Situated Knowledge, Problem-Solving and Organisational Theory

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Introduction

Since the seminal work of Simon (1947) and March and Simon (1958), organisational theory has born the indelible print of the cognitive sciences. Indeed, to an important extent Simon's work on organisations during the 1950s and 1960s can be understood as an effort to translate into the domain of organisational theory the understanding of human thinking in terms of problem-solving through heuristic search that he was contemporaneously developing with Newell (Newell and Simon 1961; Newell, Shaw and Simon, 1957). Simon's identification of the information processing activities of the human brain with those of organisations can be seen clearly in the chapter of *Organizations* (March and Simon, 1958, Ch. 6) dealing with cognitive limits on rationality, where the routinised and problem solving responses of humans and organisations are treated in the same terms:

> Activity (individual or organisational) can usually be traced back to an environment stimulus of some sort… When a stimulus is of a kind that has been experienced repeatedly in the past, the response will ordinarily be highly routinized. When a stimulus is relatively novel, it will evoke problem-solving activity aimed initially at constructing a definition of the situation and then at developing one or more appropriate performance programs. (March and Simon, [1958] 1993, pp. 160-61)

This discussion led up to March and Simon's well-know definition of organisational routines as computing routines or programs.

> We will regard a set of activities as routinized, then, to the degree that choice has been simplified by the development of a fixed response to defined stimuli. If search has been eliminated, but a choice remains in the form of a clearly defined and systematic computing routine, we will still say that the activities are routinized. (March and Simon, [1958] 1993, p. 163)

This quote points to another distinguishing feature of Simon's approach. The computer serves as model for understanding human cognition and response, something no doubt linked to Simon's view that the human brain and the computer are two members of a single family of artifacts, which he refers to as physical symbol systems.

> The computer is a member of an important family of artifacts called symbol systems, or more explicitly, physical symbol systems. Another important member of the family (some of us think, anthropomorphically, it is the most important) is the

human mind and brain. (Simon, 1996, p. 21)

Lakoff (1987) has recently summarised the underlying premises of the physical symbol view of human cognitive architecture[1], as well as pointing to its deep philosophical roots.

> The traditional view is a philosophical one. It has come out of two thousand years of philosophizing about the nature of reason… Modern attempts to make it work assume that rational thought consists of the manipulation of abstract symbols and that these symbols get their meaning via a correspondence with the world, objectively construed… A collection of symbols placed in correspondence with an objectively structured world is viewed as a representation of reality… Thought is the mechanical manipulation of abstract symbols. The mind is an abstract machine, manipulating symbols essentially in the way a computer does, that is, by algorithmic computation. (Lakoff, 1987, pp. xii-xiii)

The imprint of the information processing or physical symbol approach to human cognition on contemporary organisational theory can no doubt be seen most clearly in computational approaches, where organisational behaviour is modelled as a production system consisting of a set of condition-action rules that can be modified in order to simulate learning behaviours (Egidi, 1995, Marengo, 1992).[2] Less directly, I would argue that its impact is much wider. The idea of an organisation as a problem solver based on its use of rules and routines (e.g. Dosi, 1994 and Dosi, Nelson and Winter, 2000) bears a close affinity to the information processing system conception of human cognition.

The physical symbol system hypothesis, of course, has increasingly been challenged within cognitive science. It can no longer can be seen as holding the dominant sway over the profession which it did during the 1970s and 1980s. Probably the most well-known alternative cognitive architecture to be proposed is the connectionist one, in which knowledge is represented by large network of parallel processes which store relations between features of inputs and associated output rather than symbolic representations or descriptions. One of the appeals of this alternative cognitive architecture is that machine learning methods inspired by

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[1] Following Newell, *et al.* (1990), cognitive architecture can be defined as, "the fixed structure that provides the frame within which cognitive processes in the mind takes place." Moreover, the authors caution (p. 103) that the architecture, composed of memory, symbols, operations and interpretation, should not be confused with a representation of the external world. The architecture supports such a representation but does not itself provide it.

[2] See Preitula, Carley and Les Gasser (1998) where the use of computational methods is justified on the ontological grounds that organisations, much as computers, are complex information processing entities. "Computational organisational theory (COT) is the study of organisations as computational entities. COT

it, notably neural nets using back propagation, have shown promise in accomplishing such apparently simple learning tasks as face recognition that have proven impossible for conventional AI methods (Gallant 1993, Ch. 1).

My concern here, though, is not especially with the question of whether the architecture of human thinking is symbolic in nature. Rather I am concerned with another feature of the information processing approach to human cognition, namely the idea that knowledge consists in representations that are literally stored within the mind, presumably in long-term or semantic memory. These representations arrive in the mind via 'transducers' that transform external stimuli into internal representations. Reasoning is then understood in terms of computational operations performed on these representations. Problem-solving, for example, is typically understood in terms of search processes designed to find a match between external stimuli and the existing repertory of representations.[3]

The upshot of these premises, as Hutchins (1995, Ch. 9) has observed, is to restrict the unit of cognitive analysis to the individual mind and to view intelligence as something which is modular in nature and hence capable of being analysed and explained independently of history and external context. As Newell et.al. (1989, p. 107) put it, "Symbol systems are an interior milieu, protected from the external world, in which information processing in the service of the organism can proceed."

This feature of the dominant paradigm in cognitive science has recently been challenged from scholars in such diverse fields as anthropology, education, psychology, and artificial intelligence concerned by what is commonly referred to as the *situated* character of human knowledge and learning. Work from this perspective, much of which is ethnographic in character, seeks to show how knowledge and problem-solving capabilities emerge through one's daily practice in a particular environmental context. This involves two critical methodological shifts relative to the information processing approach. Firstly, the unit of analysis is widened to comprise *cognitive systems* made up of groups of individuals interacting with various external artifacts. The cognitive properties of these systems may be quite different from the cognitive properties of the individuals.[4] Secondly, an effort is made to

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researchers view organisations as inherently computational because they are complex information processing entities" (p. xiii).

[3] See Clancey (1997, pp. 46-75) for a discussion of this feature of the conventional approach.

[4] This, of course, is one of the major points developed by Hutchins (1995).

show how knowledge, in the sense of representations, but also problem-solving skills and procedures, are constructed through the actors' locally contexualised practices.

By tying the characteristics of human cognition to actual practice in particular artifactual settings, the *situated* paradigm has important implications for one's choice of research methodology, or at any rate for the sorts of conclusions one might reasonably hope to draw based on a particular methodology. For example, it implies the need to clearly distinguish human knowledge and learning from computer programs and representations, and it draws into question the idea that computational approaches in organisational theory can provide accurate characterisations of how humans actually perceive and conceive in organisational settings (see, notably, Clancey, 1997).

The situated cognition perspective also draws into question the idea that the controlled laboratory setting provides the best means of identifying what individuals' 'real' cognitive capabilities are independent of context. A variety of studies have show that individuals' capabilities in terms of memory, inference and calculation can differ quite substantially between the laboratory setting and outside. This insight has encouraged a growing number of psychologists, anthropologists and cognitive scientists to abandon the laboratory setting for field research designed to investigates man's exercise of 'everyday cognitive capabilities', such as those mobilised by ships navigators (Hutchins, 1995), by personnel responsible for airport ground operations (Suchmann, 1998), by manual operators in factory settings (Scribner, 1984) or by instructors and apprentices in a variety of cultural settings (Lave and Wenger, 1991).

In sections 2 and 3 below I attempt to demonstrate the relevance for organisational theory of the methodological shifts in the situated cognition paradigm by means of two case studies. The first, which I undertook myself, concerns error detection and avoidance by assembly-line operators in the UK and French affiliates of Japanese multinational producer of electronic office equipment. It is designed to illustrate the point that the cognitive properties of systems composed of individuals in interaction with external artifacts may differ from the cognitive properties of the individuals. The second case study is Scribner's (1984) classic work on the problem-solving capabilities of the employees in a medium-sized milk-processing plant in a large US city. Her study provides striking evidence of the way the knowledge and strategy repertoires available to an individuals are shaped by their daily practice in particular work settings.

By widening the unit of cognitive analysis and focusing on the way daily practice shapes problem-solving heuristics and procedures, ethnographic studies such these take an important step towards showing how the organisation's use and development of knowledge is shaped by the local context. In terms of the principal concerns of this conference, however, these studies remain limited by their emphasis on the locally constructed nature of knowledge to the exclusion of a consideration of the impact of the wider institutional and social contexts, which are the focus of the regional and national innovation systems literature. In section 4 below I will consider how the framework developed Hutchin's (1995), in his path-breaking study of ship navigators, can serve to connect the local with the societal in a way that preserves an authentic space for micro-level agency.

Avoiding error through distributed memory systems

Case studies of team organisation were carried out at the UK and French production sites of a leading Japanese multinational producer of office equipment. They were undertaken in the context of larger project investigating the transfer of business practices and methods by Japanese companies to their overseas operations in Britain and France.[5] The company employed 63,600 worldwide in 1998 with sales of approximately $10 billion. Sixty-three percent of sales were in the area of photocopiers and related products such as toner, and 23 percent were in communication and information systems.

The UK and French plants are of roughly the same size, each employing approximately 800 employees. The UK plant specialises exclusively in the production of plain paper photocopiers and related products while the French plant is more diversified. Approximately 21 percent of the 1998 turnover of the French plant is accounted for by the production of laser and ink jet faxes and 36 percent by the production of thermal paper. The case study results reported here are based on on-site visits to the plants undertaken between September 1999 and June 2000. The interviews concerned the managerial personnel and engineers responsible for production, tooling and quality control and those personnel directly responsible for photocopy

[5] For preliminary results, see Lorenz and Lazaric, 'The Transferability of Business Practices and Problem Solving Capabilities to Japanese Firms in Britain and France', DYNACOM Working Paper, http://link.sssup.it:10079/LEM/Publications/ShowWPSeries.

assembly including supervisors, team leaders, operators and maintenance personnel. These interviews were closely tied to my observations of the assembly process.

The production process itself is a rather complicated, involving the assembly of over 200 separate parts. With the exception of certain subassemblies produced in a dust controlled environment, production is organised in straight assembly lines consisting of between 10 and 14 work stations, each requiring the assembly of between 15 and 20 individual parts. Following completed assembly, each machine undergoes a series of quality control tests with consist in visually comparing output on the machines with standard test paper copies. The machine is then passed on to final inspection and packaging.

Although each plant has in place elaborate quality control and inspection procedures, it is of course highly desirable that machines are assembled without any errors. Assembly errors may require lengthy investigations by supervisors or technicians to determine the cause of the fault. Correcting detected errors may entail a costly process of stripping the machine down and reassembling it by specialised repairmen. For these reasons, considerable emphasis is placed on individual responsibility for quality and each operators quality performance is carefully recorded and is taken directly into account in semi-annual performance evaluation which bear on salary increases and individual opportunities for promotion.

The fundamental cognitive capability upon which assembly job performance depends is memory. Operators have to memorise which parts are needed at the stage of assembly for which they are responsible, they have to memorise the correct sequence in which the parts should be assembled, and they have to remember the correct way to assemble the individual parts. Thus, three types of error are possible. First, an operator may forget to assemble a part, thus passing on a defective machine to an operator at the next workstation. This might be because not all the required parts have been fetched and laid out in the area of the workstation, or it might be because the operator has neglected to assemble a part despite having fetched it. Secondly, parts may be assembled in the incorrect order. If the order matters for an operator being able to complete his or her work cycle, then this type of error will result in a loss of time since some of the work will have to undone in order to re-establish the correct sequence. Thirdly, a part, though included, may be assembled incorrectly resulting in a defective machine being passed on to the next operator on the line.

The burden on memory, and hence the likelihood of error, depends in the first instance on the length of the work cycle or what is called the ‘tack-time’. This in turn depends on how many assembly operations are allocated to the workstations and then on how many workstations an individual operator has responsibility for. The traditional arrangement in both the UK and France-based plants is one operator per workstation. In this case the work cycle lasts between two and two and a half minutes once the operator is up to his or her maximum speed. For operators with prior assembly experience, say on previous models, achieving maximum speed for a 2-minute tack-time requires approximately a week of training.

Process books exist providing detailed instructions on the order in which operations should be carried and on how to undertake individual assembly operations. These are for the most part visual in nature, consisting of diagrams showing the movements involved in undertaking a particular operation and photographs showing the completed assembly. While I was told by the engineering personnel that these process books are regularly used by operators, my interview results and observations on the shop floor indicate that they provide no essential support to memory, at least not for operators who are working near to or at their maximum rate. Indeed, any attempt to refer to these manuals would inevitably slow the process of assembly since the goal, as the operators I interviewed explained, is to achieve an entirely automatic performance in which the sequence of operations and the movements for carrying them out are committed to motor memory not requiring any conscious deliberation or reflection.

During the early 1990s, following the lead of the Japanese parent firm, both the UK and French plants put in place a system referred to as *Haizen* designed to reduce the first type of error consisting in leaving a part out in the assembly process. The system involves a separate group of employees working off the assembly line preparing in advance of assembly a series of trays containing several compartments into which the parts needed for the assembly work at a particular work station are placed. Photographs of the parts are laminated to the compartments in order to assure that the correct part is placed in the correct compartment. These trays are then stacked onto moving carts which can be wheeled onto the assembly line and moved from station to station. During the actual assembly process an operator pulls out the tray or trays which correspond to his or her workstation and finds all the pieces required in a pre-established order on the tray. When the relevant tray or trays are empty, the cart is moved on to the next workstation.

Compared to the original way of producing, the *Haizen* system distributes the memory task between two groups of workers, those responsible for filling the trays and those responsible for doing the assembly. In and of itself, there is little reason to think that this will significantly reduce the overall rate of error. What is essential about the system is the way the use of the trays and the compartments turns an error prone process of remembering which parts are needed and verifying that all the parts have been assembled into a simple perceptual inference. If at the start of the assembly process each of the compartments contains a part then the operator knows automatically that no parts have been forgotten. If at the end of the assembly process all the compartments are empty then the operator knows automatically that all the parts have been assembled. The *Haizen* system thus transforms the nature of the cognitive processes required of individuals in order to fulfil their part in a distributed task.

To some extent the way knowledge is distributed between individuals and artifacts in the *Haizen* system builds on a principle which operators apply spontaneously. Thus, prior to the introduction of *Haizen*, each operator was responsible for fetching his or her own pieces from nearby trays or boxes and laying them out on the worktable. The physical location of these boxes and trays in the traditional set-up, and the habitual way the operator laid out the parts on the worktable, would serve to jog memory regarding which parts were needed to be assembled and the order of their assembly. An empty worktable signified that the assembly task was completed. The Haizen system, however, exploits this principle in systematic way that has allowed each of the plants to substantially reduce its error rate. It brings out quite nicely the way the cognitive properties (e.g. capacity to avoid error) of the system composed of team members in interaction with a set of external artifacts (i.e. trays and compartments) are different from the cognitive properties of the individuals making up the system

Problem-solving by product assemblers *(Scribner, 1984)*
Scribner's ethnographic study concerns a medium sized milk-processing plant in the United States employing some 300 people, including an array of blue collar and white collar jobs. Her study focuses in part on the problem-solving capabilities of preloaders who are responsible for product assembly, which is classified as unskilled manual labour. Her interest is especially with the nature of skilled performance and expertise among preloaders and its relation to actual practice. To get at these issues a novice/expert contrast was built into the experimental design, with simulations of preloaders' work being conducted in order to compare the performance of experienced preloaders with that of three novice occupational groups: wholesale drivers, inventory personnel and clerks. A school-math/work math comparison was also incorporated into the design by including in the simulation a stratified group of ninth-graders from a nearby high school. The average schooling of the preloaders was tenth grade.

The basic tasks of the preloaders do not appear to be especially cognitively rich ones and certainly do not involve any esoteric body of knowledge. Based on order forms detailing the products that each wholesale driver has ordered for his day's deliveries, the task of the preloaders is to locate and assemble these products in full cases or partially full cases and to transport them to a common assembly area near a moving track that circles the refrigerated warehouse. When all the items are assembled for a driver, they are pulled onto the track and transported to the loading platforms. The cases are of a standard size with one case equal to 4 gallons, 9 half-gallons, 16 quarts, 32 pints or 48 half-pints. Orders are expressed in terms of a whole number of cases plus or minus a number of units. Thus an order calling for 12 quarts of a product would be expressed as 1 – 4 units and could be met by either removing 4 quarts from a full case (the literal strategy) or by adding 12 units to empty case. An order calling for 22 quarts would be expressed as 1 + 6 units and could be met by combining a full case either with an empty case to which 6 units have been added (the literal strategy) or with a full case from which 10 units have been removed.

Task performance is determined in the first instance by such cognitive aptitudes as the ability to retain in memory the quantities given on the order sheet and the ability to do simple addition and subtraction. Scribner, however, observed that preloaders often adopt nonliteral solutions, which involve transforming the original information into a representation that can be mapped onto an array of the physical units. She hypothesises that the mental effort this involves is only undertaken in situations where it serves to save on physical effort. For example, if an order is 1 – 6 (10) quarts and a preloader has the option of using a full case and removing 6 quarts (the literal strategy) or using a case with 2 units in it and adding 8, the literal strategy is optimal from the point of view of effort expenditure. On the other hand, is the partial case has 8 units in it and only 2 units must be added, the nonliteral strategy is superior (a saving of 4 quarts). Based on observing 53 orders being filled, Scriber provides evidence in support of the effort saving hypothesis, since in each of the 23 times that a nonliteral strategy was adopted by a preloader it was effort saving relative to the literal strategy.

In order to asses whether the cognitive skills displayed by preloaders take shape in the course of participation in socially organised practices, Scribner designed a series of simulation exercises in which the product assembly solutions of preloaders were compared with those adopted by the sample of students and the novice occupational groups identified above. The result, showed that preloaders adopt the nonliteral strategy when it is optimal in terms of physical effort a higher percentage of the time that the other groups. Inventory people and drivers ranked second, clerks third, and students last. Moreover, even when the 'novice' groups adopted the optimal strategy they tended to carry it out in a different way from the experienced preloaders. Office workers, for example, tended to rely heavily on numerical solutions involving counting operations. In contrast, the preloaders adopted 'shortcuts' working directly from their visual perception of the physical displays which provided the necessary quantitative information (e.g. automatically knowing that one layer of half-pints gives 16 or that two rows of quarts is 8). This resulted in a superior rate of task completion on the part of preloaders, who were able to correctly fill orders without recoding the information gained from visual inspection into the number system. It suggests, in a manner argued by the critics of the physical symbol approach, that skilled performance involves a tight coupling between perception, inference and practice (see, notably, Clancey, 1997).

Computation and representation in ship navigation (Hutchins, 1995)

Hutchins' field work is concerned with the work of ship navigators on a US Navy vessel. The navigation team is responsible for determining, charting and logging the ship's position at various time intervals. Correctly establishing a fix or the ship's position is of vital importance to the safety of the ship, especially when entering a harbour and in close proximity to the land. For this reason the degree of error in the fix can be directly read from the result itself: three visual bearings are taken which translate into three lines of position on the ship's chart, thus forming a triangle. The quality of the fix is determined by the size of the triangle formed by the three lines, since if the three lines do not intersect exactly the same point the ship's position is to some degree uncertain.

Navigation work, at least on large vessels such as that examined by Hutchin's, is typically distributed across the members of a team. In the case of the Navy vessel studied by Hutchin's, the computational process of determining the ship's position, the so-called fix cycle, begins with the pelorus operators observing visual bearings of landmarks with a special telescopic sightings device called an alidade. The ship's two alidades, which are located on the port and starboard wings of the vessel outside the bridge, provide angular representations of the ships position relative to the landmarks and to true north. The printed scales on the alidade's gyrocompasses permit to translate these angular representation into digital representations, which are then communicated, either by telephone connection or physically by the pelorus operators, to the ship's navigation recorder, who enters them in the bearing record log. This digitally represented bearing is subsequently communicated to the navigation plotter who represents it as an angle on a one-arm protractor called a hoey. The hoey, once configured, is brought into coordination with the navigation chart, thus reproducing the angle measured between the ship and the landmark in the world as a representation in the space of the chart's latitude and longitude grid.

As this brief sketch indicates, the work of the navigation team can be thought of as a process involving the progressive translation of a visual bearing into a series of angular and digital representations through the use of various physical artifacts in accordance with a well specified algorithm. Hutchins develops a theoretical perspective on this process in terms of the propagation of representational states across a series of representational media. The representational media include both physical objects and tools (e.g. the alidade, the hoey and the chart) and the members of the navigation team. The representations of the position of the ship take different forms in the different media: digital representation in the bearing record log, the memory of that representation in the mind of the navigation bearing recorder, the angular representation in the hoey, etc. Representational states are propagated from one media to another by bringing the states of media into coordination with one another. The tools and other media which are brought into coordination permit difficult tasks to transformed into ones that can be done by the manipulation of simple physical systems or the possibly the mental simulation of the manipulation simple physical system. As Hutchins stresses, “the tools are useful because the cognitive processes required to manipulate them are not the computational processes accomplished by their manipulation” (p. 170-71).

Performance in this cognitive system depends on various mediating structures or artifacts. For example, if a written procedure is used by team members in carrying out the fix cycle, the procedure is a mediating artifact. However, the procedure may be memorised and exist as an explicit symbolic representation within the media of an individual’s internal memory. In this case the mediating artifact or structure is internal rather than external. It is in the same class of phenomena as our knowledge and internal use of the order of the letters of the alphabet as a device for remembering the order of a sequence of operations to perform. Moreover, internal artifacts of this sort are capable, much as external tools and devices, of transforming the cognitive processes required to carry out a task.

Such mediating structures are, of course, cultural products in the sense that they are produced in particular institutional and social contexts. In the case of the navigation procedure considered here, the artifact is the product of a large organisation characterised by well defined hierarchical relations of command, the US Navy. As Hutchins points out (p.290-91), a wide variety of tasks in society are mediated by such written procedures or procedure like artifacts. In the realm of the industrial enterprise, for example, one can think of such mediating structure as standard accounting procedures, standard procedures associated with ISO quality norms, or standard operating procedures associated with such widely diffused practices, as just-in-time supply and production.

Moreover, this list does not by any means exhaust the range of mediated performances, which include performances mediated by symbolic structures such as arithmetic procedures and rules of logic, by physical artifacts such as traffic lights or supermarket layouts, and by the social contexts we arrange for one another’s behaviour. This latter idea is illustrated in Hutchins’ work by reference to way a novice quartermaster is introduced to the detailed procedures of the fix cycle. As Hutchins observes (p. 282), a good deal of the structure that the novice will have to learn in order to perform the various steps is present in the organisational relations among the members of the navigation team. Thus in coming to understand the way the various members of the team depend on each other the novice is simultaneously learning about the nature of the computation being performed and the ways the various parts of it depend on one another.

The aspect of Hutchins' approach that arguably poses the greatest challenge to the information processing or physical symbol system approach to knowledge and problem solving concerns his account of the way external symbolic mediating structure, such as written procedures for carrying out a task, become be internalised. Such internal artifacts mediate performance much as external one do. As Hutchins observes, "The performance guided by the memory of the words in such a procedure is still a mediated task performance, but the mediating structure is now internal rather than external" (p. 303). Expandng on this idea, Hutchins reverses the relationship of the external world to the architecture of cognition postulated in the physical symbol approach, namely symbols and procedures on symbols. Rather than seeing this architecture as an "interior milieu, protected from the external world" (Newell et.al. 1989, p. 107), Hutchins argues that symbols and procedures exist first as external representations or symbol tokens which are tightly coupled to social relations. It is only in a subsequent stage that these socially constructed representations are internalised and imagined. Then, with even more experience about the regularities of the world of external symbolic tokens, it becomes possible to imagine symbolic worlds formed of these tokens and to apply the knowledge gained from this experience to their manipulation (p. 292-93). In this manner Hutchins gives a social account of the origins of internally held symbols and symbol processing, and so provides the elements of a framework for situating knowledge and reasoning processes within their wider social and cultural context.

Conclusion

The literature on innovation and knowledge management within the firm has increasingly focused on the relations the firm establishes with external actors and organisations. In this manner, it has sought to situate the innovative activities of organisations within a wider institutional context. This interest in external relations and environment can be accounted in part by the perception that increasing specialisation in knowledge production, as well as a more rapid pace of change, has placed a new premium on the firm's capacity to establish partnership and similar forms of cooperation and exchange designed to increase its knowledge base. Paradoxically, though, this increasing emphasis on how external environment shapes what firm's know has not been accompanied by a comparable appreciation of the social and external determinants of the reasoning processes and heuristics used by its members in problem-solving. This, I would argue, can in large measure be explained by the imprint of mainstream cognitive psychology and cognitive science which has tended to restrict the unit of analysis to the individual mind and has seen intelligence and problem-solving as modular in the sense that their properties can be modelled independently of external context.

The situated paradigm that I have illustrated by means of ethnographic case study work provides an alternative account, in which the cognitive properties of individuals and groups are accounted for by the way they are embedded in a wider social and institutional context. It does this firstly by widening the unit analysis to include groups of individuals interacting with various external artifacts and secondly by showing how the reasoning processes and problems-solving heuristics used by individuals and groups are shaped by their daily practice, involving in part experience with the regularities of the world of external symbolic tokens and representations. In so doing it provides the elements of an framework for addressing one of the key challenges facing students of comparative organisational behaviour: explaining why firms differ and explaining why, despite these differences, they tend to display certain national regularities in their innovative behaviours and performances.

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