A perspective on all cognition? A study of everyday environments from the perspective of distributed cognition.

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Abstract

Distributed cognition is a perspective that primarily has been applied to complex socio-technical systems such as flight decks of commercial airliners, or operating rooms where professionals perform cognitive tasks in environments specifically designed for this. For some scholars distributed cognition is exactly this kind of specialized cognitive system. On the other hand it has been claimed by some workers in the field that distributed cognition is not a kind of cognition but a perspective on all cognition. We have therefore studied an environment very different from the systems previously studied, namely single people's homes. We find that there are many similarities between the home and the specialized socio-technical environments. To us this suggests that the specially designed complex environments can be seen as specialized cases of the general principles of distributed cognition which are not reflections of "particular work practices" but of general features of human cognition.

Keywords: everyday cognition; distributed cognition; memory practices.

Introduction

Situated and distributed cognition is not one but many closely related views on or approaches to cognition, which all have in common that cognition is not viewed solely a process residing in the head of the agent, but instead cognitive processes exist in, or at least are influenced by, the agents physical and social environment (Hollan, Hutchins, Kirsh, 2000). There seems however not to be any consensus between workers in the field on how these closely related but different approaches relate to each other. For Robbins and Aydede (2009, p 3) "situated cognition is the genus, and embodied, enactive, embedded, and distributed cognition and their ilk are species", though they note that this usage is not standard, and it is not difficult to find competing views. For instance, Zhang & Norman (1994) claim that distributed cognition has three key components: (1) Embodiment of information that is embedded in representations of interaction, (2) Coordination of enaction among embodied agents, and (3) Ecological contributions to a cognitive ecosystem, which suggests that in their view at least embodied cognition is a sub-aspect of distributed cognition. And Sutton (e.g. 2006) takes a still wider perspective on distributed cognition, which includes embodied and situated aspects among also others.

When it comes to empirical research, almost all the studies on distributed cognition that we are familiar with are detailed studies of complex socio-technical systems, such as flight decks of commercial airliners (Hutchins, 1995a, Hutchins & Klausen, 1996; Dekker, Nyce, & Myers, 2013, navigation teams on the bridges of large vessels (Hutchins, 1995b, Lützhöft, 2004, Lützhöft & Dekker, 2002) operating theatres (Hazlehurst, Gorman, & McMullen 2008; Hazlehurst, McMullen, & Gorman 2007). This is by some scholars taken as a defining feature of the field, as when Rogers and Ellis (1994), to take one example, writes that distributed cognition is an approach which takes as the fundamental unit of analysis "a collection of individuals and artefacts and their relations to each other in a particular work practice". And this characterization seems also to fit studies of very different settings and in very different historical periods, such as Tribble's work on actors' memory for their role and lines in early modern theatre companies, such as Shakespeare's plays when they were first performed (Tribble, 2005; Tribble & Sutton, 2011)

There are a number of features that these environments have in common. First, they consist of teams of many persons with specialized tasks and who have specialized training in performing these tasks. Second, they take place in or rather also consist of a specialized technical environment, which is specially designed to support the tasks being performed by the operators as individuals and the system as a whole.

In contrast to the views on distributed cognition as a kind of cognition particular to specific environments mentioned above, Hutchins claims that distributed cognition is not a kind of cognition but a perspective on all cognition (2013), despite the fact that almost all empirical work within the framework of distributed cognition has been on professional teams working to solve tasks which require the coordination of many agents and their tools to succeed.

One feature that characterizes this approach to distributed cognition is that it keeps the 'cognitivist' view of cognition as computation. "I do believe that the computation observed in the activity of the larger system can be described in the way cognition has been traditionally described – that is, as computation realized through the creation, transformation, and propagation of representational states (Hutchins, 1995b, p.49). This definition is further specified: "…the actual implementation of many interesting computations is achieved by other than symbolic means. For our purposes, 'computation' will be taken, in a broad sense, to refer to the propagation of representational state across representational media. This definition encompasses what we think of as prototypical computations (such as arithmetic operations), as well as a range of other phenomena which I contend are

fundamentally computational but which are not covered by a narrow view of computation" (Hutchins, 1995, p.118) Computation is here thus seen as something wider than formal computation in a strict sense. Our interpretation is that this concerns representations that have some kind of combinatorial syntax, and that the transformations of the representations are made partly based on the agents' understanding of also the semantics of the representations.

Another feature is that cognitive systems can exist on many levels which makes it similar to Cognitive Systems Engineering (Woods and Hollnagel 1983, 2005). Systems consisting of one or more agents (persons) and their physical environment including specially designed cognitive tools can have cognitive properties in their own right which are not the same as the cognitive properties of e.g. the agents in the system. One clear example of this is in Hutchins (1995a) analysis of the flight deck of a commercial airliner, where he states that "To call speed bugs a "memory aide" for the pilots is to mistake the cognitive properties of the reorganized functional system for the cognitive properties of one of its human components. Speed bugs do not help pilots remember speeds, rather they are part of the process by which the cockpit system remembers speeds" (Hutchins, 1995a, p.283).

Another feature of this version of distributed cognition is its emphasis on the close connection between cognition and culture. "I am proposing an integrated view of human cognition in which a major component of culture is a cognitive process (…) and cognition is a cultural process" (Hutchins, 1995b, p 354). A corollary of this is that the historical and cultural development of cognitive systems and functions is important for understanding its current workings, which for instance forms an important part of the analysis of the cockpit as a cognitive system.

But, as mentioned above, most if not all empirical work on distributed cognition has been in complex socio-technical environments, and it is clear that this perspective has helped us understand hitherto unobserved aspects of these environments. The question that we have sought an answer to is then: what can be seen from this perspective when studying agents and environments very different from those previously studied. To do this, we have conducted a cognitive ethnography in an environment possibly maximally distant from the ones mentioned above, namely home environments and single individuals. Previous work in everyday environments by e.g. Kirsh (1995) has primarily focused on theoretical aspects of distributed cognition in such environments with examples illustrating the theoretical points made. There are also empirical studies from home environments which have focused on the management of particular tasks such as medication management (see Palen & Aaløkke, 2006). But to our knowledge no previous study has been conducted and presented of homes as distributed cognitive systems in their own right.

On first appearances, it would seem that an apartment with one person living there, is very different from the complex specialized socio-technical environment previously studied, and that therefore many of the features mentioned above will not be present there. The aspects in focus in this study are that an apartment is in a sense more of a multi-purpose device than an environment for one or a few cognitive tasks, and it is not designed to support cognitive tasks per se. Further, there is no professional training in solving the cognitive tasks for the person living there. And finally, while there certainly is a long historical tradition behind the design of a home and how it is furnished today, this historical development has as far as we can tell, not been driven primarily by a concern for successful performance in cognitive tasks.

So what can we actually see when viewing this kind of environment from the perspective of distributed cognition**?** We are of course not claiming that one perspective is in any absolute sense better than another, but as with any changes in perspective, some aspects become more visible and some become less visible. There are two closely related questions we address here: First, what can be seen in the home as a cognitive system when viewed from the perspective of distributed cognition. Second, which are the differences between the previously studied socio-technical environments and the home.

The Cognitive Ethnography

Eight homes have been studied during a period of two years. The total number of hours in the field and to a lesser extent on the phone with the informants equals roughly 70 hours distributed across 48 occasions of observations, video recordings, and interviews. The time for real-life meetings varied from one and a half hour to four hours. Telephone chats were no longer than 10 minutes.

In-home interviews, telephone chats, and photographs have been used to study the physical settings more broadly. Some activities have been studied more closely. These include leaving home, grocery shopping, cooking and keeping track of the near future. The data collection has been explorative and has therefore not been absolutely balanced across the homes. Some homes have been studied in more detail and across more occasions than others. All homes except from one are single individual households, and all residents have been studied doing individual activities. Despite this, as in any ethnography, the data collection is conducted in a social context.

Two of the homes have been studied specifically in relationship to when residents are about to leave home. For these homes video-recordings have been the primary source of data. The participants wore a head mounted camera (GoPro Hero 2) for about one hour before leaving their home, but with no researcher or other person present during this period. In total the video analysis is based on three hours of video distributed across six occasions of leaving home (Kristiansson, Wiik & Prytz, 2014).

The residents' age span from 70 to 88, and they all manage everyday life by themselves. All except two live in apartments in central areas of a medium-sized city in Sweden. Two live in the outskirts of the same municipality.

Five live in one to two-room apartments. Two in large four room apartments and one in a house. Below the participants are anonymized and referred to by an alias.

The analytical work can be described as a combination of bricolage (Kvale & Brinkmann, 2013) and as following a funnel-approach (Agar, 2008). Bricolage is not a completely systematic approach. Instead analytical tools are used freely across the material to note patterns and themes in the material. The funnel-approach is Agar's name for the inductive approach of over time focusing on indicative aspects of the material. This consequentially means that the analysis focus on some aspects. For this article the funnel-approach has been used to zoom in on indicative aspects of the material in relationship to principles and characteristics of distributed cognition. Distributed cognition has therefore been used as the primary analytical tool. For more details on the ethnographic method see Kristiansson (2016).

Notes from the field study

In this section we will give some examples from the field work, which in the following section will be analyzed with respect to the features of distributed cognition previously presented. In this paper we concentrate on a subset of potential aspects previously used in research on distributed cognition: functional spaces, cognitive tools, routines for cognitive tasks, and the cultural historical development. In Kristiansson (2016) additional aspects are discussed.

Functional spaces supporting cognitive tasks

All participants have spaces for which they have more or less deliberately assigned functionality. All have for instance a spot for their home keys, but the particular solutions differ. Felicia has a metal cup on a bench in the hallway where she drops the keys every time coming home, while Greta puts the keys into a pocket of the jacket when coming home, and Charles always puts the keys on the high bench next to the apartment door. Despite the fact that they all have routines for this, these routines are not adhered to as strict as in professional environments. The routines can perhaps in some cases be seen as ideals for how they should do. For instance, on one occasion the observer points out that the keys are not on the bench where he claims they always are, he replies with a joking comment meaning that a non-adherence to a rule or ideal was revealed ("Nu kom du på mig").

Both the hallway and the kitchen commonly have designated areas that serve cognitive tasks. In some cases an area such as a kitchen table is used both for placing things to be remembered to bring when leaving the home and having meals. One participant, Felicia, has instead of using the kitchen concentrated written information and reminder notes regarding future events to a room, "the office", in the back of her large four-room apartment. In this office she has notes on several spots but mostly on a notice-board. The particular solutions across the studied cases differ but they all either have specific spaces used for memory purposes, or transform multi-purpose spaces when performing specific activities.

Cognitive tools

In all environments we find standard tools for remembering future tasks, such as calendars and post-it notes, but also here we see a large variability in how these are used.

In Felicia's office she has notes on several spots but mostly on a notice-board. On a couple of occasions when the observer does walking interviews in her apartment she is cued by notes on and around the board. For instance at one occasion there is an information sheet on a table below the board. When passing she stops and says that she has forgotten to tell about this event, something that she had planned to do. Putting written information and reminders on open places is one way she uses external information to remind herself. Another way appears at a sit-down discussion with Felicia about her recent activities. While Felicia browses through her calendar she suddenly finds a sticky note far in the back. She reads it and quickly says that she has already finished this intention. Putting information in less prominent places in this way is another way Felicia aims to remind herself. Also, it seems that when intentions become really important or urgent for Felicia objects or notes related to the target activity are placed in the hallway area which is normally stripped from explicit information.

Therefore, despite that Felicia uses written information a lot and to some extent concentrates it in one room her practices of using it is not confined to one kind. This can be contrasted with the case of Beatrice's home.

Beatrice is the participant that seems to use the largest quantity of cognitive tools that hold symbolic informational content. These uses of cognitive tools are the type of processes that the most resembles distributed cognition that has been observed in professional settings. Except from the card-index system that will be described below Beatrice has a pocket calendar, a wall calendar, a list of people that have invited her which she should invite back, a diary, a catalogue over read books, a to-do paper with five categories, a work-in-progress shopping list and more. For specifics of a few of them see below.

The pocket calendar presents a new week on each page turn, and the calendar is located next to the phone in the kitchen. This is a deliberate strategy because this is where most entrances are made. The calendar is almost full every day roughly two weeks onward. The calendar has two bookmarks. One silk-ribbon to mark where she last time ended moving information to her diary and one red card to signify the present.

She has a well-organized social life which is managed with a set of cognitive tools. For instance, at the back of the calendar she has a page with names ordered in a list. The order of the list signifies in which order she owes her friends an invitation. A cross next to the name means that they have managed to invite her two times before. Crossed out names means that she has invited them back and that they therefore are even. Next to the list she has a space

where she sketches on constellations over soon-to-come invitations. Currently there are two clusters of names that corresponds to the list of names. Some names have arrows to both constellations. Most often she only keeps track of her own social debts. She also mentions some aspects of some individuals on the list. Some are more tired and cannot invite back in the same pace as others. Some cannot visit at all and are handled with the tool below. One couple only comes once a year and need to be planned accordingly.

Placed next to the phone in the kitchen is a to-do-list that hold six categories: to buy (no groceries since they are managed separately), to visit, to phone, to write, to invite and, to fix.

This paper with categories leads to the fact that there are few reminder notes spread across her home. Also, because every type of future intention has a designated external spot spatially close to the other kinds, the sheet of paper works as a good overview tool. First, this shows just as previous research within work settings, that the specifics of external representations shape coordination of internal processes and external structures. Second, it also shows that the specifics of how reminder notes are used can partly determine their functionality. Altogether, what is apparent from the observations of Felicia and Beatrice is that in terms of note-taking the inter-individual differences between these distributed systems are large.

Routines for cognitive tasks

Cognitive tools or spaces are of course not enough in and of themselves. They need to be put into use, preferably through routine practices which we see many instances of. Moa, for instance, has a number of functional spaces in the kitchen and hallway where important objects are located. Before leaving home objects are moved from one of these spaces to another as a preparation for leaving. These spaces are also iteratively browsed almost every time when she passes them before leaving home, which leads to that important items are being moved, sometimes in many steps, to the bag-to-bring that is always located on the kitchen table. The kitchen table is also the functional space located farthest away from the exit door, which means that the other spaces will be scanned a final time just before leaving the apartment.

Cultural historical development

Many practices come from people's experiences of other people's practices. Consider again Beatrice. One of her cognitive tools is a card-index system over all social dinners she have made during the last 50 years. The index includes dates, invited guests, what she (and her husband) served, and comments. The idea to the card-index system, she says she remembers clearly, comes from the mother of a friend from her youth that used a similar card-index system. "I found it really smart", she says, and also says that she started using the card index shortly after she married her husband, with the incentive to not serve the same thing twice to the same guest.

An extended example

We will in the final part of this section present a longer illustration of the use of the cognitive tools and spaces. This is based on an analysis of a head mounted video recording made without any observer present.

At one occasion Moa five minutes before leaving home for an exercise session searches for something. The object(s) turns out to be two cards, one that looks like a bus card and one that looks like an exercise card, both of which she needs for the current occasion of leaving home. This search is interesting because it highlights functional relationships between residents and the home environment that involve physical resources out of plain sight that in the past have been shaped as a consequence of previous occasions of similar activities, where Moa in a stressful situation needs to use a combination of opportunistic actions and different deliberate mental resources to gain knowledge of the her own cognitive systems.

A number of objects and spaces were involved in the search: (a) the pockets of a small handbag located on a chair in the kitchen, (b) the pockets of a medium sized shoulder bag for exercise located on the kitchen table, (c) pockets on a number of jackets located on a rack in the hallway, (d) the top of a larger kitchen bench, (e) the top of a portion of the kitchen sink, (f) the top of a smaller bench in the hallway, and (g) the top of a larger bench in the hallway. At a quick glance the search started with the shoulder bag, then past the spaces over to the rack, and back to the kitchen past the spaces, then she searches handbag and finally the shoulder bag once again where she finds the cards. The entire search takes about two minutes. The top surfaces were during this short episode quickly visually looked at when passing by.

If we look closer on how the specific search of the shoulder bag and the jackets evolves we can see something that can be interpreted as a trade-off between fast and opportune actions and deliberate guiding decisions. When Moa searches the jackets she does not search all the jackets equally. Six jackets are searched with relatively distinct hand movements while the pockets of one jacket is searched with quicker in-and-out movements. The last two jackets on the racket (as seen from the entrance) she stops and stares at and determines not to search. These are the two thickest jackets on the racket. Moa likely has a more or less rough idea of when the last time she used the cards was. This knowledge conjoined with the knowledge of that it is currently spring makes it unlikely that the cards should be found in jackets intended for winter. There is therefore what can be seen as a trade-off of the opportune actions sequences of searching jackets and the ongoing guiding thoughts of when to stop the sequence of search. Moa uses what seems to be deliberate remembering processes in combination with physical search. For the jackets in the case of Moa this combination of resources appear to be an efficient search heuristic for this occasion. But if we look at the search of the shoulder bag from a similar perspective we instead see something that from an outside perspective is inefficient.

The black shoulder bag consists of six pockets: a large pocket, a large side pocket and four small side pockets. Small side pocket 2 is closed from start. When Moa searches the shoulder bag the first time she has previously, about five to ten minutes ago, interacted with the bag several times for other reasons related to the packing of the bag. Interactions these times have been with the large pocket and the large side pocket. The fact that Moa has interacted with the bag previously we can take into account when we view how she searches the bag. The first time Moa searches the bag she starts by looking into the large side pocket, stretching the opening with her hands. The missing thoroughness here is not strange given she has had her hand into that pocket before. Then she tilts the bag so that the small side pocket 2 is turned towards the head of Moa. (This is where the two cards later will be found.) After searching other pockets with her hands she will again interact with this pocket by quickly touching the pocket. It appears that she takes micro-decisions as she goes along similar to the way she made decisions about what jackets to search.

We have seen that Moa makes decisions as she goes along. We have also seen that decisions can sometimes be detrimental. We can have ideas of why Moa skipped searching some jackets given what we know about external conditions of weather and jackets. It is harder from the video to know why she does not initially searches small side pocket 2 even though she appears to consider it. But something we can see in the video is that the target pocket also contained a pair of glasses. The glasses was not a flat object. When she takes that object out from that pocket she does that quickly and puts it in another bag next to the shoulder bag. Here we can think of two paths of why she initially decided to not search this pocket. The first one is about her previous interaction with the content of the pocket (not captured by the video). This could be the last time she used the cards but it could also be the moment when she put the unidentified object into that pocket. A possibility is that this created an idea of that this space already has an object which therefore would override the pocket as a space for the two cards. Another decision path is about the physical features of cards. If we view the shape of the pocket, small side pocket 2 is the only side pocket that clearly have a content, and that content is for certain not a flat object. This is because it is closed and the ratio of the size of the pocket and the content of the pocket creates a wrap around the non-flat object. This suggests that the reason for Moa skipping searching small side pocket 2 could have nothing or little to do with remembering but instead about interpretative processes of the pocket's features.

Discussion

We asked in the introduction two questions. First, what can be seen in the home as a cognitive system when viewed from the perspective of distributed cognition. Second, which are the differences between the previously studied socio-technical environments and the home.

Our findings suggest that even though the home is not an environment specifically designed for solving one specific (professional) cognitive task or function, when looked at from the perspective of distributed cognition a number of interesting similarities with the more commonly studied complex socio-technical environments are revealed. Parts of the environments are designed or modified to serve one or more cognitive tasks, in many cases retrospective but more commonly prospective memory, and similar to the socio-technical environments previously studied, the use of these is often done through particular routines where the place, tool, and the routine together serve a cognitive function.

It should be noted that we see a large variation in the concrete implementation of these functions in the eight environments we have studied. For instance, one informant (Beatrice) has developed a large number of specialized tools for several cognitive tasks. Since the studies of professional environments in most cases concern only one instance of these, we however cannot say whether this is a difference between professional and non-professional environments.

It must also be noted that there are instances of cognition in home environments such as visits by home healthcare professionals which creates a combination of professional and non-professional environments (see Kristiansson, 2013, Dahlbäck, Kristiansson, Stjernberg, 2013 & Palen & Aaløkke, 2006). Therefore the contrast we make here between the two kinds should not be seen as two discrete cases, but rather two endpoints on a continuum.

There are further reasons for not seeing professional and non-professional environments as fundamentally different kinds. All participants display levels of expertise in how they manage their daily chores. How they for cognitive tasks shape, use and interpret their physical environments is for instance based on their knowledge of their own practices. Of course such mechanisms establishes a cognitive connectivity between the agent and aspects of their environment that equals to some sort of expertise. Further, despite the fact that participants for most daily chores have not received professional training there are cases when participants have experiences (of cooking, financial management, healthcare etc.) from their previous working lives that feeds expertise into their management of daily life. Thus, this lends support to Kirsh's (2009) claim that most people become experts or near experts in dealing with their everyday environments.

Similar to professional environments, we also found examples of a kind of cultural knowledge accumulation of the cognitive elements in the home environments, where the informants tell us how some of their routines and tool designs are learned from or influenced by older generations. What we did not see in this study is any form of socially distributed memory, which of course is a natural consequence of the fact that we have studied environments with only one person. But it is for instance interesting to note that one informant, Beatrice, decided to develop a complex memory tool for remembering social events when her husband has passed away, which can be interpreted as a

transformation of a distributed memory system initially comprising of two persons to a one person system with the same function when one of them is no longer there. So the details of the distributed memory system changes with changing circumstance while keeping the basic functionality.

Despite the differences between the two prototypical cases of professional and non-professional environments we have described, the pattern that emerges is one of a continuum in cognitive functioning between the everyday environment and the complex socio-technical environments previously studied from the perspective of distributed cognition. We have also as yet unpublished studies of e.g. families with children, which, while of course differing in details, show no fundamental differences with what we present here. To us this suggests that the specially designed complex environments can be seen as specialized cases of the general principles of distributed cognition which are not reflections of "particular work practices" but of general features of human cognition.

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