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# Representations at Work

## Abstract

This paper argues that “distributed cognition” facilitates a framework for studying aspects of organizations as socio-technical systems. An approach studying tool use and workflows is laid out and utilized in an analysis of information processing at a post office. Finally, some implications are presented – for organizational as well as cognitive studies. Research on performative representations is called for and, consequently, a widening of the cognition-as-computation framework is suggested.

## Studying Representations at Work

Organizational theories often pay lip service to the claim that organizations are complex socio-technical systems. In practice, however, the association is merely stated as a fact and abandoned for issues concerning social aspects at the expense of technological issues. This shortcoming rests on a lack of unifying notions bridging the gap between humans and things. This paper claims that “distributed cognition” (Hutchins 1995a, b) provides such a common analytical framework comprising minds and artifacts.

The general idea of distributed cognition is to expand the traditional cognitivist model to encompass whole systems of humans and

things. In this light cognitive systems are construed as entities transforming input to output through some intermediary processing apparatus. The novelty of distributed cognition is the claim that the processing capabilities are not only attributed to individual minds but also to artifacts and the mutual organization between them. To explain the processing capabilities of minds and artifacts distributed cognition offers a reinterpretation of *representation*.

## Representation

The single most important contribution of distributed cognition is the understanding of “external representation” (Zhang, 1997). In accordance with orthodox views, distributed cognition holds that cognition is a product of representations and algorithms for their manipulation. Contrary to the traditional interpretation, however, representations may be embedded both in minds (internal representations) and – more prominently – in artifacts (external representations). This leads to a definition of cognition as “the propagation of representational states across representational media” (Hutchins, 1995a, 118), which is wide enough to encompass both internal and external representations.

Representations are characterized partly by

*motivation* and partly by *friction*, and there is an intimate relationship between the two. By motivation I refer to the reason for representing in the first place, which is determined by the task at hand. Take a chart illustrating pathways between point A and point B as an example. The chart may look entirely different if you are going by bike or by car when certain roads are meant for cars or bikes exclusively. The chart is modeling potential passageways from A to B with regard to the specific means of transportation. In sum, the motivation determines the *task relevant structures* that the representation needs to represent. Representations may thus be defined as models of task relevant structures of a given domain.

This brings us to friction. The degree to which the generated representation fits the task determines the level of resistance encountered while utilizing the representation. If the representation fits poorly, the result will be accordingly. A high level of friction will trigger a reconfiguration of the representation to make it account for the unexpected findings. If, for example, somewhere along the way from A to B a road does not allow passage, the chart may be redone to illustrate this. Consequently, rather than construing representations as ideal one-to-one mappings of the world, it is important to realize the highly task dependent and dynamic character of representations.

Artifacts such as charts are cumulative in nature. Through re-adjustment charts have been successively refined and elaborated up until today when the world has been mapped out entirely. In the course of this development, more and more information about the represented domain is embedded in the artifact. Furthermore, several task relevant structures may be superimposed on the same artifact. This gives rise to crucial information processing abilities since the artifact literally facilitates the propagation of representational states across representational media. Reconfiguring the artifact to decrease friction attunes representation to task

relevant structures and permits the artifact to incorporate knowledge which it is impossible to represent mentally.

This raises a further basic point. Cognition is not something that takes place on top of representations. Cognition takes place *through* manipulation of representations. Once working representations are established, actions are guided by them. Hence it is possible to *do things* via manipulation of representations. Standing at point X between A and B, should I turn left or right at this intersection? Given that the level of friction between representation and represented is sufficiently low, the answer is immediately available from the chart. The representation may effectively come to work as a *surrogate* for the represented. Again, rather than depicting the world as it is, representations are better understood as facilitating predictions about outcomes of certain actions.

This approach gains impetus from theories on mental models (Johnson-Laird, 1989), model-based reasoning (Nersessian, 2003a), epistemic mediators, manipulative abduction (Magnani, 2002), and so forth. The thing to bear in mind is that cognition is a product of the manipulation of external as well as internal representations. Distributed cognition does not hold that no internalization occurs. It holds that neither the mind nor the artifact is the exclusive site of cognition. Rather, cognition arises from the dynamic interaction between the two.

### **Distributed Cognition as Organizational Analysis**

Above, the theoretical underpinnings of distributed cognition were sketched. In the following, some preliminary remarks on doing organizational analysis are made before turning to the field study at a post office.

According to distributed cognition, it does not make sense to study cognition in separation from social and technical aspects. Cognition may be said to be an organizational property in so far as organizations are construed as socio-

technical systems. Analyzing organizations as cognitive entities amounts to studying the “creation, manipulation, and propagation of representational states” (Hutchins, 1995a, 49) that capture the information processing capabilities of organizations. According to the theory, this is done by illuminating the various representations at work in the organization and their distribution across artifacts and minds.

Norman coined the term “cognitive artifact” which he defined as “an artificial device designed to maintain, display, or operate upon information in order to serve a representational function” (1991, 17). This term fits this framework nicely although it would have been even better if it read: “... operate on representations to serve an information processing function.” In any case, the inference that it is possible to study the representational structures embodied in artifacts should be clear. Fortunately, the majority of representations at work in organizations are readily observable which constitutes a major advantage to studies of distributed cognition over traditional studies in cognitive science.

Communication – i.e., the propagation of representations – between workers constitutes another key ingredient in the analysis. In the case study presented here, communication is mainly used to assign tasks and coordinate behavior. Interesting as this might be, this issue is left out in favor of the interaction between worker and artifacts that takes place without direct collaboration with colleagues.

Of course distributed cognition is neither the first to construe organizations as socio-technical systems nor the first to point to the crucial role of artifacts. “Situated action” and “activity theory” have both made similar points. There are, nevertheless, several reasons why distributed cognition is preferred in the upcoming case study. First, these alternatives are well established and thoroughly tested. The case study to be presented here is a kind of preliminary test bench for distributed cognition in organizational studies. Second, and more

importantly, distributed cognition facilitates a unifying analytical vocabulary encompassing both minds and artifacts. The representational analysis goes beyond situated action and activity theory in its ability to spell out the common ground between the social and technical aspects of organizations.

Some precautions are worth noticing however.<sup>1</sup> The ability to analyze the role of artifacts in the input-output processes of organizations makes distributed cognition well suited for studying workflows and tool use. These are nontrivial issues that relate to central concerns of organizational theories, but there is obviously more to organizational life than that. Distributed cognition has – in its current edition – very little to say about the goals of organizational members, the history and present tasks and challenges of the organization, asymmetric power relations, and so forth.

It should also be noted that distributed cognition already has been utilized in studies of a navigation team (1995a), a cockpit of a commercial airliner (Hutchins, 1995b), a biomedical engineering laboratory (Nersessian, 2003b), and a team of road construction engineers (Perry, 2003). Except from the last mentioned study (which draws implications for theories of human-machine interaction), however, they all remain focused on cognitive rather than organizational issues. This paper explicitly explores implications for organizational theories.

## Carrying Out Distinctions

This case study examines a small post office distributing letters at a university in Denmark. As input, the office receives letters to the various departments on campus. The output is the delivered mail at these departments. In order to facilitate the process, the postal system has devised a number of artifacts mediating between

1 I am indebted to my reviewers for guiding me towards these qualifying remarks.

input and output. Here we shall examine a few of the more salient artifacts before studying the contribution of the officers in the workflow.

### **The Cognitive Artifacts of the Post Office**

**The address:** An address is an example of a globally used artifact. Through history it has been found to remedy easy discrimination of a singular location (or addressee) in the world. As such an address may be regarded as a representation of the location of an addressee. Take my own address as an example:

Martin M. Nielsen  
Gl. Munkegade 21A  
8000 Århus C  
Denmark

Reading the address from below brings the letter in coordination with the addressee via successive binary steps: If the current location of the post officer/letter matches the designated country – move on to the subsequent level. If not, produce the match by moving the letter to the designated destination. The process is repeated at each level, virtually walking through state, zip code, city, street, street number, and so forth. The task is completed when the letter reaches a mailbox, a door slot, or a person answering the name written at the top of the address. Thus, the address provides a list of relevant destinations which the letter needs to traverse in order to reach its recipient. In our case the address needs to specify little more than name and department since the serviced area is so limited, but the procedure is the same nonetheless.

**The tour:** For obvious reasons the letters are not processed one by one. The large number of letters coming through the post office every day calls for further mediating devices. One of the most prominent mediating devices is referred to as a “tour”. It is produced by pinpointing all addressable locations of a given area and then “connecting the dots”.

Thereby a sequential order is superimposed on all locations serviced by the post office. In other words the tour is a representation of the (postal) world, and it instructs the officers about the route they need to travel to do the job. The postal area in our case study is divided into 4 tours.

**The pigeonholes:** While the tours certainly have a “physical” existence in their guidance of the officer through a postal area, they are still too “conceptual” to actually *do* anything. Despite the severe densification of the world in the reduction to a sequence of locations, further materialization needs to take place for the artifact to define a task. This is provided by a sorting device the structure of which has given rise to the term “pigeonholes”. It consists of a number of cells ordered in rows. Each cell is labeled with one address from a tour and designed to hold all the designated letters. The sorting box works as a device for segmenting letters. Stacked in front of the boxes, the letters are moved one at a time to their designated cell, producing distinctions between them through their assignment to different boxes. The device is big enough to let three officers sort mail simultaneously. This enables a parallel processing of the letters.

The pigeonholes incorporate all the tours serviced by the office, and each tour is laid out in the order in which they are to be delivered. As such, the sequential representational structures of the tours are superimposed on the cells, and that enables them to work as surrogate destinations during the sorting process. As such, the pigeonholes constitute the postal world “writ small”.

We have now encountered a number of superimposed representations at the post office. In the tour a specific sequence was superimposed on all the addresses of a certain area. In the pigeonholes a material cell structure was superimposed on the tour. Any change in the world represented by the artifacts (if a department moves elsewhere for example)

will immediately trigger reconfigurations of the representational structures.

The artifacts constitute the task faced by the officers. Instead of bringing the letters directly into coordination with the world, the letters first need to be brought into coordination with the pigeonholes. Afterwards, the distinctions provided by the artifact are maintained and carried out, thus bringing the segmented letters into coordination with the world. Through the “precognitions” facilitated by the sorting device the overall task is sequenced into successive alignments of letters and addressees. Accordingly, everything the officers need to know about the postal world is effectively incorporated in the artifacts.

### The Human Component

So far, the human component of the system has been largely ignored. The representational analysis reveals the requirements faced by the officers at the post office. The artifacts define and organize the task, and now it is up to the people to carry it out. This supports a widespread claim in organizational studies that we do not simply use tools in work processes. On the contrary, tools define the task and constrain our work process. According to Hutchins, the human element of a system is “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” (1995a, 219). As such, the officers superimpose themselves on the network of representational artifacts in order to achieve coordination of tasks.

In addition to the incorporation of the tour in the pigeonholes, the field study revealed other representational media in which it was – at least partially – instantiated, i.e., the minds of the officers. In the case study more than 100 cells were arranged in 4 rows and 25-30 columns in the sorting box, and that placed the mental abilities of the officers under severe stress. It is far too time consuming

to process the cells perceptually every time a letter needs sorting.

Video recordings reveal that – upon reading the address – the officers are immediately able to move directly towards the location of the designated cell without orienting themselves in advance. This indicates that the locations of the cells are represented internally with a precision of a few cells’ margin. This representation is not totally available to conscious manipulation, however. An officer comments on his recall of the location of cells: “It comes with routine... It lies in the back of the head.”

Furthermore, the internal representation is only approximate. The exact location of a cell is always reconfirmed perceptually before placing the letter. These findings are confirmed by a questionnaire in which the officers were asked to list all addresses of a particular tour. Despite the self-assuredness of the officers, they did not recall the tour accurately. Their errors were no more than two addresses in average (3 subjects, a tour of 29 addresses). Still, there was no pattern in the errors and no apparent explanation.

At first sight, this inaccuracy seems destructive to the proper delivery of the mail. Once again, however, closer inspection reveals subtle trade-offs between man and artifact that in effect enable them to outperform unaided individuals. Prior to delivery the letters are arranged in their newly imposed order on a “tray”. This artifact largely echoes the pigeonholes except that it only accommodates a single tour and is smaller in order to be mobile. Consequently, during delivery simple inspection of the next undelivered stack of letters informs the officer about the subsequent destination. As a result, the lack of ability to retrieve the tour from memory is inconsequential to the actual performance of the task.

Distributed cognition does not argue that no internalization occurs. It just holds that cognition is the product of the interaction between representations – internal *and* external. In fact,

the incomplete internalization of the tour is to be expected given the distributed character of cognition.

### **Preliminary remarks to the case study**

The input of the post office is a large number of disordered letters constituting the raw material. Through *propagation of addresses* (representational states) *across the tour and pigeonholes* (representational media) the letters successively reach their destinations. The output is bundles of letters delivered at their designated departments (where new input is picked up). In sum, the task faced by the post office is one of carrying out distinctions. This task is facilitated by the representations at work in the office, mediating between input and output.

As argued above, the tour is the governing artifact in the post office. Its structure is incorporated in several artifacts and, thus, controls the behavior of the system at large. Virtually walking through these artifacts carries the letters to their destinations. Through access to high-level representations of the system as a whole the officers ensure proper alignments of representational states. As such, the officers superimpose themselves on the system and reinforce the organizational architecture as part of the cognitive make-up of the system.

Even if the product of the post office is a physical entity (i.e., delivered mail), the field study serves to show the indisputable informational nature of even the most mundane operations. A layer of informational structures serves the physical entities of the postal system. This layer is what makes an analysis based on the distributed cognition of the workflow rewarding. An analysis of representational structures renders a powerful description of the information-processing capabilities of the post office. As argued, the components of the system participate in complex propagations of representational states across internal and external representational media.

Yet, a subtle difference which is unaccounted for in the contributions of artifacts and humans remains. Whereas the propagation across representational media takes place “inside” artifacts (across, for example, the sequential order of the tour, and the physical grid of cells), the human task is to propagate “between” artifacts (address and sorting device, for example).

## **Implications for Organizational Studies and Cognitive Science**

Through the analysis of the representations at work in the post office, we explicated the information processing that occurs in the office. This validates the claim that the post office may actually be regarded as a distributed cognitive system. This is by no means an intuitive conclusion and well worth examining in closer detail.

The claim, no doubt, runs counter not the least to current practices in organizational studies. There is, of course, the work done on the cybernetics of management by Beer (1972) and the classical article by Galbraith (1974) to mention a few prominent exceptions, but these studies tend to focus on the information processing in managerial decision-making. However, the study of representations at work makes it possible to install information processing as an analyzable object at the center of the production process itself. In the remainder of the paper some further implications for organizational studies and cognitive science are attended to.

### **The Informational Structures of Work**

Recently Vicente (1999) criticized the inability of distributed cognition to go beyond a mere *descriptive* stance and, hence, the inability of the theory to present *formative* directions for the design of informational systems. In



contrast, he argued for developing an analytical framework directed towards uncovering the “intrinsic constraints” of work domains. However, I shall argue that the study of representations at work gives the framework of distributed cognition a potential beyond descriptivity. The analysis of distributed cognition excavates *essential* information flows in organizations. Even if the analysis of the post office was highly descriptive, studies may be composed to reveal the minimal and necessary informational structures (i.e., the constraints) of organizations, and that is exactly what Vicente calls for. Obviously this is highly valued in organizational studies, not the least with regard to the development of information technology and cognitive artifacts in general.

It is also important to notice the intertwining of the informational and the material in cognitive artifacts. Clearly, the inputs and outputs of the post office are physical entities. In order to do any work with the letters, though, an informational layer is imposed on the physical entities. Not that the informational layer takes on a separate existence; it is exactly the *intertwining* of the physical and the informational that bestows the pigeonholes with their practical significance. The worker manipulates the material of her work through the informational layer. In this sense, information processing and activity are two sides the same thing. Distributed cognition provides organizational studies with an analytical framework that spells out relations between technology and work with a hereto unprecedented richness in detail.

This brings us to some implications for cognitive science. The representations at work in the post office are *performative*. Through the incorporation of representations in artifacts it is possible to *do things with things*. This rethinking can be seen as an attempt to accommodate the growing body of research on “environmental perspectives” (Nersessian, 2003b) suggesting a fundamental re-conceptualization

of cognition. The study of performative representations reveals that cognition is more a question of *activity* than of mental *depiction*. Likewise, it suggests an expansion of the cognition-as-computation framework since many activities are not easily described as purely symbolic manipulation. Even though Hutchins is explicit in handling the work processes of the navigation team (1995a) as fundamentally computational, he is aware of potential shortcomings of this approach:

“Many human activities are difficult to characterize as computational in nature. This raises the question of the extent to which the approach I present here can be applied to other domains. I would like to believe that the problems will be mostly methodological, but I am prepared to discover new theoretical insights as we explore the range of applicability of this approach” (1996, 67).

Even if a lot of information processing takes place through the activities of the post office, this goes beyond mere manipulation of symbols. The case study suggests that computation proper is a borderline case of a wider framework of *information processing as activity*.

### The Orchestration of Representations

The classical view of human rationality – and the one adopted by traditional cognitive science – highlights the “cogito” as the source of rationality. From the perspective of distributed cognition, however, rational behavior is a product of the interaction with artifacts in social settings. The human mind on its own is not likely to come up with novel insights. Processes utilizing the massive stock of creativity accumulated in artifacts and social collaboration are much more apt scenes of rationality. Accordingly, rationality is a socio-cultural property of a system – not an inherent attribute of the mind. As a result, the structures facilitating rationality are to be examined empirically. Evidently, it is possible to design systems to behave unintelligently, so instead of assuming

rationality a priori it is important to examine the mechanisms which do orchestrate systems to behave competently.

Through the discussion of organizational rationality we arrive at a critical issue concerning human versus material agency. As should be evident from the study of representations at work in the post office, there are differences in the cognitive contributions of human and artifact. Whereas artifacts propagate representational states inside themselves, humans propagate across artifacts. Working as a “coordinating tissue” actually sets the human contribution aside from that of the artifacts. Arguably, humans have access to higher-level representations of the system which direct the orchestration of artifacts. Surely, the artifacts define the task, but it is up to the humans to put them to work.

The leveling of human and artifact in distributed cognition is often criticized on ethical grounds (Nardi, 1996). If both things and minds are construed in representational terms, no dues are paid to the moral value of human beings. This may lead to inhuman work settings in which workers are treated on a par with machines. Despite the possibility of demarcating actions of human from artifacts even under the label of the propagation of representations, the analytical framework advanced here is much better attuned to the functional/instrumental practices of tool use and workflows than to social issues proper. Every theory has its limitations, and this is probably one to keep in mind while applying distributed cognition to organizational studies.

Considering the implications for cognitive science, the line of reasoning presented above suggests an awareness of the interplay between cognition and the orchestration of representations. Artifacts may be constantly reconfigured in light of novel situations, and this concerns not only how the artifacts are organized in relation to each other but also the internal makeup of each artifact. As noticed,

the human function is to act as a malleable tissue putting representations together to ensure proper coordination. As such, the orchestration of representations is an indispensable part of the cognitive function.

Finally, we need to consider where organizational studies and cognitive science depart. Distributed cognition simultaneously provides a specification of the functional system and of the constraints imposed on the cognitive apparatus of the individual. In the end, cognitive science is preoccupied with the latter and organizational studies with the former.

## Conclusion

Over the last decades much work has been done on the role of knowledge in organizations. Despite the low-tech standard of the representations at work in the post office, the cognitive analysis of the information processing that occurs here seems sensible. In the post office the informational structures presented themselves only as the top layer of the mail delivery system.

Information is certainly always in need of a physical vehicle, but in modern knowledge based organizations the informational layer has made itself ever more independent of physical production processes. In pure form these organizations actually produce information. This development, which seems to pick up pace through the rise of “the postindustrial society” and the related explosion in information technologies, strengthens the need for theories that capture these information processing abilities. Distributed cognition seems to be well suited for just that.

On the other hand, cognitive science may benefit equally from adding organizational studies to its already long list of disciplines. Organizations are rich sites of the propagation of representations crucial to cognition. Contrary to traditional cognitive studies, the processes transforming input to output in or-



ganizations are not opaque. Through the analytical lens of distributed cognition these propagations are readily available for inspection which makes organizations promising sites of study. Further, the case study advances a reinterpretation of representations which calls for studies of their performative nature. As a consequence, a widening of the framework of cognition-as-computation is proposed.

Finally, the mixture of distributed cognition and organizational studies provides cognitive science with a new practical discipline of putting representations to work. This practice holds the promise of delivering directions for devising cognitive artifacts, the development of informational systems, and for the entire orchestration of tool use and workflows in organizations.

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