Distributed Cognition and Communication

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Abstract
Distributed cognition is a theoretical approach that is concerned with the interactions between people, artifacts and both internal and external representations. Rather than focusing exclusively on an individual's internal cognitive processes, that traditional cognitive approaches do, it focuses on the processes that take place in an extended 'cognitive system'. These include verbal and non-verbal behavior, the coordinating mechanisms used by social actors, the forms of communication that take place and the way tacit and explicit knowledge is shared and accessed. One major benefit is the explication of the complex interdependencies between people, artifacts and technological systems that can be often overlooked when using traditional theories of cognition.

Keywords
Distributed cognition, verbal communication, cognitive science, representations, ethnographic studies, collaborative work, coordination, knowledge, distributed problem solving.

The distributed cognition approach was developed by Hutchins and his colleagues in the mid to late 80s as a new paradigm for conceptualising cognition (Hutchins, 1995). Its theoretical and methodological bases are derived from the cognitive sciences, cognitive anthropology and the social sciences. The focus is on explicating *cognitive systems*, which are the interactions between people, artifacts and both internal and external representations. Rather than focusing exclusively on an individual's internal cognitive processes, that traditional cognitive approaches do, it focuses on the processes that take place in an extended cognitive system. In so doing, it dissolves the traditional divisions between the inside/outside boundary of the individual and the culture/cognition distinction that anthropologists and cognitive scientists have historically created. One major benefit is the explication of the complex interdependencies between people, artifacts and technological systems that can be often overlooked when using traditional theories of cognition.

Hutchins argues that what is problematic with the classical cognitive science approach is not its conceptual framework *per se,* but its frame of reference being only the mental processes that occurs within an individual. He suggests that the same conceptual framework be applied to larger 'cognitive systems', namely, those where there are multiple people interacting with each other and a range of artifacts to perform an activity. Part of the rationale for this extension is that, firstly, Hutchins believes it is possible to determine the processes and properties of such cognitive systems more reliably – since they can be observed directly in ways not possible inside a person's head – and, secondly, they may actually be different and thus unable to be reduced to the cognitive properties of an individual.

Thus, distributed cognition continues to use concepts derived from traditional cognitive theories of the mind (i.e., representations, processes), but applies them to cognitive systems at large, notably, the interactions between people and the artifacts they use for a given activity. In addition, other concepts derived from the social sciences are utilized to account for the socially distributed cognitive phenomena. These include notions such as inter-subjectivity, organizational learning and the divison of labor.

Cognitive systems that consist of more than one individual have properties that differ from the individuals that participate in them (Hutchins, 1995). For example, individuals working together on a collaborative task possess different kinds of knowledge and so will engage in interactions that will allow them to pool the various resources to accomplish their tasks. In addition, individuals in a cognitive system have overlapping and shared access to knowledge that enables them to be aware of what others are up to. This enables the coordination of expectations to emerge that in turn form the basis of coordinated action (e.g., glancing and nodding at someone to signal it is their turn to do something rather than explicitly asking or telling them).

To reveal the properties and processes of a particular cognitive system involves conducting an in-depth ethnographic study of a setting, paying close attention to the activities of people, their communications with each other and their interactions with different media. These are conceptualized in terms of 'the propagation of representational state across media'. The propagation of representational state refers to how information is transformed during the conduct of an activity. The media refer to both internal (e.g., an individual's memory) and external representations (including both computer and paper-based displays.). So, for example, the information displayed by a computer system transforms its state in response to an operator keying in a command. To analyse how the various representational states are propagated, attention is focused on the transformations of information between the different media. For example, consider the activity of flying to a higher altitude in a plane that takes place through the coordinated activity of an air traffic controller, a co-pilot and a pilot. The air traffic controller tells the co-pilot over the radio when it is safe to fly to a higher altitude. This is an instance of a propagation of representational state, involving verbal communication. The co-pilot then alerts the pilot, who is flying the plane, by moving a knob on the instrument panels in front of them, indicating that it is now safe to fly. This is the next step of the propagation of representational state, but this time in terms of a physical change in the position of an instrument.

In addition to this level of analysis, the distributed cognition approach involves explicating:

- the distributed problem-solving that takes place (including the way people work together to solve a problem)
- the role of verbal and non-verbal behavior (including what is said, what is implied by glances, winks, etc. and what is not said)
- the various coordinating mechanisms that are used (e.g., rules, procedures)
- the various ways communication takes place as the collaborative activity progresses.
- how knowledge is shared and accessed

An important aspect is to identify the problems, breakdowns and the concomitant problem-solving processes that emerge to deal with them. The analysis can also be used to predict what would happen to the way information is propagated through a

cognitive system using a different arrangement of technologies and artifacts and what the consequences of this would be for the current work setting.

A much quoted example of an extensive distributed cognition analysis is the navigation of a ship (Hutchins, 1995). Here, the focus is on the cognitive and communication processes that take place when steering a ship into harbor. Hutchins describes the detailed coordination of representational states across media that take place for the relatively simple, but critical coordinating activity of plotting a fix. This involves several members of the navigation team taking and plotting bearings of the ship as it comes into the harbor at regular intervals of three minutes. It is a highly routinized activity, requiring the complex coordination of people and artifacts - all of which is crucial for ensuring the ship is on course. He also describes how these coordinated activities of plotting a fix provide a structured experience for the team members, enabling more generally, individual learning of procedures and the cultural practices of the navy. As noted by Hutchins (1995, p374):
"...since most learning in this setting happens in the doing, the changes to internal media that permit them to be coordinated with external media happen in the same processes that bring the media into coordination with one another. The changes to the quartermasters' skills and the knowledge produced by this process are the mental residua of the process".

The distributed cognition approach has been used to analyze collaborative work practices for a number of different application areas, including cockpits (Hutchins & Klausen, 1996), call centers (Ackerman & Halverson, 1998), control centers (Garbis & Waern, 1999), software teams (Flor & Hutchins, 1992) and design and engineering teams (Perry, 1997; Rogers, 1992). More recently, Hutchins and his colleagues (Hollan et al., 2000) have set an agenda explaining how distributed cognition can be applied to wider contexts. In particular, they maintain it is well suited both to understanding the complex networked world of information and computer-mediated interactions and to informing the design of digital work materials and collaborative workplaces. Others have also shown how the approach can be adapted for more applied concerns. Kirsh (2004) and Rogers and Brignull (2003), for example, have recently shown how ideas from distributed cognition can be used to inform the design of interactive multimedia applications and new physical workspaces. The distributed cognition approach has also been used as a basis for a user modeling technique, known as the 'resources model' (Wright et al., 2000). It provides a method for analyzing and comparing how interfaces work through identifying the way different interaction strategies exploit different information structures as resources for action. It has been particularly useful for showing the limitations and problems of poorly designed dialog-based interfaces that assume too much on behalf of the user as to know what to do next.

In sum, the distributed cognition approach seeks to explicate the complex interdependencies between people and artifacts in their work activities, of which an important part is identifying the problems, breakdowns and the distributed problem-solving processes that emerge to deal with them. In so doing, it provides multi-level accounts, weaving together "the data, the actions, the interpretations (from the analyst), and the ethnographic grounding as they are needed" (Hutchins & Klausen, 1996, p.19).

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