## Cognitive Artifacts

Cognitive artifacts are physical objects made by humans for the purpose of aiding, enhancing, or improving cognition. Examples of cognitive artifacts include a string tied around the finger as a reminder, a calendar, a shopping list, and a computer. In the modern world, many cognitive artifacts rely on LITERACY and numeracy skills. Lists of various kinds support not only MEMORY, but also reasoning about classification and comparison. Goody (1977) argues that the advent of WRITING SYSTEMS fundamentally transformed human cognition. Nonlinguistic inscriptions such as maps, charts, graphs, and tables enable the superimposition of representations of otherwise incommensurable items (Latour 1986). Tabular formats for data are at least three thousand years old (Ifrah 1987), and support reasoning about the coordination of differing category structures, types, and quantities of goods, for example.

People often engage in activities characterized by the incremental creation and use of cognitive artifacts. Doing place-value arithmetic amounts to successively producing artifact structure, examining it, and then producing more structure (Rumelhart et al. 1986). Everyday tasks such as cooking involve a continuous process of creating and using cognitive artifacts. Kirsh (1995) refers to the systematic creation and use of spatial structure in the placement of cooking implements and ingredients as the *intelligent use of space.* Here, the arrangement of artifacts is itself a cognitive artifact.

Norman (1993) relaxes the definition of cognitive artifacts to include mental as well as material elements. Rules of thumb, proverbs, mnemonics, and memorized procedures are clearly artifactual and play a similar role to objects in some cognitive processes (Shore 1996). Of course, material cognitive artifacts are only useful when they are brought into coordination with a corresponding mental element—the knowledge of how to use them.

The behaviors of other actors in a social setting can serve as cognitive artifacts. The work of VYGOTSKY (Vygotsky 1978, 1986; Wertsch 1985) on activity theory emphasizes the role of others in creating a "zone of proximal development" in which the learning child is capable of cognitive activities that it could not do alone. Activity theory takes words and concepts to be powerful psychological tools that organize thought and make higher level cognitive processes possible. In this view, language becomes the ultimate cognitive artifact system, and cognitive artifacts are absolutely fundamental to human consciousness and what it means to be human.

One of the principal findings of studies of SITUATED COGNITION AND LEARNING is that people make opportunistic use of structure. The *method of loci* in which an orator who must remember a speech associates elements of the speech with architectural features of the place where the speech is delivered is a well-known example. Lave, Murtaugh, and de la Rocha (1984) examined the way that shoppers made use of the structure of supermarkets. The layout of the supermarket itself with the orderly arrangement of items on the shelf is the ultimate icon of the shopping list. Regular shoppers develop routine trajectories through this space, thus creating a sequence of reminders of items to buy. Scribner (1984) documented the ways that dairy workers take advantage of the layouts of standard diary product cases in filling orders. Beach (1988) went to bartender's school and learned how to use the shapes of drink glasses and their placement on the bar to encode the drinks in a multiple drink order. Hutchins (1995b) showed how airline pilots take advantage of an incidental feature of the airspeed indicator to identify +/–5 knot deviations from target speeds

by looking at the display in a particular way rather than by calculating. Frake (1985) showed how medieval sailors in northern Europe used the structure of the compass card to "see" the times of high and low tides at major ports. In each of these cases people use designed objects in ways that were not intended by the artifact's designers.

Sometimes even structures that are not made by humans play the same role as cognitive artifacts. Micronesian navigators can see the night sky as a 32-point compass that is used to express courses between islands (Gladwin 1970; Lewis 1972), and forms the foundation for a complex layered mental image that represents distance/rate/time problems in analog form (Hutchins and Hinton 1984; Hutchins 1995a). The Micronesian navigator uses the night sky in the same way that many manufactured navigational artifacts are used.

There is a continuum from the case in which a cognitive artifact is used as designed, to cases of cognitive uses of artifacts that were made for other purposes, to completely opportunistic uses of natural structure.

If one focuses on the products of cognitive activity, cognitive artifacts seem to amplify human abilities. A calculator seems to amplify my ability to do arithmetic, writing down something I want to remember seems to amplify my memory. Cole and Griffin (1980) point out that this is not quite correct. When I remember something by writing it down and reading it later, my memory has not been amplified. Rather, I am using a different set of functional skills to do the memory task. Cognitive artifacts are involved in a process of organizing functional skills into *functional systems.*

Computers are an especially interesting class of cognitive artifact. Their effects on cognition are in part produced via the reorganization of human cognitive functions, as is true of all other cognitive artifacts (Pea 1985). What sets computers apart is that they may also mimic certain aspects of human cognitive function. The complexity and power of the combination of these effects makes the study of HUMAN-COMPUTER INTERACTION both challenging and important.

While cognitive artifacts do not directly amplify or change cognitive abilities, there are side effects of artifact use. Functional skills that are frequently invoked in interaction with artifacts will tend to become highly developed, and those that are displaced by artifact use may atrophy.

Any particular cognitive artifact typically supports some tasks better than others. Some artifacts are tuned to very narrow contexts of use while others are quite general. The ones that are easy are easy because one can use very simple cognitive and perceptual routines in interaction with the technology in order to do the job (Norman 1987, 1993; Hutchins 1995a; Zhang 1992).

Cognitive artifacts are always embedded in larger sociocultural systems that organize the practices in which they are used. The utility of a cognitive artifact depends on other processes that create the conditions and exploit the consequences of its use. In culturally elaborated activities, partial solutions to frequently encountered problems are often crystallized in practices, in knowledge, in material artifacts, and in social arrangements.

Since artifacts require knowledge for use, the widespread presence of a technology affects what people know. Most members of Western society know how to read, use a telephone, drive a car, and so on. Conversely, the distribution of knowledge in a community constrains technology. If everyone already knows how to do something with a particular technology, an attempt to change or replace that technology may meet resistance because learning is expensive.

There is no widespread consensus on how to bound the category "cognitive artifacts." The prototypical cases seem clear, but the category is surrounded by gray areas consisting of mental and social artifacts, physical patterns that are not objects, and opportunistic practices. The cognitive artifact concept points not so much to a category of objects, as to a category of processes that produce cognitive effects by bringing functional skills into coordination with various kinds of structure.

*See also* ARTIFACTS AND CIVILIZATION; HUMAN NAVIGATION; SITUATEDNESS/EMBEDDEDNESS

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