Book Reviews

Review Symposium: *Cognition in the Wild.* E. Hutchins.
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This book brings us two scientific revolutions. For anthropologists Hutchins demonstrates that "culture... is a human cognitive process that takes place both inside and outside the minds of people" (p. 354) thereby transcending debates of long duration in which ideas are pitted against context as opposed realms of anthropological study. For cognitive scientists he reembodies and socializes cognition situating mental activity in the goal-oriented settings of human accomplishment. This is a fundamentally cultural approach to information processing, which requires a reorientation of traditional cognitive science research from laboratory tasks to real life achievements.

Cognition in the Wild is composed of acknowledgments, an introduction and nine substantive chapters. In the Introduction, Hutchins tells us that the book is about "softening some boundaries" by "locating cognitive activity in context" (p. xiii). The boundaries are primarily those that have been established by science to analytically separate mental activity from behavior. Yet in the process of reporting his research Hutchins softens the boundaries between cognitive science disciplines as well.

The plan for the book is outlined in the Introduction. Hutchins proposes a holistic framework for understanding human accomplishment. The requirements for successful completion of many tasks, he suggests, are satisfied by distributed systems; systems that interrelate minds, behaviors, artifacts and the arrangement of physical space as constitutive elements. These are the dimensions of naturally occurring human behavior, the wilds referred to in the title of the book.

Hutchins sets out to demonstrate that "humans create their cognitive powers by creating the environments in which they exercise those powers" (p. xvi). Achievement, he will argue, does not rest on individual ability alone, but on the coordinated efforts of people facilitated by the constructed tools and devices of their trades. This he suggests requires attention to history and learning. The

contexts and goals of human work are the long term "residue" of people interacting with each other and with material objects. In other words, they are historical products. Learning, he tells us is both an individual and societal process that takes place "as local adaptations in a dynamic system of coordinations of representational media" (p. xvii). These media include human minds, material artifacts, communicative routines and behavioral practices integrated for the accomplishment of specific ends. Hutchins promises at the outset to demonstrate that the micro-processes of activity both transform individuals and drive "the engines of culture change" (p. xvii, see also p. 374).

The subsequent nine chapters do not disappoint.

Chapter 1, "Welcome Aboard," situates the reader ethnographically on a large U.S. Naval vessel and introduces the navigation team whose accomplishments when maneuvering the vessel in restricted waters are the subject matter of this book. The challenges facing the seamen and officers charged with responsibility for guiding the massive vessel are outlined and the instruments and procedures available are detailed.

The tasks of navigation are presented as a series of well-structured computations. Taking visual bearings, recording these, and plotting lines of position allow a navigation team to fix the location of their ship at regular intervals and project its trajectory. These are routine accomplishments for which the most useful data have been predetermined and procedures for processing information established. The challenges require using available tools and techniques to perform the procedures to locate the ship in space, establish or update a course to the destination and preserve information to justify actions taken should a mishap occur.

Hutchins impresses upon us in this early chapter that the unit accomplishing the navigational tasks is an integrated system of individuals and material artifacts contextualized by the immediate environment and culturally prescribed goals and practices.

In Chapter 2, "Navigation as Computation," Hutchins develops a general account of the problems to be solved in navigating a vessel in the vicinity of land. The central question to be answered by any navigational system is "Where am I?" Navigational systems worldwide address this question "by combining one dimensional constraints on position" (p. 52). Course planning subsequently involves setting a direction from a present position to a known destination within the parameters of depth contours, rate, time, and distance.

Comparing Western and Micronesian systems, Hutchins demonstrates the variability in culturally specific representations for fixing position and specifying a course. Western navigators pose questions and answer them in terms of a vessel moving through stationary geographic space. Conceptual tools include the nautical mile, knot (nautical mile per hour), the horizon as circle, latitude, and longitude. Material artifacts include the compass rose, aledaide, fixed landmarks, and the nautical chart. Computations involve measurement, analog to digital and digital to analog conversions, and arithmetic manipulations. A position fix is represented as a bird's eye view of intersecting lines plotted on the chart.

By contrast, Micronesian navigators determine relative position and project a course premised on the assumption of a stationary vessel, moving landmarks, and a straight line horizon. The sidereal compass, reference islands, star bearings, linear constellations, knowledge of the behavior of waves

at sea, and birds near land are among the conceptual tools of the trade. Position fixing is accomplished in the mind's eye by establishing relative bearings radiating from a stationary navigator outward to moving landmarks defined by the star bearings, which partition the linear image of the horizon. Distance, rate and time are represented "in the superimposition of temporal landmarks" on this imagery (p. 93).

Hutchins illustrates brilliantly both the universal and qualitatively distinctive properties of navigational systems. The contributions of cultural principles and material artifacts to the structuring of tasks and representations are clear.

A history of Western navigation follows, showing how navigational problems have been approached and represented differently at different points in time within a continuous tradition. Hutchins introduces the idea of a cognitive ecology, a task oriented system of activity and artifacts. He demonstrates the role of history in shaping such cognitive systems through "crystallization of knowledge and practice in the physical structure of artifacts" (p. 96). The mutual dependencies of the "various instruments and techniques" (p. 112) that emerge in practice over time provide what Hutchins refers to as connective tissue for the system.

The notion of cognitive ecology is more fully developed in the third chapter, which details the implementation of pilotage in contemporary U.S. Naval procedures. Hutchins argues that people are good at pattern recognition, modeling simple dynamics of the world and manipulating objects in the environment (p. 155). An advantage of distributing task accomplishment in a social and material system is that the individuals can be assigned those segments of a task that they can perform with greatest facility while the instruments and procedural orderings can accomplish steps less easily performed by the human participants. Precomputations, for example, remove invariant aspects of a task from the manipulations required by participants during the relatively brief time span allotted for completing a fix cycle. Instrument reading provides predetermined scales for reporting data. And the structure of instruments, such as slide rules, in combination with procedures for reading them may embed the algorithms for problem solving. Computing complex problems becomes a task of entering data and reading the outcome rather than manipulating information according to remembered formulas. It is the system as a whole that exhibits expertise.

The next two chapters address the organization of team performances and the role of communication in coordinating team activities. Hutchins shows how the accomplishments of a system differ from those of the individual team members by virtue of the transformational capacities of tools, the social organization of the group, and the local co-ordination among tasks. The reader is reminded that Hutchins is exploring a well established activity system in which goals, procedures and even the amount and quality of information to be communicated through language are prescribed.

Hutchins models this distributed cognitive system with the conceptual anchors: computation, constraint, and co-ordination. An architecture emerges as he outlines the convergence of top down and bottom up processes in activity flow, specifies the distribution of expertise, experience and task responsibility among team members, and identifies constraints on meaningful representational states and communicative messages.

Here the hypothesis "that the cognitive properties of groups may differ from those of the individuals who constitute the group" (p. 239) is tested by computer simulation of confirmation bias, the tendency to maintain interpretations of experience once arrived at. Hutchins uses the concept of

constraint-satisfaction network as developed by Rumelhart, Smolensky, McClelland and Hinton to simulate the reconciliation of evidence and interpretation. For an individual the process depends upon preestablished cognitive schema, preconceptions about a current state of the world and external evidence. Hutchins shows that confirmation bias also characterizes social groups but only under certain conditions. Movement to a position of commitment by a group entails consensus formation. Patterns by which consensus may (or may not) emerge depend on communication and social organization within the group. The trade off between the potential for decisive action and the availability of diverse interpretations is unique for each potential system.

This simulation should stimulate considerable further research. The framework for project design and hypothesis testing is clear. Ties to traditional anthropological concerns with group performances and traditional cognitive science concerns with schematic representations will promote investigation in both areas. Perhaps most fortuitous is the ability this framework provides to design research investigating the integration of individual psychology and community organization.

In chapters 6, 7 and 8 Hutchins takes up learning. Chapter 6 presents the structure of the navigational system as a context for learning. Chapter 7 develops a theory of learning as "adaptive reorganization in a complex system" (p. 289). Chapter 8 presents a detailed example, which demonstrates that "the processes by which work is accomplished, by which people are transformed from novices into experts, and by which work practices evolve are all the same processes" (p. 351).

Hutchins follows Vygotsky in setting up chapter 6. He builds from the position that development of "any higher mental function necessarily goes through an external stage because it is initially a social function" (p. 283). He outlines the distribution of knowledge and responsibility among members of the navigation team and traces the career trajectory of a seaman from entry-level to quartermaster. Each member of the team has a unique function requiring communication of information with others. The communication process itself facilitates learning of one's assignments and provides access to the responsibilities of others, which may subsequently come to be one's own.

The particular character of any distributed system has consequences for error detection and correction, processes that affect both the system's efficiency and individual learning. Hutchins discusses the tension between the costs and benefits of error occurrence. He develops the position that cooperative work can be organized more or less efficiently with respect to error detection, recovery, and learning. An efficient system would minimize occasions for error occurrence and recovery time and maximize opportunities for detection of errors that do occur, providing accompanying mechanisms for learning from those errors.

In the next chapter Hutchins develops his approach to learning as adaptive reorganization. Internal changes in individuals, material developments, and reorganizations of practices are all possible outcomes of learning. This is a novel and insightful perspective, which suggests a uniform cognitive theory applicable to the diverse elements of activity systems. Learning is the adaptation of structure in one part of the system to organizational changes in other parts. It is simultaneously an historical and developmental process.

Within this chapter Hutchins models expert performance as a system of integrated states. External media, internal representations and actions are coordinated through mutual constraints. Automated sequences of actions and reasoned behaviors are accounted for.

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Hutchins elects not to delve into the construction of deep conceptual dependencies or explanatory accounts of work practices. He does present a fascinating anecdote about a navigation instructor's sudden insight into the relationship between relative and geographic motion which this instructor came to see as the explanation for established procedure. Such knowledge, Hutchins suggests, "consists of filling in conceptual details and relationships in tasks we already know how to do" (p. 307).

Brief as his attention to this issue is, it provides a crucial link to problem solving research in cognitive psychology and to the investigation of cultural premises by cognitive anthropologists. The relationships yet to be articulated among external and internal structures challenge us to integrate proximal and explanatory accounts and to resolve the public/private debate that has plagued the culture concept throughout this century.

In the third chapter on learning three sources of organizational change are acknowledged: global design, local design, and situated response. Hutchins concentrates on the latter presenting a detailed example of an actual navigational crisis. His analysis illustrates the emergence of a distributed solution to the task of fixing position when the gyrocompass and back up systems had failed. Local adjustments in interactions and task distribution among team members ultimately resulted in a set of stable procedures. Influencing the final outcome were a set of factors including the availability of data to participants, construction of meaningful computational tasks in terms of the navigator's world view, capturing temporary invariants in precomputations, and the possibilities for coordinating social and computational structures. Hutchins' promise to demonstrate that the same microprocesses of activity transform novices into experts and reproduce or alter the practices and contexts of work is fulfilled here.

Hutchins concludes with a conception of culture encompassing cognitive processes operating inside and outside the head and with the reciprocal claim that "cognition is a cultural process" (p. 354). He discusses the consequences of marginalizing culture for the cognitive sciences and directly attributes our slow progress in understanding the human condition to this marginalization.

The framework Hutchins offers aims to account for the human intellect and social accomplishments as products of naturally occurring events. He moves effortlessly from ethnographic description to abstract modeling, presenting his ideas with equal clarity and precision whether in prose or graphic form. As he emphasizes the "material means of thought" in concert with mental modes of cognition Hutchins envisions a science that rests on the foundational question, "What is a mind for?" His answer, that it is for accomplishing ends in context, establishes the field of cognitive ecology. The sophistication of this intellectual agenda promises new horizons for the cognitive sciences in general and cognitive anthropology in particular as we develop his ideas in the decades to come.

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Hutchins frames *Cognition in the Wild* as a contribution to cognitive science, by arguing for a cultural and material understanding of cognition and against individualist mentalistic models associated with the digital computer and artificial intelligence. Cognition, as it occurs in life, is not separate from perception, material circumstance, and activity. He shrewdly points out that cognitive science has not modeled cognition, but only the formal symbolic tools and systems that human cognition had created and adapted to; these computer-based models may then themselves be seen as cultural symbolic tools.

Hutchins makes this argument explicitly only in the short closing chapter "Cultural Cognition." Until that point, Hutchins has painstakingly constructed a 350 page description of an actually occurring situated intelligent activity, carried out collaboratively in a concrete material setting by socially related individuals working within a structured organization, embedded within an elaborate culture and employing historically developed cultural tools, both material and symbolic. That is, Hutchins describes with ethnographic detail how a navigation crew on the naval vessel *U.S.S. Palau* guides that amphibious helicopter transport ship through San Diego harbor. That description includes such diverse elements as the system of military hierarchy and discipline; the physical layout of the ship; the location of the various personnel cooperating in navigation; the history and physical manipulation of navigation instruments for taking sightings, of charts on which sightings are mapped, of the graphing tools by which those sightings are translated into symbolic representations on the charts; the collaborative interaction and communicative practices of the several participants in the navigation process; the socialization of individuals into their competent performance of their separate roles and more comprehensive understandings of the entire process so that they can monitor the role performance of the more junior personnel and support the work of the whole; and the improvisatory behavior of the group when a major mechanical failure requires the entire team to learn new ways of organizing the work of navigation.

Thus, Hutchins argues by detailed example rather than by abstractions. By describing the intelligent practice of navigation as it actually occurs—"cognition in the wild"—he shows it is more in the use of physical and symbolic tools, social interactions, and cultural practices—all of which happen visibly in the physical and social worlds—than in formal abstract operations in the head of any individual. Even the symbolic activities of representing positions in mathematical and graphical terms are more matters of manipulations of maps, rulers, and a protractor-like tool called the hoey, than of imaginative reconstructions in the head.

To summarize, on the *Palau*, navigation during Sea and Anchor Detail is accomplished by a team consisting of up to ten people fixing the position, bearing, and speed, in a cycle usually repeated every three minutes. At the moment announced over the intercom by the navigation reporter, the two pelorus operators, posted on the two sides of the ship, sight three previously identified landmarks through a device called the alidade, which allows the operator to coordinate a visual sighting with a bearing scale from the gyrocompass. These readings are then repeated over the intercom to the recorder located on the bridge. The recorder writes the positions in the log and repeats them aloud for the plotter, who uses the protractor-like hoey to mark the bearings on the chart, locating the vessel within the triangle formed by the intersections of the three bearings. Simultaneously the fathometer operator measures the depth

of water below and records it. Further readings from radar, satellite, dead-reckoning, and other devices are also monitored and recorded and periodically compared to the visual sightings. The navigator and assistant to the navigator supervise all the activity, interpret the data recorded on charts and logs, and provide orders to the restricted maneuvering helmsman. The activities of these various personnel are regularized by naval regulations, standardized training, and practices local to this particular vessel. Although the more senior personnel may have an understanding and experience with the work of all members of the team and the overall coordination of the working of the team, no one person at any moment is aware of everything going on in the process. This is a paradigmatic case of distributed cognition, with each person having a limited cognitive task that is coordinated with the work of others into a more complex intelligent activity than one individual would be capable of.

Without denying that people do have representations in the head, which aid in their participation, Hutchins shows that much of the activity is external so that the internal cognitive work is much narrower and task specific than any formal decomposition of navigation would suggest. The problem for the alidade operator posted alone on a wing of the bridge is to locate the landmark, sight it through the alidade and read the numbered scale at the appropriate moment, and then report that number in a timely way without overlapping with other messages on the intercom. There are cognitive in the head tasks here, such as associating names or descriptions of landmarks with the visually perceived object, but these are small local tasks rather than total navigational overviews. Even the navigator who from long experience and training has an overview for the entire process, the operation of the sighting and recording tools, and physical knowledge of the harbor, still works primarily by inspecting the inscribed data on charts and logs.

To contrast with the symbolically mediated and socially distributed means of contemporary Western navigation, Hutchins examines traditional Micronesian navigation. Micronesian navigation—based on sighting islands neighboring one's path against the background of sun and star motion—maintains the visceral sense of the physical location of the navigator moving through an unabstracted world of islands, tides, starlight, sunrises and sunsets, and birds hunting fish. This unabstracted physical situatedness maintains, when the navigator projects islands not visible beyond the horizon, or even imagines fictive islands to provide landmarks where there are none. This alternative navigation system shows that navigation is possible without the abstractions of charts and our grid-like mathematical reconstruction of the mapped globe. This comparison highlights just how mediated and abstracted our system is. Nonetheless, it also reminds us of the physicality of crafts moving through water, a sense regained by experienced and knowledgeable contemporary navigators, as they internalize the abstractions of charts, positions, and movement lines into an embodied sense of their craft's orientation and motion—a sense that allows them to feel when there is an error in the many instrument readings, translations, communications, inscriptions and calculations of the abstracted navigational system.

As one already well-convinced of and acclimated to a situated activity orientation, I find Hutchins' account persuasive and intriguing. I cannot, however, judge how many cognitive science minds are likely to change, how many eyes that see only formal operations will open, how many discussions will take a different direction, or how many Artificial Intelligence designs will take a different shape as a result of this book. That sort of uptake is in the hands of those in the cognitive and computer science worlds to whom Hutchins has addressed his argument.

Readers of this journal, as myself, are likely to find congenial, but not novel, Hutchins' use of detailed ethnographic and comparative cross-cultural accounts of collaborative work to make the case

for situated, socially distributed, cultural cognition. Nonetheless, Hutchins' detailed analysis of navigation bears value for the study of situated cognition beyond being a fine example of how such studies might be done. His analysis pays close attention to several aspects of situated cognition that often do not get their full empirical due, and by doing so challenges us to take far more seriously the influence of cultural history; ordered systems of recurrent activities; the history and use of tools; the development, structure and manipulation of symbolic representations; the regularization of tasks; the commitment and motivation of individuals to shared tasks; and the socialization of individuals into standard practices, work roles, and group affiliation.

Because Hutchins is observing a well-regulated activity (even encoded in procedural manuals), developed over tens of centuries employing physical and symbolic tools developed over the same period, from compasses and compass roses on maps to global positioning satellites (whose histories have been exhaustively traced in numerous scholarly works), the meaning of any action can only be understood by unpacking what history over the centuries has embedded in material practice, symbolic tools, communicative systems, and organized social interactions. Thus, substantial parts of the book are devoted appropriately to such arcania as the astrolabe, cartography, and military hierarchy. Hutchins starts to deliver on Vygotsky's interest in tools and the history of cultural forms.

The embeddings of cultural history that frame the activity system not only focus each person's participation in the collaborative activity and define their cognitive tasks, these embeddings act as constraint, limiting improvisatory behavior and motivational concerns. The constrained environment for action raises issues of the sources and degree of commitment of individuals to the tasks that do not arise from any person's immediately felt sense of need or curiosity. Everyone's welfare is dependent on each doing their assigned job with sufficient attention no matter what their mood or personal needs or feelings about their co-workers might be. The cognitive task is to align the self with narrowly defined pre-determined roles and behaviors—a very different situation than most studies of collaborative work, in education or industry, where the emphasis is more on individualized and improvisatory behaviors to meet personal perceptions and needs. Even when Hutchins observes a mechanical breakdown that requires the improvisation of a new set of procedures, the improvised procedures rapidly move to a new set of regularities. One of the doors opened by this study is the issue of individual alignment with group concerns and historically stabilized systems. Simply to invoke military discipline is not nearly enough to explain what is going on. Similar team navigation occurs on commercial vessels and leisure yachts. Moreover, most cooperative work in industry and organizations is accomplished through individuals taking on externally defined roles and mandates, subordinating their own interests and attentions into that of the group.

Within this structured activity environment, individual history and characteristics take on more limited roles. What is most relevant is one's experience, learning, and socialization within the organized community of practice, often reflected in one's role and rank. Only rarely would experience outside the activity system emerge as relevant and useful. Individuality of personal history is more likely to emerge as a barrier to alignment, motivation, or ability to address the task, witness the harsh judgments Chief Richards makes about Major Rock's intelligence and abilities because the marine major had a limited vocabulary for phases of the moon: "Rock is a great big guy with a brain about this big. He must never have taken an amphib mission on a beach at night. He might get by on a crescent moon, but on a gibbous moon he'll be dead" (231).

Hutchins' project to see how much of cognition can be found outside the self within the culturally ordered system, in the constraints and affordances of tasks and tools, in conventionalized manipula-

tions of visible symbolic representations, and in ordered social relations, not only helps demystify cognition within intelligent activities, it helps demystify our cultural beliefs in individuality, individual intelligence, and imagination—beliefs that have often found an ally in the cognitive tradition. These are mystifications that we all need help working our way through

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Cogito ergo sumus! Or psychology swept inside out by the
fresh air of the upper deck . . .

A Review of Ed Hutchins' *Cognition in the Wild*, Cambridge, MA: The MIT Press, 1995.

> "Decouvrez-vous, messieurs, car nous sommes
> dans St Pierre de Rome!"
> Captain Haddock in *Le Tresor de Rackam le Rouge*

There is an old and inevitable feud every sailor has lived through, and that is the one that pits the skipper in the breeze, mist and cold of the cockpit against the navigator, down in the cabin, slightly nauseated, looking over the chart and leafing through the Nautical Instructions. "The buoy should be there straight ahead and the tower on starboard" claims the navigator, cursing the lack of faith and the poor eyesight of the skipper; but the skipper detects no buoy at all and cannot take this slim rock battered by the surf for the tower of the Nautical Instructions, and she too curses the bookish knowledge and arrogant superiority of the navigator stuck in the cabin comforting himself with arithmetics and brandy... And it is indeed an extraordinary achievement when the skipper and the navigator reconcile the chart inside with the landmarks outside and do it together to lead the frail ship safely in to the harbor. This marvelous book is about this feud and this truce and about the feat of coordinating actions across so different social and mental spaces. But it is not about small boats like the one I used to sail in Brittany, but about the dreadnoughts of the U.S. Navy that San Diegans are accustomed to see sailing by, together with the whales deep down and the hang-gliders high above the cliff.

The feud between the world of navigators and skippers is also a good metaphor for the divide between two cognitive sciences, the one that believes in laboratory experiments, mental state, internal representation, and the other one that believes in the wind, in the wild, that claims to represent the real cognitive tasks in an organized and collective work site. Ed Hutchins has written the book that adds to cognitive psychology the view from the upper deck, which was missing until now.

The expression "in the wild" in his title may appear strange given that it leads the reader into one of the most disciplined, formalized, structured and routinized human cultures there is, that of the

military. And yet, his field site is as wild and naturalistic as the Kenya where Shirley Strum decided to study baboons on foot instead of the caged and trapped animals of psychology laboratorics. It is as wild as the scientific laboratories some of us decided to study, 20 years ago, to escape from the stuffy atmosphere of epistemology. All of these field sites are wild because the subjects of study - sailors, baboons, scientists - are allowed to raise the questions that interest them and to deploy the courses of action of their daily behavior, instead of answering the narrow range of questions that interested psychologists, primatologists or epistemologists. The results of Hutchins' inquiry are as devastating for psychology as the results of sociology of science were for epistemology or those of Shirley Strum for primatology. Everything that was crammed inside the mind of individuals is deployed outside and shared collectively with the culture, through the social connections and with the many cognitive artifacts the group has been able to devise.

One of the great merits of the book is that it takes cognitive science seriously enough to make, in the last chapter, the extraordinary claim that computers - the darling model of mind in the classical view - might actually be good descriptions of socio-cultural systems, but *not* of human cognitive functions. This claim puts this book completely apart from others. Many anthropologists and sociologists, disgruntled by the sweeping claims of cognitive sciences, although they object with tears in their eyes "but where is the rest of humanity, where is the body, the feel, the emotion, the social?", still accept that the more formal, abstract, and symbolic functions of the human mind have been at least well modeled by their cold and scientistic enemies. They simply want the "human dimension" to be put back in. Hutchins, on the contrary, denies that cognitive science has even been able to model those "higher functions." For him, this is a case of mental surgery (p. 363) that put a computer in place of the mind. The very description of formal reasoning remains to be made, and to do so, one has to get on the deck, with the artifacts, in a work site, within a group. This refusal to grant to the classical view even the description of computation and formalism makes this book infinitely better than most social psychology and should interest, for that reason, not only the "softies," but also the hard core of cognitive scientists. What is at stake here is not the human dimension or the "low" aspects of thought, but the very content of the higher cognitive functions.[1]

Hutchins has done for the Navy what he did so magnificently, for the Trobrianders in his first book.[2] Instead of finding excuses for the bad reasoning of the Trobrianders by jumping on their symbolic order, as so many anthropologists had been prone to do, he single-handedly went for their land tenure system, and, sure enough, all the so called "mistakes in reasoning" that had taxed the charity of cognitivists for decades disappeared. In his rendering, Trobrianders were thinking like everyone else, but on a very different material: their incredibly complex land tenure. For the Navy, for the Trobrianders, or for the Pacific navigators - beautifully rehabilitated in chapter two - the material world, the work site, the groupware, replaced the many extravagant and unwarranted assumptions about what it is to think or not to think. Through this beautiful instance of symmetry, the difference between primitive and advanced thinking disappears:

> If one believes that technology is the consequence of cognitive capabilities, and if one further believes
> that the only place to look for the source of cognitive capabilities is inside individual minds, then
> observed difference in level of technology between a "technologically advanced" and a "technologi-
> cally primitive" culture will inevitably be seen as evidence of advanced and primitive mind. (p. 355)

Hutchins, is one of the few symmetric anthropologists, like Jean Lave, Lucy Suchman, Chuck Goodwin or Helen Watson,[3] who had the chance to study in the course of the same career, low-tech traditional people and high-tech "modern" culture. One of the main advantages of the field study presented here, however, is that Hutchins has hit on a task that is much more richly endowed with

mathematics, formal reasoning, and metrological traditions than any of the others described by anthropologists interested in "mundane reasoning."[4] Jean Lave's shoppers have to do arithmetic, to be sure, but when they cannot get at the solution they abandon the problems. Navigators aboard ships have to find their bearings and complete the calculation even when there is no steam - this is what happens in the gripping first chapter of the book. So the chosen setting with its strong hierarchy, its massive use of formal procedures, its necessity of carrying out the calculations no matter what, makes it one of the best "fruit flies" of cognitive science. Hutchins demonstrates that one can be "in the wild" and yet better equipped empirically than in any psychological laboratory with all the variables controlled. The amusing paradox is that in leaving psychological laboratories for the deck of an helicopter carrier, Hutchins has managed to build a better laboratory, equipped with video and tape recorders and was able to describe in excruciating details the achievements of navigational tasks. Out in the wild, it is even better than inside as far as laboratory experimentation goes . . .

So what is left of cognitive science after this study of those fruit flies? One central phenomenon, repeated over the whole book, although it is not treated as a full blown theory:[5] cognition has nothing to do with minds nor with individuals but *with the propagation of representations through various media, which are coordinated by a very lightly equipped human subject working in a group, inside a culture, with many artifacts and who might have internalized some parts of the process.*

Let me sketch this central claim, which is so radical that it may very well reorganize around itself the whole of the cognitive sciences, once the hopes of artificial intelligence (AI) and scientistic psychology will be recognized for what they are, beautiful ruins in an old romantic landscape. The first point is not to follow mental or individual activities but *trajectories* of modified representations.[6] In other words, there is not, according to Hutchins, any meaning in the expression "I think" or "I represent." What can be documented is a shift in representation through different media. For instance, it is not observable in the chart itself, but it is there in a group trying to make features of the landscape *correspond* with features on the chart. There is no meaning in asking what is in the mind of the plotter. But there is meaning in observing how the plotter *coordinates* various media - bearings reported on the phone by the pelorus operators, instructions precoded on the chart, orders from the captain - in one single line on the paper.

This attention to modification of media instead of "mental events" has, in my reading, three decisive consequences.

The first one is a renewed attention to intellectual technologies - attention that is shared with the history and sociology of science that Hutchins almost totally ignores (I will come back to this later). His notion of mediation by artifacts is infinitely much more advanced than the notions of those who see technology - compasses, hoey, rulers - as situated "in between" mental events. It is much more interesting, for instance, than the conception of Don Norman, Hutchins' mentor.[7] A few quotations will make the originality of Hutchins clearer:

None of the component cognitive abilities has been *amplified* by the use of any of the tools. Rather, each tool presents the task to the user as a *different* sort of cognitive problem requiring a *different* set of cognitive abilities or a *different* organization of the same set of abilities. (p. 154, my italics)

In this sense, these mediating technologies do not stand *between* the user and the task. Rather, they stand with the user as resources used in the regulation of behavior in such a way that the propagation of representational state that implements the computation can take place. (p. 154)

Rather than focus on the mediating artifact as something that "stands between," I will view it as one of many structural elements that are brought into coordination in the performance of the task. Any of the structures that are brought into coordination in the performance of the task can be seen as a mediating structure. (p. 290)

This definition of mediation and technology allows Hutchins to pay passionate attention to the details of practice, which do not take him away from cognition, as if cognition was "implemented" in the artifacts, but, and this is the decisive move, as if technology was the real stuff cognition was made of. Having cognition is devising intellectual technologies.

The second consequence is that Hutchins thus escapes the pitfalls of *pliabilism*, this dire intellectual disease due to excessive reading of Wittgenstein and Harry Collins, I should add.[8] Pliabilists are disappointed rationalists, so the only way for them to show that a task is not formal, is to show that some human, some locally situated action, is always necessary to make sense of the formalism or to interpret the data. Fortunately, with his theory of propagation through different media, Hutchins does not have to insist on the indefinite pliability of interpretations or to show with endless delight that there is no formal rule to describe the application of a rule. On the contrary, he shows, very convincingly, that every propagation through a different medium modifies the distribution of the required skills and allows for *simpler* cognitive processes to be brought in:

In producing the coordination between the and the chart, the task performer can *transform* the task to an *easier* one by achieving coordination with an internal artifact: the knowledge of this technique. (p. 144)

These tools permit the people using them to do the tasks that need to be done while doing the kinds of things people are good at: recognizing patterns, modeling simple dynamics of the world, and manipulating objects in the environment. (p. 155, my italics).

So the notion of propagation is clearer. It does not mean a transportation without deformation, but a modification, a translation, a shift, a reformatting of the skills. Thinking becomes an ingenious way of constantly shifting from one medium to the other until one reaches "simpler" or "easier" tasks by delegating more and more tasks to other actors in the setting, either humans or non-humans. Thanks to Hutchins' theory, one is freed from the stifling alternative either to believe in formalism in the head, or to be stuck in the indefinite pliability of local skilled practice. To be a local skilled practitioner is to be able to propagate representational states in other and simpler forms *elsewhere*. Attention to local practices leads *away* from the locus and into tasks that require *different* practices.[9]

The third consequence is even more interesting for cognitive science. With this positive notion of mediating artifacts, and this idea of propagation as redistribution of skills, Hutchins, going much further than Vygotsky, can extend his definition to internal phenomena. As he shows in great details, cognitive processes are not internal, but rather partially and provisionally *internalized*. In one of the most radical sentences of the book, Hutchins writes:

Internalization has long connoted some thing moving across some boundary. Both elements of this definition are misleading. What moves is not a thing, and the boundary across which movement takes place is a line that, if drawn too firmly, obscures our understanding of the nature of human cognition. Within this larger unit of analysis, what used to look like internalization now appears as a gradual propagation of organized functional properties across a set of malleable media. (p. 312)

This means that there is nothing below the skin except the continuation of the same processes that go on outside. But this is not to be seen as a socialization of psychology as if sociology and context had taken over what psychology would be unable to reveal. This is not the case because what gets inside is cognition through and through, but a cognition distributed, materialized and propagated. Approaching the mental states of the subject leads the analyst away and beyond, and if it is possible to seize the internalized translations, they have the *same* mediating properties as what occurs outside.

Language also, in this sweeping view, becomes a mediating artifact like the ruler, the chart, or the hoey, even when we talk to ourselves, memorize a routine, or invent shortcuts and rules of thumb to overcome the difficulty of calculating (see the marvelous case of the rule of three). One rather radical sentence summarizes the author's point:

> It is tempting to think that the words and the world are coordinated by language in order to produce the meanings. It is more accurate to say that the meanings, the world, and the words are put into coordination with one another via the mediating structure of language. (p. 300)

What is true of language is of course truer of symbols, which are not seen as what is in the head but as what is written, marked, underlined, manipulated, reshuffled, and which only later, through other routines and by reformatting once again the tasks, may be put in the head. "Ontogenetically speaking, it seems that symbols are in the world first, and only later in the head" (p. 370).

To do full justice to the book, it is crucial to realize that internalized cognition is almost the exact opposite of internal cognition as it is conceived by other psychologists.[10] If you believe in internal processes, you can *start* with individual cognition, and then, by aggregation or implementation, you may reach the collective level or the material world. If you talk about internalized artifacts and if you observe the propagation of different media inside, there is no way you will ever be able to talk again about disembodied or individual cognition. You will be forced to start from collective tasks and cultural systems. Rephrasing the old sensualist motto, one could say that for Hutchins, "there is nothing in the mind that was not before in the sense," provided that "the senses" now mean shifts from one representational mediator to another one.

> Putting the question of the flexible constitution of functional systems first means approaching the study of cognition from a different starting point. It requires a different view of cognition, and it demands that our models of cognition be capable of different sorts of computations. This is a consequence of an attempt to build a theory of cognition that comes after, rather than before, a description of the cultural world in which human cognitive behavior is embedded. (p. 291).

The main interest of this definition of cognition as propagation through different media is that it gives a very original role not only to the artifacts, not only to internalized tasks, but also to the social structure of the Navy and to the local groups. Usually, when groups and societies are brought in to psychology, it is with the worst consequences, producing the monster known as "social psychology" which cumulates the worst of both disciplines. This is not the case here, since Hutchins does not abandon cognition when talking about groups. He simply goes on distributing the tasks further, hence sentences that would make no sense either to an internalist psychologist or to a contextualist sociologist:

> When a problem has a deeply nested goal structure, a social hierarchy can provide a mechanism for distributing the attention to various parts of the goal structure. (p. 203)

> The computational dependencies among the steps of the procedure for the individual watchstander are present as interpersonal dependencies among the members of the team. (p. 282)
> The novices' understandings of the social relations of the workplace are a partial model of the computational dependencies of the task itself. (p. 283)

> Because society has a different architecture and different communication properties than the individual mind, it is possible that there are interpsychological functions that can never be internalized by any individual. (p. 284)

In the detailed analysis of the groupware - which I cannot even summarize in this brief note - Hutchins offers a very compelling extension of his propagation argument to the social relations.[11] Exactly in the same way as internalized cognition reformats the tasks - so that they are not the same tasks as those outside - exactly in the same way as externalized artifacts redefine the tasks -so that they are not the implementation of mental events - then the social organization modifies once again the representational media. The question is no longer to know whether cognition is in the mind, in the things, in the group, but what are the modifications in the formats of the tasks that are necessary at each point of the trajectory, which from now on forms the only observable content of cognition.

But who is doing the coordination of all those shifting media? A very lightly equipped human agency, not defined by Hutchins as an individual mind endowed with consciousness and foresight, but more precisely, and more originally in my view, as being itself a mediator, a shifter, a propagator. That it is lightly equipped - like the actor of ethnomethodology strangely absent from the discussion - this is very clear from the deflation strategy of the book. Instead of cramming endless numbers of modular boxes and special purpose rules in the head, Hutchins, takes everything out and "render to Caesar what pertains to Caesar." The only clear definition of the human agency, the "most active integral parts" (p. 287), is this cryptic but decisive sentence:

> The thinker in this world is a *very special medium* that can provide *coordination* among many structured media - some internal, some external, some embodied in artifacts, some in ideas, and some in social relationships. (p. 316)

This is the final dissolution of psychology since there is no agency left that could sustain a psyche at all. Instead of the huge crates and heavy luggage that was necessary before for the internal actor to carry around all the rules and boxes necessary to think about the world, Hutchins' thinking agent is more like the desk of a well organized executive: empty since everything else has been delegated outside to something or to someone else.

After having summarized the setting and sketched the radical theory of the book, I would like to offer not so much objections as openings for what I hope will be a long lasting trail of field studies and discussion.

In spite of the definition offered of cognition:

> I propose a broad notion of cognition because I want to preserve a concept of cognition as computation, and I want the sort of computation that cognition is to be as applicable to events that involve the interaction of humans with artifacts and with other humans as it is to events that are entirely internal to individual persons. (p. 118)

Nothing, absolutely nothing of what is considered essential to the very existence of psychology is left in the book.[12] However, Hutchins seems convinced that it is a question of better study and that

an alternative to psychology will be taken on board provided it is empirically grounded, productive and convincing. This looks to me as overly naive. Psychology is not there to describe events but precisely to cram cognition inside an individual mind endowed with consciousness and responsibility. This is one half of the modernist project - the other being on the nature side and the building of objectivity and that part of the dirty job is done by epistemology, which is as impervious to facts and empirical studies for the same reason. To believe that a better cognitive science will simply take over is to miss the anthropology of the moderns and to underestimate the history that made the myth of internal state so essential to our Occidental life.

I was equally disturbed by the idea, frequent in the book, that on one side there is the world and on the other cognitive skills. Distribution, in my view, does not go all the way. This leads Hutchins to make mistakes even in navigational matters. In a sentence like this one "the problem of identifying landmarks may be one of *direct* reconciliation of the chart and the world" (p. 136), the author obviously forgets his own attention to mediation. If there is a coordination that is far from "direct," it is that one. The pelorus operators are not reconciling the world with the map, they are reconciling readings on the compass with landmarks that have been put there at the tip of Point Loma *because* of the map and by the same body of nautical engineers and cartographers. As many mediations are required to transform the world into a map-like or a map-compatible shape as they are inside the ship and then inside the heads of the calculators. The common organization, which the ship, the sailors, the landmarks and the Nautical Instructions all inhabit is curiously absent from the book. This is even more telling with the Global Positioning System, which transforms the whole Earth in the inside of a laboratory - imitating, curiously enough, the strategy of the "primitive" islanders with their navigation system. In other words, Hutchins still hesitates between a *menso-centrism* that would pit a mind, albeit redistributed, against a world which is simply there, and a truly symmetric anthropology, symmetry meaning not only that between Trobrianders and Americans, but that between the world and cognition. A sentence such as the following indicates the hesitation of the author, since it advocates one thing and then exactly its opposite:

> Instead of conceiving the relation between person and environment in terms of moving coded information across a boundary, let us look for processes of entrainment, coordination, and resonance among elements of a system that *includes* a person *and* the person's surrounding (p. 288, my italics).

The reason for this lapse of symmetry comes, in my view, from another disturbing feature of the book. Hutchins makes almost no use of the literature on history and sociology of science - except kind of references to some of my work - which would have made such a strong complementary case on many of the same points.[13] This is even stranger knowing that the Science Studies group at the University of California, San Diego is about 200 meters from the Cognitive Science Building! No doubt this is another case of the division of cognitive labor so well studied by him (for instance p. 178). This is all the more unfortunate since science studies would have allowed him to answer a strong objection to his point of view. He writes, cogently in my view:

> The system for ship navigation (. . .) is based on formal manipulation of numbers and of the symbols and lines drawn on chart. It is a system that exploits the powerful idea of formal operations in many ways. But not all the representations that are processed to produce the computational properties of this system are inside the heads of the quartermasters. Many of them are in the culturally constituted material environment that the quartermasters share with and produce for each other. (p 360)

The objection from the traditional view would be that what is true for "mere" quartermasters is certainly not true for "higher minds," for example the Thales, Galileo, Mercator, and Le Verrier, whose work went into the fabrication of those artifacts.

Hutchins should have countered the objection that there must be a huge difference in applying routine knowledge and producing new knowledge.[14] Without the help of social history of science, the myth of "higher cognitive functions" would simply shift elsewhere and abandon the decks of helicopter carriers for the minds of scientific geniuses. The fascinating thing, in my eyes at least, is that, when turning to those "geniuses," many of the same results that Hutchins obtains with his sailors have been documented. Exactly in the same way as thinking is a property of the navigation team aboard the ship, so that there is no sense for any sailor to say "I compute," the making of major discoveries, according to the new history of science, is a property of whole subcultures of science and of their artifacts, so that there is no sense for an isolated scientists to exclaim "cogito!" or "eureka!" Laboratories think, communities discover, disciplines progress, instruments see, not individual minds.

The lack of coordination - to use one of the fetish words of the book - between science studies and "wild" cognitive science, is all the more a pity since Hutchins' definition of the distribution of cognitive tasks and his understanding of context are much more sophisticated than most accounts in history of science. The groups of navigators, the artifacts, the work site, the requirements of the Navy, are not influencing or constraining the individual mind - as if we had to chose between the individual mind thinking freely beneath its skin, and a social entity, which would be endowed, somewhat mysteriously, with emergent cognitive abilities. Hutchins' point is to turn cognitive science inside out, but *not* to turn it into sociology. It is the very boundary between what goes inside and what goes outside that is at stake in the book. The individual mind endowed with internal states is certainly gone, but so is the "context" in which thinking was supposed to take place. The context is cognitive as well, and not composed of maligned and dark social forces foreign to thought and constraining it. Distributed intelligence is exactly that: distributed and intelligent.

On the other hand, Hutchins would have benefited, in my view, from history of science in order to make more precise what exactly is propagated from one representational medium to the next. On the surface, Hutchins' vocabulary is very reminiscent of the one used in the sociology of scientific instruments, metrology, collections and centers of calculation in general. Mobility, immutability and connectability are crucial to all these media.[15] But this is not the end of the story and immutable mobiles -to use my own wording - are typical of very *few* cognitive trajectories. It is already clearly different when Hutchins tries to follow the legal requirements of all the same elements when they are used not to take bearings but to offset a litigation. Now that Hutchins has redefined cognition in terms of coordination of representational media, his responsibility is to specify the various modes of coordination. Instead, he uses very weak and spongy metaphors sensing the difficulty but escaping it:

> The people are the *glue* that sticks the hardware together... The causal relationship is a *tissue* of human relationships in which individual watchstanders consent to have their behavior constrained by others, who are themselves constrained by the meaningful states of representational technologies. (p. 202)

And again,

> This permits the human component of the system to act as a *malleable and adaptable coordinating tissue,* the job of which is to see to it that the proper coordinating activities are carried out. (p. 219, my italics)

Escaping from the traps and artifacts of cognitive science is one thing, and Hutchins does the job beautifully, but the tasks that lies ahead will not be easier for that. It would be a pity, in my eyes at least, if this revamped cognitive anthropology was not collaborating closely with those scholars in science studies who have the same interest, and many of the same enemies.

I hope it is clear from the critical as well as from the positive remarks that this is a remarkable and foundational book.[16] Let me add one personal note. When I published *Science in Action,* in 1987, I proposed a "moratorium" on cognitive explanations, which had been so freely and cheaply entertained by epistemologists. I already knew Hutchins' work and made good use of his first book, but I did not know that I would be able to safely lift the ban, less than 10 years later, since in the meantime, cognitive explanations would have been dissolved beyond recognition by the very same Hutchins and made thoroughly compatible with the social explanations of science, technology and formalism devised by my colleagues and myself. Let us now exclaim together "cogito ergo sumus! . . ."

Notes

[1] The author seems, however, to ignore the work done on the history, sociology, materiality of formalism by scholars like Livingston, E. (1985). *The Ethnomethodological Foundations of Mathematical Practice.* London: Routledge; or Warwick, A. (1992). Cambridge Mathematics and Cavendish Physics: Cunningham, Campbell and Einstein's Relativity 1905-1911. Part I: The Uses of Theory. *Studies in History and Philosophy of Science,* 625-656. More surprisingly, he seems unaware of the work of Leigh Star and her many colleagues on the work sites of computers, although much of his methods are entirely compatible with ethnomethodology -minus the jargon, Hutchins writes beautifully - and symbolic interactionism.

[2] Hutchins, E. (1980). *Culture and inference: A Trobriand case study.* Cambridge: Harvard University Press, curiously is not even referred to in this one!

[3] The latter is not cited in the book although her work on the contradictions of Australian whites and aborigines is one of the very few instances of real symmetric field study.

[4] Traweek, S. (1988). *Beam times and life times: The world of high energy physicists.* Cambridge, MA: Harvard University Press, which is not cited, would have been extremely useful here because it describes physicists' environments producing new knowledge.

[5] The only overt reference to it is found on page 230 where it is named "the theory of computation by propagation of representational state."

[6] In intent, if not in method, this move from cognition in the subjects or in the objects, to trajectories is similar to the move advocated by A. Cussins - another San Diegan - with his notion of "trails," which are the new embodiment of cognitive virtue. See Cussins, A. (1992). Content, embodiment and objectivity: The theory of cognitive trails. *Mind, 101*(404), 651-688.

[7] Norman, D. (1993). *Things that make us smart.* New York: Addison Wesley, is only superficially in accordance with Hutchins' thesis, precisely because of the complete difference in the theory of mediation.

[8] Collins, H. (1990). *Artificial experts: Social knowledge and intelligent machines.* Cambridge, MA: The MIT Press, which is not cited here, tackles many of the same issues, but with the opposite conclusions.

[9] It seems to me that his theory should have led Hutchins to differentiate himself on this point from Suchman's and from Goodwin's works, which are cited but not discussed.

[10] This also includes Roy D'Andrade's own brand of cognitive anthropology, which is totally opposite to that of Hutchins, hence the rather embarrassed praise for the book on the dust cover . . . "I think this is a great book." It is indeed, but one that will forever forbid to D'Andrade the use of "I think!"

[11] He also offers an amusing computer simulation of which type of social division of cognitive labor offers the best ability to contemplate alternative viewpoints.

[12] Cognition is so broadly conceived that it seems to have no limits. There is only one brief allusion to the fact the writing would have been different if the author had paid attention to energy instead of cognition.

[13] He does not use Lynch, M. (1985). *Art and artifact in laboratory science: A study of shop work and shop talk in a research laboratory*. London: Routledge, whose descriptive stance, attention to details, and many of the conclusions are very much in resonance with his.

[14] Law, J. & Lynch, M. (1990). Lists, field guides, and the descriptive organization of seeing: Birdwatching as an exemplary observational activity. *Representation, in Scientific Practice*, edited by M. Lynch & S. Woolgar (pp. 267-300). Cambridge, MA: The MIT Press, would have allowed him, for instance, to clearly state the different skills in recognizing that this bird is an instance of a mockingbird compared to the invention of the new mockingbird species.

[15] See for instance the crucial and classic piece by S. L. Star and J. Griesemer (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-1939. *Social Studies of Science, 19*, 387-420.

[16] There are very few mistakes in this very nicely produced work. I noticed however the following: 2 lines from the bottom of page 110 "of" is missing; in the second paragraph of page 282 a "the" should be crossed; Figure 1.7 on page 323 should be labeled 1.2; and on page 371 the reference date "in press" should be 1994.