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Abstract

This paper argues that distributed cognition provides a unifying framework for analyzing organizations as socio-technical systems. The framework is utilized in an analysis of information processing at a post office. Finally, implications – both for organizational and cognitive studies – are presented. Research on performative representations is called for and, consequently, an abandonment 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 provides such a common analytical framework comprising minds and artifacts.

The general idea of distributed cognition is to expand the traditional cognitivist model to comprise whole systems of humans and things. In this light organizations are construed as input-output devices with intermediary processing capabilities. The novelty of distributed cognition, however, is the claim that the processing capabilities are as much attributed to artifacts as to individual minds and their organization. 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 "propagation of representational state across representational media" (Hutchins, 1995). Contrary to these views the representations may be embedded both in minds (internal representations) and – more prominently –in artifacts (external representations). Consequently, according to distributed cognition it does not make sense to study cognition in separation from social and technical aspects. In short, representations constitute the common ground connecting minds and artifacts, thus making cognition a fundamental feature of socio-technical systems.

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 that 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 if certain roads are meant for cars or bikes exclusively. It is modeling possible ways from A to B with regard to the specific means of transportation. In sum, the motivation determines the *task relevant structures* the representation needs to represent. 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 1:1 mappings of the world, it is important to realize the highly task dependent and dynamic character of representations. In fact, representations may be defined as models of task relevant structures of a given domain.

Artifacts like charts are cumulative in nature. Through time artifacts may come to incorporate knowledge impossible to represent mentally. Through re-adjustment the charts have been successively refined and elaborated up until today when the world has been mapped out entirely. Once the friction between representation and task relevant structures wears off the artifact reaches its highest level of development and its highest value in use. In time, several task relevant structures may be superimposed on the same artifact thus embedding numerous representational media in it. This gives rise to crucial information processing abilities since the artifact literally facilitates propagation of representational state across representational media.

This raises another basic point. Cognition is not something taking place on top of representation. Cognition is taking place *through* manipulation of representation. Once a working representation is established actions are guided by it, 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 artifact. The representation may effectively come to work as a task-specific surrogate for the represented. Again, rather than depicting the world as it is, representations are better understood as facilitating predictions about outcomes of certain practices.

This approach obtains impetus from theories on mental models (Johnson-Laird, 1989), model-based reasoning (Nersessian, 2003), epistemic mediators and manipulative

abduction (Magnani, 2002) etc. 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 alone is the exclusive site of cognition. Cognition is exactly distributed across the two and arises from their interaction.

Distributed Cognition as Organizational Analysis

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

Analyzing organizations as cognitive units amounts to studying the *generation, propagation, and manipulation of representations* that capture the information processing capabilities of organizations. According to the theory this is done by spelling out the various representations at work at the organization and their distribution across artifacts and minds.

Norman coined the term *cognitive artifacts* which he defined as "an artificial device designed to maintain, display, or operate upon information in order to serve a representational function" (1991). 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.

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

Contrary to common beliefs in organizational studies it is insufficient to study the individual and her function at the work place. It is equally important to analyze the (cognitive) artifacts encountered. Distributed cognition suggests that these artifacts will be crucial to the understanding of workflows in the organizations. Fortunately, the majority of the representations at work at organizations are readily observable which constitutes a major advantage to studies of distributed cognition over traditional studies in cognitive science.

Carrying Out Distinctions

This case study examines a small post office distributing letters at the University of Århus 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 input and output. Here we will examine just a few of the more salient before studying the contribution of the officers in the workflow.

The address An address is an example of a global standard for an artifact. Over history it has been found to remedy an easy procedure for discriminatingly pinpointing 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 etc. The task is completed when the letter reaches a mailbox, a door slot, or a person answering the name written at the top level of the address. In our case the world is confined to a rather limited area, but the procedure is the same nonetheless.

The tour For obvious reasons the letters are not processed one at a time. The huge amount of letters coming through the post office daily calls for further mediating artifacts. One of the most prominent of these artifacts is referred to as "the tour". It is produced by locating all addressable locations of a given area and then "connecting the dots", thereby reducing the world to addresses put into sequence and imposing a temporal order on otherwise unordered juxtaposed locations. In other words the tour is a representation of the (postal) world.

The pigeonhole While the tour certainly has a "physical" existence in its guidance of the officer through a postal area, it is 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 perform a task. The "sorting device" provides this materialization. Materially this device consists of a number of cells ordered in rows and columns. Each cell is labeled with one address from the tour and designed to hold all the designated letters. The shape of the device gives rise to the term "pigeonhole" (meaning the entire structure – not any individual compartment). The sorting box works as a device for segmenting letters. Stacked in front of the boxes, the letters are moved one at the time to their designated cell, producing distinctions between them through their assignment to different boxes. The device is big enough to let 3 officers sort mail at same time. This enables parallel processing of the letters.

The pigeonhole represents the tour while giving it material existence. The cell structure is superimposed on this representation, thus permitting the device to work as a temporary compartmentalization device. As such, the pigeonhole comprises the whole postal world "writ small". Here the letters find their final destination albeit in surrogate form.

The Cognitive Artifacts of the Post Office

A number of superimposed representations have been encountered at the post office so far. In the tour a specific sequence was superimposed on all the addresses of a certain area. In the pigeonhole, a material cell structure was superimposed on the tour. As such, most of what the officer needs to know when working at the office is incorporated in the artifacts. Any change in the world represented by the artifacts (if a department moves somewhere else for example) will immediately trigger reconfigurations of the representational structures.

The artifacts totally restructure the task faced by the officers. Instead of bringing the letters directly into coordination with the world, the letters need to be brought into coordination with the pigeonhole at first. 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. Notice how both of these tasks are consistent with the tour, which simultaneously coordinates the procedures for sorting and delivery. 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 the task and now it is up to the people to carry it out. This supports a claim widespread in organizational studies that we do not simply use tools in work processes. On the contrary, tools by and large define the task and constrain our work process. According to Hutchins' analysis, the human component 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" (Hutchins, 1995). As such, the officers superimpose themselves on the network of representational artifacts in order to achieve coordination of tasks.

Besides the incorporation of the representational state of the tour in artifacts, the field study revealed yet another representational medium in which it was – at least partially – instantiated, i.e. the human mind. In the case study more than 100 cells were arranged in 4 rows and 25-30 columns in the sorting box which put 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 expose a large degree of internalization of the structure of the device, which is substantiated by the observation that the officers after reading the address 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. In this case, however, the representation is not totally available to conscious manipulation. An officer comments on the recall of the location of cells: "It comes with routine... It lies in the back of the head."

The internal representation is only approximate, however. The exact location of a cell is always reconfirmed perceptually before placing the letter. The same findings are confirmed by a questionnaire in which the officers where asked to list all the addresses of a particular tour. Despite the self-assuredness of the officers they did not recall the list accurately. The errors were no more than 2 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 damaging to the proper delivery of mail. Once again, however, closer inspection unveils subtle trade-offs between man and artifact that in effect enable them to outperform individuals on their own. Remember, that distributed cognition does not argue that no internalization occurs. It just holds that cognition is a product of the interaction between representations – internal and external. In fact, this partial internalization is to be expected given the distributed character of cognition.

Prior to delivery the letters are arranged in their newly imposed order on a "tray". This artifact largely echoes the pigeonhole 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 actually performing the task.

Summary

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 pigeonhole (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). As such, the representations at work at the office mediate between input and output.

As argued, the tour is the governing artifact at 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. The organization of the workflow between the officers and the artifacts represents the system taken as a whole. As such, the organizational architecture is itself part of the cognitive make-up of the system.

There remains, however, a subtle (and unaccounted for) difference in the contributions of artifacts and humans. Whereas the propagation across representational media is taking 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).

Even if the product of the post office is a physical entity (i.e. delivered mail) the field study serves to show the indisputable cognitive nature of even the most mundane operations of any system. A layer of informational structures serves the physical entities of the postal system. This layer is what makes a distributed cognition analysis 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 state across internal and external representational media.

Implications for Organizational Studies and Cognitive Science

Through the analysis of the representations at work at the post office the information processing occurring at the office was explicated. 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 runs counter not least to the current practice 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 tend to focus on the information processing in decision-making. Through the representational analysis it is possible, however, to get a hold of the workflow of the actual production process in hereto unprecedented detail. In the remainder of the paper further implications for organizational studies and for 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 development of informational systems. In contrast, he argued for developing an analytical framework directed towards uncovering the "intrinsic constraints" of work domains. However, I will argue that the study of representations at work gives the framework a potential beyond descriptivity. Through the analysis distributed cognition excavates essential information flows at organizations. Even if the analysis of the post office was highly descriptive, studies may be composed to reveal the minimal and necessary informational structures of organizations which is exactly what Vicente calls for. Obviously this is highly valued in organizational studies, not 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 input and output of the post office are physical entities, i.e. letters. 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 pigeonhole with its cognitive attributes. The worker manipulates the material of her work through the informational layer. In this sense information processing and practice are two sides the same thing.

This brings us naturally to some implications for cognitive science. The representations at work at 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 situated cognition (Lave, 1988) suggesting a fundamental re-conceptualization of cognition. The study of performative representations reveals that cognition is more a question of *practice* than of mental *depiction*. Likewise, it suggests an abandonment of the "cognition as computation" framework since many practices do not lend themselves easily to computational terms. Even though Hutchins is explicit in handling the work processes of the navigation team (1995) as fundamentally computational, he is aware of possible 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).

Even if there is a lot of information processing taking place through the practices of the post office there is – strictly speaking – not much computation. The case study suggests that computation proper is a borderline case of a wider *information processing as practice* framework.

The Orchestration of Representations

The classical view of human rationality – and the one adopted by traditional cognitive science – highlights the "cogito" as the site of rationality. From a distributed cognition perspective, 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 that do orchestrate systems to behave competently.

Through the discussion of organizational rationality we derive at a critical issue concerning human vs. material agency. As should be evident from the study of representations at work at the post office, there are – so far unattended to – differences in the cognitive contributions of man 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 artifacts. Arguably, the humans have access to a higher-level representation of the system itself in which the distinct functions of the artifacts need orchestration. Surely, the artifacts define the task, but it is up to the humans to put them to work.

The leveling of man 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 man from artifacts even under the label of propagation of representations, the analytical framework pushed forward here is much better attuned to the functional/instrumental practices of 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. The artifacts may be constantly reconfigured in light of novel situations. Not only the way the artifacts are organized in relation to each other, but also with regard to 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.

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 at the post office the cognitive analysis of the information processing occurring seems sensible. At 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 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 capturing 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 processing between input and output in organizations is not opaque. Through the analytical lens of distributed cognition these propagations are readily available for inspection which makes organizations even more promising sites of study. Further, through the case study a reinterpretation of representations is carried forth calling for studies of their performative nature. As a consequence, an abandonment or a widening of the cognition as computation framework was 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 orchestration of entire organizations.

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