

the electrical excitability of neurons. *Patch clamping* is also a technique for studying the flow of current through cell membranes. As in the case of voltage clamping, voltage across the membrane is typically controlled and the resultant current flow is measured. Mild suction is applied to the microelectrode when the tip comes in apposition with the cell membrane, which thereby creates a very tight and reliable connection. A variant of this technique, called *whole-cell clamping*, involves applying enough suction to rupture the cell membrane within the small opening of the pipette tip. Whole-cell clamping has the benefit of ease of fluid exchange. In general, these last two methods, compared with other intracellular recording approaches, can provide a more detailed description of the characteristics of membrane channel proteins; the experimenter has better control of the experimental situation and can study smaller cells than with previous methods.

To establish the relationship between function and morphology, investigators have carried out intracellular recordings using dye-filled glass pipettes; first, the response characteristics of the cell are studied, after which the dye is injected into the cell. Some dyes, such as Lucifer yellow, diffuse through the entire dendritic network of the cell so that subsequently, using a variety of anatomical procedures, the morphology of the cell can be disclosed in detail. Such studies have succeeded in establishing the functional characteristics of the major cell types identified in the mammalian RETINA, in the CEREBELLUM, and in several other neural structures.

Lastly, microelectrodes can also be used to eclectically stimulate various brain regions. When areas involved in the execution of motor acts are stimulated in alert animals with brief trains of 60- to 500-Hz pulses, the responses elicited provide important clues about the role these structures play in the control of eye, head, limb, and body movement.

See also CEREBRAL CORTEX; COMPUTING IN SINGLE NEURONS; ELECTROPHYSIOLOGY, ELECTRIC AND MAGNETIC EVOKED FIELDS; MAGNETIC RESONANCE IMAGING; NEURON; POSITRON EMISSION TOMOGRAPHY

—Peter Schiller

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Situated Cognition and Learning

Situated cognition and learning is the study of cognition within its natural context. This perspective emphasizes that individual minds usually operate within environments that structure, direct, and support cognitive processes. "Context" can be defined as physical or task-based (including artifacts and external representations of information), environmental or ecological (such as workplace and marketplace), and social or interactional (as in educational instruction or clinical settings). This emphasis on the physical, environmental,

and social contexts for cognition was termed SITUATEDNESS/EMBEDDEDNESS by Lucy Suchman (1987).

As Roy Pea and John Seeley Brown (1987) note, "It may appear obvious that human minds develop in social situations, and that they use the tools and representational media that culture provides to support, extend, and reorganize mental functioning. But cognitive theories of knowledge representation and educational practice, in school and in the workplace, have not been sufficiently responsive to questions about these relationships." As evidence, Jean Lave (1988) cites laboratory studies of cognition that report extremely poor performance by adults on simple arithmetic problems. She argued that asking the same questions in the context of grocery shopping at a supermarket reveals people's competence, and the strategies (e.g., "get best price per unit") used to solve familiar problems. Ceci and Roazzi (1994) also demonstrate the importance of context by showing that child street vendors can solve sophisticated arithmetic problems only when posed as familiar vending decisions. But though related to the ECOLOGICAL PSYCHOLOGY movement, the situated perspective goes beyond arguing for realistic settings and problem content.

Instead, this situated cognition approach argues that the *nature* of cognitive processing is uniquely determined within its context, and that it cannot be studied in isolation without destroying its defining properties. Consider this example: Imagine the myriad devices and agents that play critical roles in cognition while flying a plane. Edwin Hutchins (1995a) conceptualizes this circumstance as a cognitive system extending beyond the physical boundary of the pilot's head, and *distributed* over the people and objects within the environment. The control panel on a 747 can be taken into a lab and studied; however, important features of its use by the pilot may only arise when she is functioning within a team of crew members, during a complete flight sequence, talking to flight controllers in her nonnative English, under darkness, in an airplane with a history of hydraulic indicator failures, for the second time. Hutchins (1995a) argues it is impossible to understand the cognition involved in flying a plane apart from this distributed system in which it is embedded.

Mind and environment interact not only in highly technical tasks, but also in everyday tasks where COGNITIVE ARTIFACTS represent needed information, support decisions, and potentially even interfere with performance (Norman 1987). For example, the mental artifact of the columnar format for arithmetic provides a structure to keep track of information when short-term memory would otherwise be overwhelmed. As Agre and Chapman (1987) suggest, the physical setting can greatly lighten the processing load of the thinker by providing external cues about what to do next and when goals are accomplished (such as giving feedback through elevator buttons that light up when activated). This relationship of cognition to environmental structure is also used in HUMAN-COMPUTER INTERACTION to design artifacts that can exploit cognitive processes while supporting difficult tasks (Winograd and Flores 1986).

The social environment also influences cognition through the presence of other minds to influence, assist, mislead, demonstrate, question, and raise other perspectives. The interactionist method (Cicourel 1987; Jordan and Henderson

1995) examines communication between participants as an externalized measure of cognition. The social context may also provide a method for LEARNING through the demonstration and assistance of others in a “socially constituted world” (Chaiklin and Lave 1993). For example, novices often learn through apprenticeships, where they spend many hours observing and interacting with more experienced team members as they learn to perform tasks on the job (Seifert and Hutchins 1992; Lave and Wenger 1991). Lev Semenovich VYGOTSKY’s activity theory (c.f. Wertsch 1985) proposes that cognitive development even occurs through the witnessing of acts within a social context that are later internalized by the individual. For example, a child may first participate in a class where questions are asked and answered aloud during reading; later, the child may internalize these social interaction processes as the self-monitoring of comprehension during reading (Palincsar 1987).

This *social mediation* approach to the development of cognitive skills has had a tremendous impact on theories of learning and EDUCATION. For example, Tomasello, Kruger, and Ratner (1993) have theorized that underlying sociocognitive concepts and processes give rise to a developmental ordering of learning strategies, from imitative to instructed and finally to collaborative learning. Much recent work in education has focused on identifying the role of social interaction in classroom learning, and proposing ways of facilitating its effects (McDermott 1993; Brown 1989). The notion that a learner’s progress can be understood only in the context of the social classroom directs educational interventions toward altering the social context (Cole 1991), rather than the individual. Many of these interventions are aimed at changing social context through new technology-based activities (Pea 1985; Tripp 1993; Wood 1995) that can expand the learning environment far beyond the time and space delimited by classroom walls.

The situated cognition perspective argues that our goal as cognitive scientists must be to understand the mind as it operates within a natural context. Our theories must account for “cognition in the wild” (Hutchins 1995b) because that is where cognition usually occurs, and where it demonstrates its true capabilities and limitations. The benefits of achieving this goal are not only theoretical, but may also provide many benefits for the structuring of cognition in our daily lives. As this example from Norman (1980) demonstrates, there is much at stake in this enterprise: “In March of 1977, two Boeing 747 airliners collided on a runway at Tenerife, in the Canary Islands, and the crash killed 582 people. What caused the accident? No single factor. The crash resulted from a complex interaction of events, including problems of attentional focus, the effects of expectation upon language understanding . . . a technically limited communication . . . the subtle effects of differences of social structure among the participants, the effects of stress, economic responsibilities and social and cultural factors upon decision making. All in all, it is a fascinating—if horrifying—story for Cognitive Science (pp. 4–5).”

See also DECISION MAKING; ECOLOGICAL VALIDITY; EXPERTISE

—Colleen M. Seifert

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Situatedness/Embeddedness

The situated movement—situated language, SITUATED COGNITION AND LEARNING, situated behavior—views intelligent human behavior as engaged, socially and materially embodied activity, arising within the specific concrete details of particular (natural) settings, rather than as an abstract, detached, general-purpose process of logical or formal ratiocination.

Situatedness arose in the 1980s as a reaction against the then-dominant classical view of mind. The classical approach, inherited from the logical and metamathematical traditions (dubbed “GOFAI” by Haugeland 1997, for “good old fashioned artificial intelligence”), views cognition as: *individual*, in the sense that the essential locus of intelligence is taken to be the solitary person; *rational*, in that deliberative, conceptual thought is viewed as the primary exemplar of cognition; *abstract*, in the sense that implementation and the nature of the physical environment are treated as of secondary importance (if relevant at all); *detached*, in the sense that thinking is treated separately from perception and action; and *general*, in the sense that cognitive science is taken to be a search for universal principles of general intellection, true of all individuals and applicable in all circumstances.

Situated approaches reject one or more of these assumptions, arguing instead that cognition (indeed all human activity) is: *social*, in the sense of being located in humanly constructed settings among human communities; *embodied*,

in that material aspects of agents’ bodies are taken to be both pragmatically and theoretically significant; *concrete*, in the sense that physical constraints of realization and circumstance are viewed as of the utmost importance; *located*, implying that context-dependence is a central and enabling feature of all human endeavor; *engaged*, in that ongoing interaction with the surrounding environment is recognized as primary; and *specific*, in that what people do is seen as varying, dramatically, depending on contingent facts about their particular circumstances.

Within these broad outlines, situated approaches vary widely, from incremental proposals incorporating a degree of context-dependence within largely classical frameworks to more radical suggestions with substantial methodological and metaphysical commitments.

Closest to traditional models are “situated language” proposals for treating INDEXICALS, tense, and other context-dependent linguistic constructs (Barwise and Perry 1983). Terms such as *here*, *I*, and *now* are used on different occasions, by different individuals, to refer to different people and places, in ways that depend systematically on the circumstances of use. Formally, treating such context-dependence requires a two-stage SEMANTICS, distinguishing the MEANING of a word or sentence (the stable “rule” or pattern that the child learns, such as that “I” is used to refer to the speaker) from the *interpretation* of any particular utterance. Thus when two people shout “I’m right! You’re wrong!” their utterances are said to coincide in meaning, but to differ in interpretation. Similarly, “4:00 p.m.” can be assigned a single, constant meaning, mapping utterance situations onto times, depending on the date and time zone.

This general strategy of treating meaning as a function from context to interpretation (λ context . interpretation) has been applied to other forms of circumstantially determined interpretation, including anaphora and ambiguity (Gawron and Peters 1991). Methodologically, it requires a shift in focus from sentence types to individual utterances, and a generalization of inference from truth-preservation to reference-preservation (e.g., to understand why tomorrow we use “yesterday” to refer to what today we refer to with “today”). Nevertheless, such treatments remain largely compatible with classical views of cognition as individualistic, deductive, even relatively abstract (see INDIVIDUALISM).

Many, however, feel that situated intuitions run deeper. A further step, embodied in research on COGNITIVE ARTIFACTS, recognizes that an agent’s embedding situation is not only a semantical resource for determining REFERENCE, but also a material resource for simplifying thought itself. Agents need not remember what remains in their visual fields, nor measure what they can directly compare. More generally, as captured in Brooks’s (1997) slogan that “the world is its own best model,” it is more efficient for an agent to let the world do the computing, and determine the result by inspection, than to attempt to shoulder the full load deductively. Moreover (see, e.g., Kirsh 1995), if the world happens not to provide exactly what one wants, one can sometimes rearrange it a bit so that it does. Lave, Murtaugh, and de la Rocha (1984) cite a near-mythic example of someone who, when asked to make 3/4 of a recipe that called for 2/3 of a cup of cottage cheese, measured out 2/3 of a cup,