

In Search of the Holy Grail: Understanding Artefact Mediation in Social Interactions

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Abstract

Traditionally cognition has been regarded in terms of internal symbolic representations and computational processes, while the environment largely has been reduced to inputs and outputs. More recent situated cognition approaches emphasise the role of environmental resources in cognition, and today it is well known that artefacts affect, not only the individual, but also social interactions. Despite a growing emphasis on the role of artefacts we still have only a limited understanding of the ways artefacts are used and adapted to support cognitive capabilities. This paper presents initial steps in the development of a framework that can contribute to a more principled understanding of the role of artefacts in social interactions. This focus on artefacts is based on concepts from human-computer interaction and cognitive science: triggers, placeholders, and entry points. Triggers and placeholders concern the way environmental resources affect, and are used in, work processes. Entry points, on the other hand, concern the ways people adapt their environments, with a focus on the properties of artefacts. These concepts complement each other and provide a perspective that integrates agent, environment, activities, and temporal aspects. This part of the framework is illustrated by a case study conducted in a setting where artefacts take a central role in the ongoing work processes.

Keywords: artefacts; social interaction, trigger; placeholder; entry point, case study.

Introduction

Traditionally cognition has been regarded in terms of internal symbolic representations and computational processes, while the environment largely has been reduced to inputs and outputs (e.g., Pylyshyn, 1990). However, since the mid-1980s there has been a growing awareness that individuals are socially and culturally situated and that the environment needs to be considered in order to understand cognition (Clancey, 1997; Clark, 1997; Hendriks-Jansen, 1996; Hutchins, 1995; Suchman, 1987). From this perspective, cognitive processes are not confined to the individual's head, but instead extend to include external, material and social, resources (Clancey, 1997; Clark, 1997, 1999; Clark & Chalmers, 1998; Susi, et al., 2003). It has even been stated that one of the fundamental findings of cognitive science is that artefacts shape cognition and collaboration (Woods, 1998). The general idea reaches back to the Russian cultural-historical school in psychology, and Vygotsky's research in particular (e.g., Galperin, 1969; Leontiev, 1978; Vygotsky, 1978). According to Vygotsky, "[t]he inclusion of a tool in the process of behavior...re-creates and reorganizes the whole structure of behavior" (1981, p.139-140). Recognising artefacts as an important

element in human activities does not mean that they are merely some kind of appendages, or external elements that exert some influence on cognitive processes. Rather, they are part and parcel of our cognition, and it can be considered a mistake "to posit a biologically fixed 'human nature' with a simple 'wrap-around' of tools and culture. For the tools and culture are indeed as much determiners of our nature as products of it" (Clark, 2002, pp.27-28; Rogoff, 2003). While research in cognitive science has led to insight into individuals' cognitive processes (Day, 1988; Cox, 1999; Norman, 1991), other perspectives, such as ethnographical, anthropological, cultural-historical, and situated cognition research have taken a broader view on cognition, including social and material aspects (e.g., Engeström et al., 1999; Heath & Luff, 1996; Hutchins, 1995). These broader perspectives have shown the crucial role of artefacts in the coordination of collective activities (Hutchins, 1995; Rambusch et al., 2004; Susi & Ziemke, 2001). However, despite the emphasis on external resources and their use, and a large number of studies of artefacts, we still have a poor understanding of the ways people utilise and adapt artefacts in their work to scaffold their cognitive abilities (Clark, 2002; Gauvain, 2001; Perry, 2003; Preston, 1998; Wynn, 1993). Clark (2002), for instance, argues that "the single most important task...is to better understand the range and variety of types of cognitive scaffolding, and the different ways in which non-biological scaffoldings can augment (or impair) performance on a task". Clark further states: "The Holy Grail here is a taxonomy of different types of external prop, and a systematic understanding of how they help (and hinder) human performance" (p.29).

This paper describes part of a framework concerning artefacts (with a focus on material objects) and human activities, based on the integration of concepts from two different research areas (human-computer interaction and cognitive science). The possible use of the combined concepts is illustrated by a case study in a collaborative work setting.

The next section describes in some detail the concepts of triggers, placeholders, and entry points. Then an emerging framework, focusing on the integration of the three concepts, is described. The next section presents an illustrative case study, followed by a discussion.

Triggers, Placeholders, and Entry Points

In human-computer interaction, in the work of Dix et al. (1998a; 1998b; 2004), we find a concern for the ways in which environmental resources contribute to work activities. Dix et al. (2004) propose *trigger analysis* as a way to analyse work activities, and to find out why things happen

when they happen. Trigger analysis is a complement to other task analysis methods and shows the ways external resources initiate activities, function as reminders of where in a work process people are, and ensure that tasks are carried out in full. This kind of analysis also reveals whether a certain task is robust to interruptions and delays, and if there are failing triggers that may cause a breakdown in a work task. Of interest, for present purposes, are the concepts of triggers and placeholders. A *trigger* is something that prompts an activity, something that tells you that you need to *do* something. Triggers identified by Dix et al. (1998; 2004) include:

- *Immediate*: takes place when an activity begins immediately after a previous task is completed (e.g., open post as soon as it has been brought to the desk).
- *Temporal*: actions that happen at regular intervals or after a particular delay (e.g., check diary first thing every morning, send a reminder letter two weeks after the original letter was sent, regular routines).
- *Sporadic*: when someone remembers that something must be done (e.g., remembers to write something in a diary after having been interrupted)
- *External event*: some external event occurs (e.g., phone call, face-to-face request, signal/reminder from automatic calendar).
- *Environmental cue*: something in the environment that reminds us that something needs to be done. The cues are coded explicitly (e.g., to-do-list, entry in calendar) or implicitly (e.g., half-written letter).

A *placeholder*, on the other hand, is something that tells you *what* you need to do. Placeholders help people keep track of where in the process they are, reminding them of what to do next, thus making sure that tasks will be carried out. Placeholders are stored in different ways (Dix et al., 2004):

- In people's heads: they remember what to do next.
- Explicitly in the environment: to-do-lists, planning charts, notes.
- Implicitly in the environment: whether the in-tray is empty yet.

Some triggers and placeholders may seem similar to one another, but in some cases an artefact can in fact be both a trigger and a placeholder. A to-do-list, e.g., may trigger an activity written on the list. At the same time the list may be a placeholder telling what needs to be done next. One of the questions Dix et al. (1998) ask is what it is that makes someone notice a cue. An answer that fits the question is found in another line of research, in cognitive science, that is also concerned with artefacts and work activities.

Kirsh (1996; 2001) takes an interest in the ways people actively use environmental resources to structure their work, e.g., in offices. According to Kirsh, concepts like reminders, placeholders, and triggers may be helpful for understanding work contexts, but they do not help us gain more insight into their deep structure. Instead, he argues, we need to move beyond such "surface structures", and describe environmental elements in more abstract terms. Some central concepts in Kirsh's work are *activity landscapes*,

coordinating mechanisms, and *entry points*. In short, activity landscapes are people's interactively constructed workspaces, whereas coordinative mechanisms refer to the use of environmental resources that help people achieve their goals. In the present context, however, it is the third concept that is of most interest - entry points. The concept, influenced by Gibsonian psychology (1986), refers to structures or cues that invite people to do something, "typically information or communication related things". In other words, an entry point is "a structure or cue that represents an invitation to enter an information space or office task" (Kirsh, 2001, p.305). As such, entry points are used as a way of achieving cognitive affordances. Entry points in an office are, e.g., folders, to-do-lists, and day planners. What people do is that they create collections of entry points that tell them what is going on, what needs to be taken care of the next day, and so on. Such collections are personal and subjective as preferences for the number and type of entry points differ. The entry points that office occupants create have different properties, or characteristics that affect the way people react to them, properties that vary along a number of key dimensions (Kirsh, 2001):

- *Intrusiveness*: how much attention, visually or sensorially, an entry point attracts. Items with different colours, e.g., or shape and quality of papers attract different amounts of attention. Intrusiveness determines the probability that the entry point will be approached.
- *Richness in metadata*: how much the entry point conveys about its underlying information. Headings, markings, etc., all provide information about what the entry point holds. The more metadata the entry point holds, the less needs to be kept in memory.
- *Visibility*: how distinct or unobstructed the entry point is. Some entry points, e.g., a calendar or a pile on the desk are more visible than others, like folders in a filing cabinet. The higher the visibility of the entry point, the higher the chance it will be used.
- *Freshness*: when was the entry point last touched? Recency influences recall, and recently touched files, papers, notes, etc., are more likely to be used in current activity.
- *Importance*: how pressing the activity, associated with the entry point, is. An upcoming due date, for example, increases the importance of a matter.
- *Relevance*: how useful an entry point is to a current activity. The probability of using a certain entry point increases the more relevant the entry point is.

The number of entry points created vary from one office occupant to another. So-called "neats" keep their desks tidy with few items on them, which provide a clear structure with a controlled amount of entry points (Kirsh, 2001). "Scruffies", on the other hand, are, or at least seem to be, less in control. Their desks are filled with all kinds of things found in an office, and they make use of ad hoc categories to a greater extent, that is, they create categories as needed.

Either way, with a high or low degree of structure, it provides external scaffolding for their work tasks.

In sum, Kirsh investigates how active subjects make use of environmental structures to scaffold their daily work and to achieve various work tasks. Emphasis lies on the co-adaptation of agent and environment (or office occupant and office), i.e., the individual's cognition and her use of artefacts. The structure provided by entry points reduces cognitive demands and helps people to improve their performance. A central concern is the various *properties* of entry points that affect the way people react to them. Dix et al.'s work primarily focuses on work *processes*, and central issues are why things happen when they happen, and how people know what to do next. Part of the answer lies in the role of artefacts as triggers and placeholders. This work has its focus mainly on individuals' use of environmental resources, but adds a temporal aspect that is much less clear in Kirsh's work.

An Emerging Framework

The concepts described in the previous section provide some initial steps in the development of a framework for further understanding of artefacts and their role in social interactions. First, however, let us clarify what the term "framework" itself means in the present context. The view adopted here is based on Crick and Koch's (2003) description of framework. In their view, a framework combines different ideas that are novel, or ones that have been previously presented by an author herself or by others. Although the ideas in themselves may not be new it is the *combination of ideas* that is original. According to Crick and Koch, a framework is "not a detailed hypothesis or set of hypotheses; rather, it is a suggested point of view for an attack on a scientific problem, often suggesting testable hypotheses" (p.119). They argue that "[a] good framework is one that sounds reasonably plausible relative to available scientific data and that turns out to be largely correct. It is unlikely to be correct in all the details. A framework often contains unstated (and often unrecognized) assumptions, but this is unavoidable" (Crick & Koch, 2003, p.119). The framework under consideration here takes Activity Theory

(AT) as a basis (Engeström, 1987, Leontiev, 1978). However, even as AT emphasises the mediating role of artefacts, their role needs to be explained in further detail. The combination of triggers and placeholders, and entry points, can contribute to a more principled understanding of the role of artefacts in social interactions. Due to space limitation, the framework as a whole is not discussed here in further detail. Instead the remainder of the paper mainly focuses on the previously described concepts.

At a first glance, the concept of entry points may perhaps seem to be more elaborated than the concepts of triggers and placeholders, but these two lines of work have different foci, and can be seen as complementary rather than alternative views. While entry points describe in more detail the properties of an artefact, triggers and placeholder comprise 'knowing that' and 'knowing what' in work activities, and they add a temporal aspect. By integrating these concepts (Table 1) we get a fuller view of a work process, including more fine-grained details of artefacts' properties. The rows of Table 1 include the different dimensions of entry points, and the columns include triggers and placeholders. Examples of where these coincide are marked with an "x". Where exactly an "x" should go depends on the activity and setting under study. Subsequently, the table would appear differently in different settings. A schedule, for example, may be an important placeholder and a trigger with different kinds of entry points in one setting, but only play a minor role or not exist at all, in another.

A case study

The potential use of the combined concepts, focusing on artefacts, is illustrated with a recent case study of ours, conducted in a control room at a Swedish grain silo (Lantmännen AB). The use of artefacts in this setting illustrates some of the aspects shown in Table 1. The study was ethnographically inspired, using observations, video recording, and interviews (at present the study is still in progress, and data analysis has not been completed). The participants in the study were two women and four men. Their experience from working in silo control rooms varied

Table 1. Triggers and placeholders (columns), "knowing that" and "knowing what", integrated with entry points (rows) which describe different properties of artefacts. Each "x" exemplifies a case where the concepts complement each other.

Entry points	Triggers					Placeholders		
	Immediate	Temporal	Sporadic	Ext. event	Env. cue	In the head	Expl. in env.	Impl. in env.
<i>Objective</i> Intrusiveness	X	X			X		X	X
Metadata rich					X			
Visibility					X		X	X
Freshness					X		X	
<i>Subjective</i> Importance	X	X			X		X	
Relevance					X		X	

from no previous experience (novices) to 26 years experience. The work processes at the silo are quite complex (the silo actually consists of 29 separate silos, but for the sake of convenience the whole plant is here mostly referred to as 'the silo'). During the harvest season, grain is delivered by local farmers, and by trucks that collect grain from distant farms. There is up to a hundred deliveries per day of (up to) 11 different types of grain. In this setting mistakes can be very costly. One kind of a serious mistake is to (accidentally) transport different kinds of grain into one and the same silo – a mistake that can cost some 70 000 \$. One factor that adds to the complexity is the control panel through which all the mechanical processes are operated (Figure 1). The control panel represents the whole plant, but the mapping between the representation and its underlying machinery is not very good – partly a consequence of new technical features that have been added incrementally over a period of some 10-15 years. The complexity of the control panel is evident from the fact that it takes 2-4 years to learn to use the control panel properly, i.e., to know the effects of all the buttons and switches, and the proper sequences for their use (to start transportation of grain into a silo, e.g., requires a sequence of 12-15 pushes of buttons, with different time intervals). The control room staff, 2-3 people working at a time, coordinates the off-loading and transportation of grain into different silos.

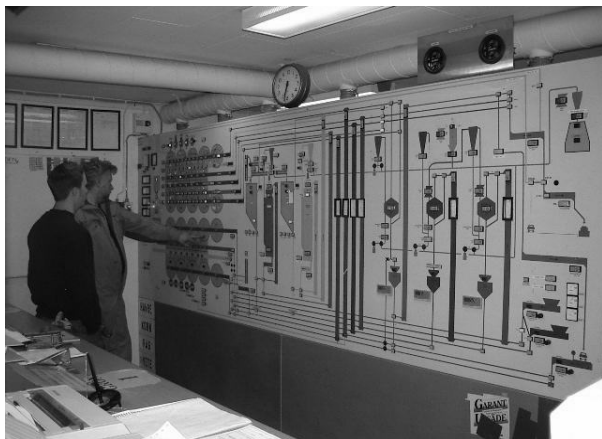


Figure 1. Control panel in the control room. The panel represents the whole plant, e.g., silos ("circles" that the staff is pointing at), and transportations shafts (vertical and horizontal lines). To the left on the wall behind the staff is the whiteboard.

Many work activities are performed individually, but much of what is seemingly individual work, is in fact collective collaborative activities, where much of the coordination is achieved through the use of artefacts. Some of the most important, and most often used, artefacts in this setting are the control panel and a whiteboard (to the left in Figure 1), and documents and the scales used for monitoring transportation of grain (Figure 2). The process of transporting grain into the silo is roughly as follows. On

arrival, the farmer fills in a form (delivery assurance for type of grain, contract number, etc.). The staff prints out additional documents from the computer: forms for all the data concerning the delivery, a strip of bar codes unique to each delivery, etc. All the documents are put together and placed on the desk (Figure 2). The farmer off-loads the grain into one of three pits, from where the grain is mechanically transported into a silo. Each pit is connected to a scale through which the process is monitored (Figure 2). Watching the numbers on the scale is the only way of knowing whether transportation of grain is still in progress, has come to a halt, or been completed. The control panel only indicates whether some mechanical process is running, not whether grain is being transported or not. While the grain is being transported, the staff takes two samples of the grain to check its humidity, protein level, etc., and each sample is labelled with a bar code. When grain transportation is completed, all forms are filled in and filed.



Figure 2. Above the desk, near the ceiling are three scales (black "boxes") used for monitoring grain transportation processes. On the desk lie printers (connected to the scales) and piles of documents.

Next, let us consider a few of these artefacts in terms of the previously described concepts. The *control panel* holds indicators (light on or off), hand-written notes, and magnetic plaques that are all environmental cues (triggers) that prompt different kinds of activities. But what makes someone notice these cues? First of all, what is going on, on an overall level, constantly guides the staff's attention, but whether a certain cue is noticed or not also depends on what kind of an entry point it is. For instance, a yellow post-it note on the control panel catches all the staff's attention (due to its intrusiveness). But the control panel is also 'cluttered' with small magnetic plaques in several different colours, indicating what kind of grain is stored in which silo, if a silo has been filled to its limit, ongoing repairs in the facility, etc. Unlike the post-it note, one more of the small magnetic plaques blend in well among fifty or so others. Being much less intrusive, the magnetic plaque can go unnoticed and cause a breakdown in the ongoing activity.

The indicators are both temporal triggers and placeholders. For instance, as grain transportation is started, there is a whole sequence of pushing buttons, where some of the buttons are not to be pushed before some indicator's light turns on (or off). The indicators thus provide a temporal guidance and structure to the process. In addition, they are also placeholders that tell the staff where in the process they are. As the lights turn on, one by one, they provide very useful environmental cues in the current activity, i.e., each indicator is an entry point where the dimension of relevance affects the staff's reaction to them.

The *whiteboard* is used for leaving notes to each other, things to take care of, some more urgent than others, etc. The whiteboard is also used as storage for magnetic plaques not needed on the control panel. Hence, the whiteboard is also, at times, quite 'cluttered'. All the markings are explicit environmental cues (triggers), but have varying properties. The meaning of some markings is very clear, while others may be more cryptic. The markings vary along the dimension of "richness in metadata". Unclear or much abbreviated messages require that more of its underlying information be kept in memory, than is the case with clear messages.

A number of *documents* are central during the process of transporting grain into the silo. The staff constantly keeps an eye on the documents kept on the desk, as its constitution changes during the process. The bar codes are usually kept on top of the other documents, which provides an environmental cue indicating that a sample needs to be taken. At the same time, the strip of bar codes is a placeholder indicating the process' status. Sometimes the strip of bar codes is placed (accidentally) beneath one of the other documents. In that case it has a very low degree of intrusiveness and visibility, and unless someone actually goes through the documents in time, they sometime miss the opportunity to take a sample, which causes a breakdown in the workflow (the problem then requires other solutions).

Discussion

This paper has combined different ideas concerning artefacts as part of a framework for a more thorough understanding of the role of artefacts in human activities, and the ways we make use of and adapt artefacts. The potential use of the concepts has been illustrated by a case study. Besides necessary theoretical advancements on the issue, a deeper understanding of artefacts also has implications for more applied areas like human-computer interaction and computer-supported cooperative work (Perry, 2003). One favourable aspect of the work discussed here, from a situated cognition perspective, is that it integrates agent, environment, activities, and temporal aspects. Such a combination of views takes us one step further than trigger analysis, as it considers not only 'what' and 'where' of a process, but looks in more detail into *why* something prompts (or not) an activity, and how we make use of artefacts and their features to adapt our environments to support our cognitive capacities. However, the use of the concepts, as presented here, is still work in progress, and their combination needs further elaboration. For instance, depicting a framework as a table implies a rather static

environment where the presence of things can be "ticked off" according to the table's entries, when in fact we are dealing with complex, dynamical interactions between people and environmental resources. These complexities and dynamics are not captured by the table in its present form. Another point concerns theoretical issues. There is much more theoretical work that can, and should, be integrated with the (few) concepts used here, but space limitations do not allow for such discussions here. However, issues of interest are, e.g., the concept of affordances (Gibson, 1986) to which the entry point concept is already related. Of special interest are furthermore *sequential* and *nested affordances* (Gaver, 1991; McGrenere & Ho, 2000).

It is well known that artefacts coordinate collective activities, and work on distributed cognition (DC) (Hutchins, 1995), for instance, has shown the interdependencies between people and artefacts, and the way information is propagated and transformed in ongoing (collective) activities. An important point shown in the present case study, which is not discussed in DC work, is the way the organisation of collective work processes provides a structure to individual activities that in turn continually produces new triggers (and placeholders) for one's own and others' activities. Roughly speaking, when person A puts the documents on the desk, it prompts person B to push the buttons on the control panel to start the mechanical grain transportation process. The start of the process (indicator light on) prompts that person, or someone else, to keep an eye on the scale. The list of bar codes on the desk prompts person C to take a sample, and so on. The coordination of such work activities can also be described in terms of stigmergic principles (Susi & Ziemke, 2001), which explain the achievement of coordinated behaviour through indirect communication via artefacts. Similarly, Activity Theory emphasises the mediating role of artefacts, but it does not provide explanations of the role of artefacts in enough detail. Much research has focused either on the individual's (internal) cognition, or group level activities. However, from an activity theoretical perspective there is no such thing as individual activity, since all activities are social (Leontiev, 1978). If we are to gain a better understanding of the role of artefacts in human activities, we cannot just focus on either individual *or* collective activities. To paraphrase Rogoff (2003), a focus on either/or activity is "as pointless as asking whether people rely more on their right leg or their left leg for walking" (p.65). Hence, a further step in elaborating the present work is to take activity theory as a basis, which considers individual *and* collective activities, and describe typical sequences of activities that take place in a work situation. Such descriptions can then be combined with the concepts of triggers, placeholders, and entry points. That would allow a more fine-grained analysis for each activity, including individual and collective activities, what it is that prompts the activity in the first place, and which new triggers the activity produces. While the framework proposed here may not be the Holy Grail that Clark requests, it can very well serve as a starting point for a more principled understanding of the role of artefacts in human activities.

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