they do not produce self-fulfilling prophecies. But when they strive for stability and predictability, their interactions...will lead to behavioral confirmation of their beliefs and expectations (Weick, 1995).

Because beliefs and actions are so closely interrelated, sensemaking can start at any point at either end of Fig. 2.

> Structures of mutual causality mock the language of independent and dependent variables. They invite instead, description of those situations where beliefs can affect themselves through the mediation of action, and situations where actions can affect themselves through the mediations of beliefs (Weick, 1995).

Sensemaking processes that are driven by action rather than belief derive from the fact that organizations are above all, "activity systems that generate action". In spite of formalized descriptions of organizations (including farms) as rational systems for pursuing goals, Weick contends that "organizations are…loosely coupled systems in which action is underspecified, inadequately rationalized, and monitored only when deviations are extreme.". This means that there is ample freedom for actions in times of uncertainty or ambiguity to originate out of personal *commitments* to act, e.g. to continue to do what a farmer does in this culture, but with a new degree of attention on cues in the environment and on feedback to beliefs from outcomes – attention not paid during unproblematic times (Fig. 1). Weick's second action-originating strategy for making sense of a problematic situation is *manipulation* of the world in order to learn. Here action serves also as an experiment or probe that may start a process that leads to insight and new beliefs/mental models.

These 'sensemaking' processes are techniques for 'bootstrapping' decisions and action under conditions when uncertainty and/or ambiguity prevail. They provide a starting point for progression to a new, adapted, everyday management routine based on mental models of the situation that are products of these sensemaking processes.

> Sensemaking, after all, is about the world. And what is being asserted about that world is found in the beliefs and categories implied by frames (Weick, 1995.)

Before turning to the third question concerning the nature of the alternative mode of intervention, it may be helpful to synthesize responses to the first two. The basic occasion for sensemaking support is most readily visualized as an unexpected change in the decision maker's environment—a surprise that destabilizes activity and creates uncertainty or ambiguity. But a need for making sense of the situation can also arise from a farmers sense of new *possibility* beyond what had been assumed previously in goal setting (Weick, 1995). Although perception of an opportunity is more welcome than a threat, both bring the destabilizing, problematic effects of pressure to act, difficulty, and importance (Starbuck and Milliken, 1988). A third occasion for sensemaking, according to Weick (1995), and one especially important to interventionists, is initiated in response to a request for increased conscious attention, as when farmers are challenged by others to think about an issue or to answer questions about matters that are potentially problematic. Significantly, when a sense of the latent problematic can be channeled into a process of *inquiry*, the emphasis shifts from tactic to strategy, from deciding to *learning* that will influence future decisions.

What does sensemaking support look like?

In a critique of the Group Decision Support System (GDSS), Weick and Meader (1993), acknowledge the potential value of simulation for support of groups whose deliberation and action are impaired by uncertainty and ambiguity, and which are in most need of support in sensemaking processes. There exists a considerable body of literature on the use of simulation models in the field of business management as instruments for enabling such learning by managers. The basic idea is the use of a comprehensive and competent model of a business to provide a virtual world in which a participating manager can engage in the realistic activities of assessing the environment, deliberating about meaning for the business which is represented in the simulator, making decisions, taking action, and evaluating the outcomes of his/her actions.

These elaborate computer programs have been variously termed 'microworlds,' 'management games,' 'management flight simulators,' 'Computer-Based Learning Environments (CBLEs),' 'business simulators,' and 'learning laboratories' (Senge, 1990; Lane, 1995; Maier and Grobler, 2000).

Lane (1995) reviewed the 'second coming' of this phenomenon and noted that the first such product was created by the American Management Association in 1956 and was called 'Top Management Decision Simulation;' by 1966 they were used by the majority of U.S. business schools and the commercial market for simulations exceeded $US100 million per year; by 1970, they were largely out of favor. They returned in the 1980s with PCs. The major resurgence later in the '80s was due to activity in the field of 'systems dynamics,' a field pioneered in the 1960s by Jay Forrester. Led by groups in the Sloan School of Management, MIT, and the London School of Economics, numerous management simulators have been developed in conjunction with business corporations, e.g. People Express Airline Management Flight Simulator, B&B Enterprises Management Flight Simulator (Lane, 1995); Index Computer Company Microworld, Hanover Insurance's Claims Learning Laboratory (Senge, 1990); Mobile Phone Subscriber Microworld, Professional Services Microworld (Romme, 2002).

Comment [R L1]: Fidelity of this statistic is confirmed.

How does learning take place in a management simulator? The theory is that a participant learns from 'virtual' experience—experience that, while less authentic than firsthand experience, has peculiar advantages over many real life situations. Senge (1990) explains that "learning by doing" only works so long as the feedback from our actions is rapid and unambiguous and this is often not the case. When we act in a complex system the consequences are often neither immediate nor unambiguous, but are removed from us in time or space. This leads to what he calls the dilemma of learning from experience: "we learn best from experience, but we never experience the consequences of our most important decisions." The rationale for management simulators is that 'virtual worlds' are created,

> …learning environments where time can be slowed down or speeded up, complexity can be simplified, irreversible actions made reversible, and the risks of experimentation eliminated (Isaacs and Senge, 1992).

The processes in which learning takes place are represented in Figure 3, adapted from Isaacs and Senge (1992). In the real world, learning by experience takes place as actions are evaluated and mental models updated through processes of reflection, discussion, sensemaking, and satisficing. This new learning modifies subsequent perception and the interpretation of situations and the decisions and action that follow. Terms in bold text comprise the action model of Figure 2. When a management simulator is available, real world action, which can be slow, expensive, and risky, can be by-passed for purposes of learning, without changing the concepts in the cycle. Because of the reduced authenticity, I think this learning better qualifies as 'sensemaking,' i.e. as the generation of prototypes of new beliefs/mental models, which can be tested by action in the real world. This view seems to be supported researchers in virtual reality.

> Virtual reality is not "real," but it has a relationship to the real. By being betwixt and between, it becomes a play space for thinking about the real world. It is an exemplary evocative object. When a technology becomes an evocative object, old questions are raised in new contexts and there is an opportunity for fresh resolutions (Turkle, 1997).

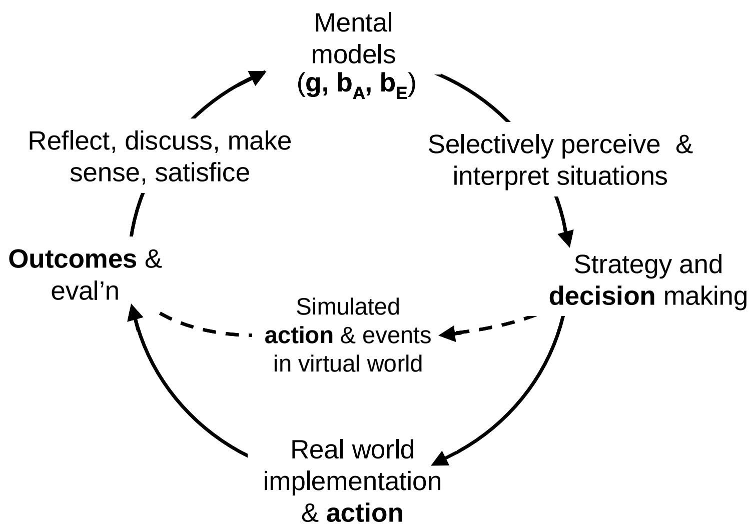


Figure 3. A real world action learning cycle (action, evaluation, reflection, decision) and a shunt in which simulated action substitutes for real action. Bold terms are those of the action model, Figure 2.

The key feature of a simulator designed to aid management learning is its verisimilitude – its realistic mapping to the real world (Lane, 1995). Because of the complexity needed to achieve this, there is generally a need for a briefing session before the simulation and a debriefing session afterwards "which helps participants to reflect on their actions during the experience so as to derive the most learning from it" (Lane, 1995). One of the explanations for the demise of the 'first coming' of business simulations was poor facilitation, with the result that simulations were often run carelessly, merely for entertainment (Lane, 1995).

In principle, scientific support for agents' sensemaking entails facilitation of discovery learning of new concepts that lead to modifying beliefs/frames/mental models to varying degrees. Associated with this is 'paying attention' to new cues in the environment rather than acting on the taken-for-granted belief about the situation. The key tool for both such interventions is the computer simulation model.

Challenges

Although this intervention approach has an impressive track record, one of the harsh realities for management consultants has been that business managers are often reluctant to change their beliefs about the environment, their actions, or their goals—to change their mental models—in spite of management situations becoming problematic to a degree where change seems warranted to consultants. A great deal of attention has been given to methods for stimulating, in conditions suitable for inquiry and exploration, reflection that prompts learning rather than the defense of existing beliefs. A prominent business/organizational consulting approach, Action Science, is largely committed to this single activity (Argyris et al., 1986). Informed by the experience of action science, Isaacs and Senge (1992) interpret limitations they experience in using management simulators. Even with the advantages afforded by this approach

> …there are difficulties in the ways human beings move from new understandings to new behavior. These difficulties are greatest when new understandings produce insights into the counterproductivity of basic assumptions and values. Thus, even if CBLE's [computer-based learning environments] can illuminate systemic factors which confound learning, this will not guarantee that new policies will be recognized or implemented (Isaacs and Senge, 1992).

A common expression of this phenomenon is the selective use of simulation results by participants to reinforce their existing beliefs. These authors suggest adoption of action science methods for 'surfacing' tacit beliefs to enable their discussion as part of the encompassing facilitation methodology in which the management simulator sits.

In his best-selling management book *The Fifth Discipline* (Senge, 1990) distinguishes among three cognitive modes managers can use to interpret situations: *reactive* to events, *responsive* to behavior patterns, and *generative*, utilizing knowledge of systemic structure. The phenomenological account of Schutz identifies the first as characteristic of routine, unproblematic activity in the 'natural attitude' of everyday living and working. But management consultants in advanced capitalism tend to see this state as a liability in an environment that is fiercely competitive and rapidly changing. It is taken as 'the problem' and consultants intervene to move clients to more active cognitive levels. Senge (1990) strongly advocates the generative mode, which utilizes formal knowledge of the structure of E, because it is the "most powerful," but acknowledges that it is the least common.

In Figure 4, Senge's three management modes are used in constructing a framework to aid thinking about model-based intervention in farm management. This discussion is partly speculative and partly reflects experience over the past 12 years in the FARMSCAPE (Farmers', Advisers', Researchers', Monitoring, Simulation, Communication, And Performance Evaluation)project. . FARMSCAPE is the only substantial case in agriculture of the use of a management simulator in a methodically constructed learning environment for farmers of which I am aware, and progress reports can be found in Carberry et al., (2002) and Hochman et al., (2000). (Analysis of the FARMSCAPE experience using the theory covered in the present essay is presently being finalized.)

Management Modes	*Characteristics*
'Reactive' management ↑	Manager in 'natural' attitude. Situation unproblematic. Manager not receptive to 'support.'
'Responsive' management	Manager in 'exploratory' attitude. Sensemaking → change of beliefs/mental models *via* 'experience.'
'Generative' management	Manager in 'theoretical' attitude. Learns system structure & function. Mental model change due to internalisation of conceptual model

Figure 4. Characteristics of management modes (Senge 1990).
Arrow indicates direction of pragmatic preference.

A particular management mode refers to behavior pertaining to a specific problematic area or issue, rather than to a manager's approach to practice generally. I have assigned 'attitudes' to each management mode that characterizes behavior; 'natural' and 'scientific' were used by Schutz and Luckman (1973). The arrow emphasizes that managers move away from habitual practice in the familiar situation only as little as possible but as often and as far as is warranted by a problematic situation. Once the needed learning is achieved, it grounds a new habitual practice in an increasingly familiar situation allowing a return to a *reactive* management mode.

Typology of Research Oquist (1978)	Typology of Systems Thinking Jackson (2000)		Management Intervention Modes	Cognitive Representation Level	Implications for Management	Management Modes Senge (1990)
				World model	• Farmer in 'natural attitude.' • Situation unproblematic. • Farmer not receptive to 'support.'	'Reactive' management (in 'natural attitude') ↑
Action research ↓		'Soft' systems	Model aided 'sensemaking' as virtual situated experience	Frame/scheme, script	Simulation enhanced 'experimentation', sensemaking, & change of beliefs *via* experience of 'virtual' history.	'Responsive' Management (in 'exploratory attitude')
Policy research	Systems thinking for 'problem solving'		Most decision support systems		Mainly normative recommendations for action	
		'Hard' systems	Model aided sense-making as insights to structure	Mental model	• Model-aided farmer learning about system structure & function. • Mental model change due to internalization of scientists' model.	'Generative' Management (in 'theoretical' attitude')
Nomothetic research	Systems thinking in the disciplines					
Descriptive research			Manager's life-world			
Scientist's life-world						

Figure 5. A synthesis of typologies of behaviors of scientists and managers that shows both congruence of concepts (horizontal alignment) and incongruence of pragmatic motives in their respective life-worlds (arrows in opposite directions, with direction indicating increasing pragmatism under 'normal' conditions and frequency in the science community).

Figure 5 brings a number of typologies of activity in scientists' life-worlds together with Senge's typology of management cognitive modes. Oquist (1978) ordered the four types of research in the first column and is based on the logic that each type 'above' presumes the content of those ‘below.’ However, as discussed later, this is not the case regarding the relationship between action research and policy research. The first two types of systems thinking of Jackson (2000) (depicted earlier in Fig. 1) align well with Oquist’s research types, as do the sub-categories of ‘problem solving. In the manager’s life-world, as shown earlier by the phenomenological account of practice, there is no opportunity for intervention in the *reactive* mode of normal, everyday farm management, when the farmer is “traveling well enough,” or at least feels like this is the case. Action can be taken without deliberation, under the overall control of a cognitive ‘world model.’

Invitation to join inquiry with scientists and other farmers regarding potentially problematic, or unresolved, issues can prompt an ‘exploratory attitude’ in which a farmer takes great interest in using the simulator to explore the nature of the environment and new possibilities for actions. As reported by Carberry (2002), some participants accrue ‘virtual experience’ which influences their subsequent management. During the inquiry, a few farmers find in the discussions a particular scientific concept to be a more useful mental model than one they held in the past, and can be considered to temporarily adopt a ‘scientific attitude. This better equips them for management that is more *generative* of solutions and innovations until a new unproblematic situation is created.

‘Some decision support systems’ appears in the column headed ‘Management Intervention Modes.’ It is often reported that farmers have ceased using a DSS because they learn how to do what it enabled without continued use of the DSS. Since such software is designed to be a tool in decision making rather than to aid learning, any contribution to changing mental models is incidental. But these reports have led to the suggestion that this desirable result could be enhanced if the products were designed for this purpose.

The horizontal dashed line in mid-Fig. 5 significantly indicates the demarcation of objectivist and subjectivist approaches—‘hard’ below and ‘soft’ above. Not surprisingly, the scientists’ life-world ‘territory’ is dominated by ‘the objective’ and that of managers’ by ‘the subjective’. The central point of Figure 5 is that likelihood of scientific decision support for farmer’s decision making is much lower than the expectations commonly-held, or at least once held, in agricultural

RD&E circles. The vertical arrows indicate direction of preferred mode of practice by managers and scientists respectively. Managers will move away from, 'automatic,' reactive management to the degree that is required by the situation. They are much more prepared to explore action possibilities experientially than to learn new theory. Scientists on the other hand, generally prefer working in their discipline, but systems researchers are prepared to apply their knowledge and tools to Oquist's policy research (policy to guide managers' actions, rather than the government's), which equates to design of best farming practice and decision support for stereotypic decisions, but, in general this normative approach has been ignored by farmers. Very few scientists have attempted to engage in action research, as per Figure 3, where the scientist's hard tools can contribute to soft, 'experiential' learning (e.g. Carberry 2002). This indication that the preferences/interests of farmers and scientists lie in opposite directions will surprise few farmers or scientists, but it does provide an explanatory framework as a substitute for blame.

Explanation in terms of 'attitudes' of scientists who take their models into 'the wild' to engage farmers on relevant management matters is less well developed. Such activity will not be done in the 'natural attitude' until organizations formally reward it to a degree that makes it driven by scientists' pragmatic motive or it becomes successfully commercialized. Until then, participating scientists probably have an 'exploratory' attitude and, a few, a 'theoretical attitude.' For those that do venture out, more are more comfortable and more adept in using models to explicate scientific principles than in providing a virtual world for farmers to experiment. Unfortunately, the opportunities for the former arise within the latter. It has become clear that scientists with both the intimate knowledge of the models needed for competent mimicking of farming and the skill in conducting compelling discussions are as yet rare. But it remains to be seen if large numbers will be needed and, if they are, if they can be produced cost-effectively.

The issues of ecological sustainability of farming and of off-farm ecological effects raise radically different and challenging decision making issues. Does this theory of decision making and of intervention apply when the boundaries of farm decision making are shifted?

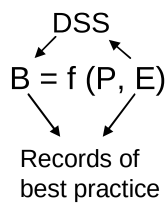
4. Implications for intervention in farmers' decisions concerning the environment

One of the central unresolved (and perhaps irresolvable) issues in social science concerns the degree of the control of human behavior by constraining structures of the world, both natural and social on the one hand, and by the driver of human agency, free will on the other (Giddens, 1979). In this essay I have used Lewin's model of behavior, B = f (P, E), to organize theories of structural determination. Various decision making and intervention theories have featured either constraints of the external environment, E, or of the internal environment, P. As an opposing model for agentive control of behavior, I have proposed an action-oriented model of decision making (Figure 2).

Although I emphasized the limitations of the structural model's 'one eyed' view, I have waited until now to acknowledge that this 'action' model is equally one-eyed in that it ignores the very real, but partial, structural determinism that we all experience. But this omission seems justified in the context of the challenge of inventing effective intervention practice when acceptance of intervention is entirely voluntary. Creating a market for decision support in family farming depends on creating value where, as Arie de Geus says in an earlier quote, "People… embracing the responsibility of their life…trust only their own understanding of their world as the basis for their actions." But when system boundaries change to include not only decision and action being influenced by the external environment, but decision and action substantively *influencing* the quality of the environment of others, the inadequacies of a purely agentive model of intervention stand out.

In terminating the review of 14 DSSs, McCown (2002b) concluded that although the record of performance of the DSS fell far short of expectations, there were reasons to expect a 'future' for some members of four categories of software for supporting farmers' decision making: (1) 'small,' technical calculators; (2) aids for recording conduct of environmental 'best practice'; (3) flexible simulators for system analysis by a consultant; and (4) flexible simulators in providing a learning environment for farmers. The second and fourth of these seem relevant to providing support for farmers on environmental matters, but in quite contrasting ways.

Support systems in the second category seem useful in the context of environmental regulations which many farmers are facing or will face. Intervention with software that first supports ‘best practice,’ and then documents it, is support in the traditional knowledge transfer paradigm. In an example supplied by Hearn and Bange (2002), Australian cotton farmers are highly motivated to avoid negative political implications of environmentally damaging pesticide application. Documented adherence to best practice is enhanced by a prescriptive use of a ‘hard’ DSS to determine a practice (B) and the keeping of similarly objective records of actions actually taken.



In a formal sense, farmers have not lost agency in this case because the conforming action is entirely voluntary. But the considerable influence on behavior of social pressures to conform and the risk of mandatory practices in the future amounts to an *effective* loss of agency.

Nevertheless, farming in advanced capitalism is predominantly a business, and for farmers acting in their life-worlds in the ‘natural attitude,’ their primary ‘pragmatic motive’ can be expected to be directed toward profit taking and wealth creation. However, to the degree that environmental issues become problematic in the farmer’s life-world, attention can be expected to shift and new sensemaking take place. But the occasion for this new sensemaking is created by what makes the situation problematic. Candidates for this stimulus include visible negative effect on production, imposed legislative or social penalties, and interventions that raise consciousness of the potential to become problematic.

As is the case in most Western democracies, Australian governments are reluctant to impose environmental regulations on farmers. Although the threat to do so is a ‘stick’ which is not all that well hidden, the preference is for voluntary changes. What might be the role for an action-oriented intervention to support farmers’ sensemaking in these circumstances? Depending on the competence of the simulator, three classes of relevant interactions could be explored.

1. Time trends of detrimental effects of prevalent practices on politically sensitive aspects of the environment in relation to alternative practices, providing an opportunity for farmers to test their beliefs about their actions in relation to the environment.
2. The comparative profitabilities of production options within new boundaries of E 'imposed' by environmental political pressures.
3. The comparative profitabilities of production options when combined with provision of newly remunerated 'landscape services' such as clean water and, possibly, enriched biodiversity.

In '1' and '3,' the simulator must be able to deal competently with effects of actions on the environment, whereas in 2, the requirements for the simulator remain those needed for simulating production in response to the environment.

Intervention of this nature is only embryonic. The FARMSCAPE team has only recently turned attention to production systems with the added dimension of environmental goals. A sobering early finding was that farmers who had demonstrated for some time a high degree of confidence in the simulator for exploring management possibilities in terms of production risk and profitability were quick to challenge the competence of the simulator when unwelcome outputs regarding the environment were produced. When the most profitable rotation produced the highest quantity of potentially hazardous deep drainage, the response tended to be, "This is only a model, and how do we know if it is telling the truth on drainage."

In summary, the environmental challenge to farming is, in many places stark, and farmers *need* for support in bringing about change in decisions and actions is often clear. However, in light of the history of the DSS and the dramatic progress in naturalistic decision theory, any strategy based on technical extension of traditional DSS technology seems extraordinarily heroic, if not doomed to failure. If DSSs which targeted farmers' primary concerns have been largely ignored by farmers, why would farmers use DSSs that target environmental matters of, generally, only secondary importance to them? And when the situation is made problematic by environmental legislation, a DSS may be seen to be an inefficient route to the achievement of compliance.

Use of the action-oriented intervention paradigm has produced significant developments in effective intervention in farm *production* matters over the past decade. Although in FARMSCAPE we have done no more than pilot this new intervention paradigm in *environmental* matters, we expect that the results should be a source of encouragement to those who expect that model-based learning facilitation might be preferable to coercion as a way to influence farmers on environmental matters.

Concluding remarks

The time has passed when decision support systems could be assumed to be the means by which results of research on matters of farm management would be 'communicated' to farmers. The evidence is overwhelming that, in the main, the DSS for farmers is an inadequate idea. But to prevent the 'baby from being thrown out with the bath,' greater discrimination among products and approaches, as attempted in the four types of decision support of McCown (2002b), must be made. This essay has featured the dichotomy between products which provide models applied to stereotypic problems and a mediated process in which scientists with flexible simulators facilitate farmer learning. I have attempted to show that there is a great body of convincing argument and some evidence that the mediated process more realistically accommodates the nature of farmers' cognitive behavior related to decision making. But the challenges to the cost-effective delivery of support in this mode create a dilemma. Mass delivery of a DSS is highly feasible, but generally of low value. The mediated process is of generally of high value, but does not lend itself to mass delivery. Research on how to alleviate this bottleneck through training and accreditation of mediators and internet meetings is being conducted (Hargreaves et al., 2004; Carberry et al., 2002; McCown et al., 2002). Much work remains to resolve this dilemma and opinions are divided as to which point of the dichotomy is the prudent starting point. I hope I have conveyed my belief that, although there are 'horses for courses,' the great relatively untried, opportunity lies in the new intervention paradigm I have advocated. While this paradigm is complementary to, rather than exclusive of, the traditional paradigm, 'making space' for it in our profession entails a battle for scientists' minds. I want to leave the 'last word' in this excursion to the anthropologist, Norman Long, who spent most of his career on the battlefield of ideas pertaining to intervention in farmers' life-worlds.

> It would appear then that as long as we conceptualize the issues of knowledge processes in terms of information transfer without giving sufficient attention to the creation and transformation of meaning at the point of intersection between different actors' life-worlds, and without analyzing the social interactions

> involved, we shall have missed the significance of knowledge itself. Knowledge emerges as a product of the interaction and dialogue between specific actors. It is also multi-layered (there always exists a multiplicity of possible frames of meaning) and fragmentary and diffuse rather than unitary and systematized. Not only is it unlikely therefore the different parties (such as farmers, extensionists and researchers) would share the same priorities and parameters of knowledge, but one would it also expect 'epistemic' communities (i.e. those that share roughly the same sources and modes of knowledge) to be differentiated internally in terms of knowledge repertoires and application. Therefore engineering the creation of the conditions under which a single knowledge system (involving mutually beneficial exchanges inflows of information between the different actors) could emerge -- the main goal of knowledge management intervention -- seems unattainable…(Long and Long, 1992).

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Farm planning is thinking ahead about farm activities and making decisions some time before they will be carried out. As a farmer becomes more market-orientated, the farmer will need to improve planning and decision-making skills. Module 3.Â Farmers need to think carefully about options for providing power on the farm and to plan for them in advance. Some of the options might include: Labour saving technologies Changing farm enterprises and combinations.Â Some possible changes include: Intercropping. Introducing a new crop. Module 3. 59. Increasing productivity. There are a number of ways to increase labour productivity ; Introducing new technology. Producing more per hectare. Choosing the right enterprises to produce.