Extended cognition

From Wikipedia, the free encyclopedia

Extended cognition is the view that mental processes and mind extend beyond the body to include aspects of the environment in which an organism is embedded and the organism's interaction with that environment.[1] Cognition goes beyond the manipulation of symbols to include the emergence of order and structure evolving from active engagement with the world.[2] As described by Mark Rowlands, mental processes are:[3]

- **Embodied** involving more than the brain, including a more general involvement of bodily structures and processes.
- **Embedded** functioning only in a related external environment.
- **Enacted** involving not only neural processes, but also things an organism *does*.
- **Extended** into the organism's environment.

This contrasts with the view of the mind as a processing center that creates mental representations of reality and uses them to control the body's behaviour. The field of extended cognition focuses upon the processes involved in this creation, and subsumes these processes as part of consciousness. which is no longer confined to the brain or body, but involves interaction with the environment. At a 'low' level, like motor learning and haptic perception,[4] the body is involved in cognition, but there is a 'high' level where cultural factors play a role.[5][6] This view of cognition is sometimes referred to as **'enaction'** to emphasise the role of interplay between the organism and its environment and the feedback processes involved in developing an awareness of, and a reformation of, the environment.[7]

References

1. *Robert D Rupert (August 2004). "Challenges to the Hypothesis of Extended Cognition" (PDF). The Journal of Philosophy **101** (8): 389–428. doi:10.5840/jphil2004101826.*
2. *Tim van Gelder (1999). "Chapter 8: Wooden Iron? Husserlian Phenomenology Meets Cognitive Science". In Jean Petitot, Francisco J Varela, Bernard Pachoud, Jean-Michel Roy, eds. Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science. Stanford University Press. p. 252. ISBN 978-0804736107.*

3. *Mark Rowlands (2010). "Chapter 3: The mind embedded". The new science of the mind: From extended mind to embodied phenomenology. MIT Press. pp. 51 ff.ISBN 0262014556.*
4. *Pietro Morasso (2005). "Consciousness as the emergent property of the interaction between brain, body, & environment: the crucial role of haptic perception" (PDF).* Slides related to a chapter on haptic perception (recognition through touch): *Pietro Morasso (2007). "Chapter 14: The crucial role of haptic perception". In Antonio Chella & Riccardo Manzotti, eds. Artificial Consciousness. Academic. pp. 234–255. ISBN 978-1845400705.*
5. *Carl Ratner (2011). Macro Cultural Psychology: A Political Philosophy of Mind. Oxford University Press. p. 96. ISBN 0199706298. Culture produces the mind; brain circuitry does not. The mind-body problem of how the physical body/brain produces mental, subjective qualia, is the wrong way to frame the origin of consciousness.*
6. *McGann, Marek; De Jaegher, Hanne; Di Paolo, Ezequiel (June 2013). "Enaction and psychology". Review of General Psychology **17** (2): 203–209. doi:10.1037/a0032935.*
7. *John Stewart, Oliver Gapenne, Ezequiel A DiPaolo (2014). "Introduction". In John Stewart, Oliver Gapenne, Ezequiel A DiPaolo, eds. Enaction (Paperback ed.). MIT Press. p. vii. ISBN 978-0-262-52601-2.*

Further reading

- *Robert A. Wilson, and Lucia Foglia (July 2011). Edward N. Zalta, ed, ed. "Embodied cognition". The Stanford Encyclopedia of Philosophy (Fall 2011 Edition).*
- *Monica Cowart. "Embodied cognition". Internet Encyclopedia of Philosophy.*
- *Joe Lau, Max Deutsch (Jan 22, 2014). Edward N. Zalta, ed, ed. "Externalism About Mental Content". The Stanford Encyclopedia of Philosophy (Spring 2014 Edition).*
- *Basil Smith. "Internalism and Externalism in the Philosophy of Mind and Language". Internet Encyclopedia of Philosophy.*
- *Mark Rowlands (2010). "Chapter 3: The mind embodied, enacted and extended". The new science of the mind: From extended mind to embodied phenomenology. MIT Press. pp. 51 ff. ISBN 0262014556.*

The Extended Mind

From Wikipedia, the free encyclopedia

The paper ***The Extended Mind*** by Andy Clark and David Chalmers (1998) [1] is a seminal work in the field of extended cognition. In this paper, Clark and Chalmers present the idea of *active externalism* (similar to semantic or "content" externalism), in which objects within the environment function as a part of the mind. They argue that it is arbitrary to say that the mind is contained only within the boundaries of the skull. The separation between the mind, the body, and the environment is seen as an unprincipled distinction. Because external objects play a significant role in aiding cognitive processes, the mind and the environment act as a "coupled system". This coupled system can be seen as a complete cognitive system of its own. In this manner, the mind is extended into the external world. The main criterion that Clark and Chalmers list for classifying the use of external objects during cognitive tasks as a part of an extended cognitive system is that the external objects must function with the same purpose as the internal processes.

In *The Extended Mind*, a thought experiment is presented to further illustrate the environment's role in connection to the mind. The fictional characters Otto and Inga are both travelling to a museum simultaneously. Otto has Alzheimer's Disease, and has written all of his directions down in a notebook to serve the function of his memory. Inga is able to recall the internal directions within her memory. In a traditional sense, Inga can be thought to have had a belief as to the location of the museum before consulting her memory. In the same manner, Otto can be said to have held a belief of the location of the museum before consulting his notebook. The argument is that the only difference existing in these two cases is that Inga's memory is being internally processed by the brain, while Otto's memory is being served by the notebook. In other words, Otto's mind has been extended to include the notebook as the source of his memory. The notebook qualifies as such because it is constantly and immediately accessible to Otto, and it is automatically endorsed by him.

Going further, the authors ask and answer their own question about the role of enculturation:

> "And what about socially-extended cognition? Could my mental states be partly constituted by the states of other thinkers? We see no reason why not, in principle."

They bring up the recurrent theme of the role of language:

"The major burden of the coupling between agents is carried by language...Indeed, it is not implausible that the explosion of intellectual development in recent evolutionary time is due as much to this linguistically-enabled extension of cognition as to any independent development in our inner cognitive resources."

Background

The "extended mind" is an idea in the field of philosophy of mind, often called extended cognition, which holds that the reach of the mind need not end at the boundaries of skin and skull. Tools, instrument and other environmental props can under certain conditions also count as proper parts of our minds. Closely related topics often conjoined with the idea of "extended mind" are situated cognition, distributed cognition, and embodied cognition.

References

1. *Andy Clark, David J Chalmers (January 1998). "The extended mind". Analysis* ***58*** *(1): 7–19. doi:10.1093/analys/58.1.7.*; reprinted as: *Andy Clark, David J Chalmers (2010). "Chapter 2: The extended mind". In Richard Menary, ed. The Extended Mind. MIT Press. pp. 27–42. ISBN 9780262014038.*; and available on line as: *Andy Clark, David J Chalmers. "The extended mind". Cogprints.*

Further reading

- Adams, Frederick, and Kenneth Aizawa. (2008). *The bounds of cognition*. Oxford: Wiley-Blackwell.
- Arnau, Eric; Estany, Anna; González del Solar, Rafael and Thomas Sturm. (2014). The extended cognition thesis: Its significance for the philosophy of (cognitive) science. "Philosophical Psychology", 27 (1), 1-18.
- Chemero, Anthony. (2009). *Radical embodied cognitive science*. Cambridge MA: MIT Press/Bradford.
- Clark, Andy. (2008). *Supersizing the mind: Embodiment, action, and cognitive extension*. Oxford and New York: Oxford University Press.

- Clark, Andy, and David J. Chalmers. (1998). The extended mind. *Analysis* 58: 7-19.
- Crisafi, Anthony, and Shaun Gallagher. (2010). Hegel and the extended mind. *AI and Society* 25.1: 123-129.
- Estany, Anna, and Thomas Sturm. (2014). Extended cognition: New philosophical perspectives. Special Issue of "Philosophical Psychology", 27 (1), 2014.http://www.tandfonline.com/toc/cphp20/27/1#.Uw7BgXkzd0o
- Menary, Richard. (2006). Attacking The Bounds of Cognition. *Philosophical Psychology 19.3 (June): 329-344.*
- Menary, Richard. (2007). *Cognitive integration: Mind and cognition unbounded*. New York: Palgrave/Macmillan.
- Menary, Richard, ed. (2010). *The extended mind*. Cambridge, MA: MIT Press/Bradford.
- Noë, Alva. (2004). *Action in perception*. Cambridge, MA: MIT Press.
- Robbins, Philip, and Murat Aydede (Eds.). (2009). *Cambridge handbook of situated cognition*. Cambridge: Cambridge University Press.
- Sterelny, Kim. (2004). Externalism, epistemic artifacts, and the extended mind. In Richard Schantz (Ed.), *The externalist challenge* (239-254). New York: de Gruyter.
- Sterelny, Kim. (2012). *The evolved apprentice: How evolution made humans unique*. Cambridge: MIT Press/Bradford.
- Wilson, Robert A. (2004). *Boundaries of the mind: The Individual in the fragile sciences: Cognition*. Cambridge: Cambridge University Press.
- Wilson, Robert A. (2005). Collective memory, group minds, and the extended mind thesis. *Cognitive Processing* 6.4: 227-236.

Extended mind thesis

From Wikipedia, the free encyclopedia

The **extended mind thesis** (**EMT**) says that an agent's mind and associated cognitive processing are neither skull-bound nor even body-bound, but extend into the agent's world.[1] As Clark and Chalmers see it:

Where does the mind stop and the rest of the world begin?...We propose to pursue... an *active externalism*, based on the active role of the environment in driving cognitive processes.

— Andy Clark and David Chalmers: "The Extended Mind"[2]

The question is raised as to the division point between the mind and the environment. The EMT proposes that some objects in the external environment are utilized by the mind in such a way that the objects can be seen as extensions of the mind itself. Specifically, the mind is seen to encompass every level of the cognitive process, which will often include the use of environmental aids.

Criticism

Philosophical arguments against the extended mind thesis include that:[3]

1. When focusing on cognition, the thesis confuses claims about what is constitutive about the concept of cognition with claims about causal influences on cognition (the "causal-constitutional fallacy"), for example, Adams and Aizawa (2010) ask "Question: Why did the pencil think that 2 + 2 = 4?, Clark's Answer: Because it was coupled to the mathematician";
2. It stretches the limits of our ordinary concept of cognition too far ("cognitive bloating") potentially implying that everything on the internet is part of individual cognitive systems;
3. It uses a coarse-grained functionalism about the mind that ignores plausible differences between internal and external processes, such as differences between beliefs and external props and devices; or for creating a notion of cognition too heterogeneous to make up a scientific natural kind.

Each of these arguments is addressed in Clark (2008), in which he notes that:[4]

1. While coupling is important for cognition, that is not to say that it is sufficient - the coupling must play a functional role in cognition. Many

couplings do not do so and thus would not be 'extensions' (and this is consistent with a strong extended mind thesis).
2. If we take any putative part of a system – internal or external – is unlikely to yield "cognition", thus examples such as calculators, pencils, should be considered in parallel with neural regions. Simply looking at the part is not enough for cognition.
3. One can imagine circumstances under which a biological being might retain information in non-neural ways (suggesting a Martian with a bitmap based memory, or humans with prosthetics to support memory), thus being neural cannot be a necessary condition for being cognitive.

While in *Supersizing the Mind*, Clark defends a strong version of the hypothesis of extended cognition (contrasted with a hypothesis of embedded cognition) in other work, some of these objections have inspired more moderate reformulations of the extended mind thesis. Thus, the extended mind thesis may no longer depend on the parity considerations of Clark and Chalmers' original argument but, instead, emphasize the "complementarity" of internal and external elements of cognitive systems or processes. This version might be understood as emphasizing the explanatory value of the extended mind thesis for cognitive science rather than maintaining it as an ontological claim about the nature of mind or cognition. [4]

References

1. *Wilson, Robert A. and Foglia, Lucia (July 25, 2011). Edward N. Zalta, ed, ed. "Embodied Cognition". The Stanford Encyclopedia of Philosophy (Fall 2011 Edition).*
2. *Andy Clark, David J Chalmers (January 1998). "The Extended Mind". Analysis **58** (1): 7–19. doi:10.1093/analys/58.1.7.*; reprinted as: *Andy Clark, David J Chalmers (2010). "Chapter 2: The extended mind". In Richard Menary. The Extended Mind. MIT Press. pp. 27–42. ISBN 9780262014038.*; and available on line as: *Andy Clark, David J Chalmers. "The extended mind". Cogprints.*
3. *Adams, Fred., Aizawa, Ken (2010). Defending the bounds of cognition, in The Extended Mind (Eds, Richard Menary). pp. 67–80.*
4. ^ Jump up to:*[a] [b] Clark, Andy (2008). Supersizing the Mind: Embodiment, Action, and Cognitive Extension. Oxford University Press.*

Distributed cognition

From Wikipedia, the free encyclopedia

Distributed cognition is an approach to cognitive science research that deploys models of the extended mind (see, for example, the paper The Extended Mind) by taking as the fundamental unit of analysis "a collection of individuals and artefacts and their relations to each other in a particular work practice" (Rogers and Ellis, 1994). "DCog" is a specific approach to distributed cognition (distinct from other meanings[1]) which takes a computational perspective towards goal-based activity systems.[2] Dcog frameworks employed were originally developed in the mid-1980s by Edwin Hutchins, who continues to be the leading pioneer and whose research is based at the University of California at San Diego.

Using insights from sociology, cognitive science, and the psychology of Vygotsky (cf. cultural-historical psychology) it emphasizes the ways that cognition is off-loaded into the environment through social and technological means. It is a framework for studying cognition rather than a type of cognition. This framework involves the coordination between individuals, artifacts and the environment. According to Zhang & Norman(1994),[3] the distributed cognition approach has three key components:

1. Embodiment of information that is embedded in representations of interaction
2. Coordination of enaction among embodied agents
3. Ecological contributions to a cognitive ecosystem

'Dcog' studies the "propagation of representational states across media" (Rogers and Ellis, ibid.). Mental content is considered to be non-reducible to individual cognition and is more properly understood as off-loaded and extended into the environment, where information is also made available to other agents (Heylighen, Heath, & Overwalle, 2003). It is often understood as an approach in specific opposition to earlier and still prevalent "brain in a vat" models which ignore "situatedness, embodiment and enaction" as key to any cognitive act (Ibid.).

These representation-based frameworks consider distributed cognition as "a cognitive system whose structures and processes are distributed between internal and external representations, across a group of individuals, and across space and time" (Zhang and Patel, 2006). In general terms, they consider a distributed cognition system to have two components: internal and external representations. In their description, internal representations are knowledge and structure in individuals' minds while external representations are

knowledge and structure in the external environment (Zhang, 1997b; Zhang and Norman, 1994).

DCog studies the ways that memories, facts, or knowledge is embedded in the objects, individuals, and tools in our environment. DCog is a useful approach for (re)designing the technologically mediated social aspects of cognition by putting emphasis on the individual and his/her environment, and the media channels with which people interact, either in order to communicate with each other, or socially coordinate to perform complex tasks. Distributed cognition views a system of cognition as a set of representations propagated through specific media, and models the interchange of information between these representational media. These representations can be either in the Mental space of the participants or external representations available in the environment.

These interactions can be categorized into three distinct types of processes:

1. Cognitive processes may be distributed across the members of a social group.
2. Cognitive processes may be distributed in the sense that the operation of the cognitive system involves coordination between internal and external (material or environmental) structure.
3. Processes may be distributed through time in such a way that the products of earlier events can transform the nature of related events.

Early research

John Milton Roberts thought that social organization could be seen as cognition through a community (Roberts 1964). He described the cognitive aspects of a society by looking at the present information and how it moves through the people in the society.

Daniel L. Schwartz (1978) proposed a distribution of cognition through culture and the distribution of beliefs across the members of a society.[*citation needed*]

In 1998, Mark Perry from Brunel University London explored the problems and the benefits brought by distributed cognition to “understanding the organisation of information within its contexts." He considered that distributed cognition draws from the Information processing metaphor of cognitive science where a System is considered in terms of its inputs and outputs and tasks are decomposed into a Problem space (Perry, 1998). He believed that information should be studied through the representation within the media or artefact that

represents the information. Cognition is said to be “socially distributed” when it is applied to demonstrate how interpersonal processes can be used to coordinate activity within a social group.

In 1999, Gavriel Salomon stated that there were two classes of distributive cognition: shared cognition and off-loading. Shared cognition is that which is shared among people through common activity such as conversation where there is a constant change of cognition based on the other person's responses. An example of off-loading would be using a calculator to do arithmetic or a creating a grocery list when going shopping. In that sense, the cognitive duties are off-loaded to a material object.

Later, John Sutton (2006)[4] defined five appropriate domains of investigation for research in Dcog:

1. External cultural tools, artefacts, and symbol systems.
2. Natural environmental resources.
3. Interpersonal and social distribution or scaffolding.
4. Embodied capacities and skills.
5. Internalized cognitive artefacts.

Applications]

The application area of DCog is systems design and implementation in specific work environments. Its main method is Field research, going into the workplace and making rigorous observations, e.g. through capturing work performances with video, studying and coding the recorded activities using qualitative research methods to codify the various ways in which cognition is distributed in the local environment, through the social and technical systems with which the workers engage.

Distributed cognition as a theory of learning, i.e. one in which the development of knowledge is attributed to the system of thinking agents interacting dynamically with artifacts, has been widely applied in the field of distance learning, especially in relation to Computer Supported Collaborative Learning (CSCL) and other computer-supported learning tools. For example, in the field of teaching English Composition, Kevin LaGrandeur has argued that CSCL provides a source of common memory, collaborative space, and a cognitive artifact (tool to enhance cognition) that allows students to more easily build effective written compositions via explicit and implicit machine-human collaboration. Distributed cognition illustrates the process of interaction

between people and technologies in order to determine how to best represent, store and provide access to digital resources and other artifacts.

Collaborative tagging on the World Wide Web is one of the most recent developments in technological support for distributed cognition. Beginning in 2004[5] and quickly becoming a standard on websites, collaborative tagging allows users to upload or select materials (e.g. pictures, music files, texts, websites) and associate tags with these materials. Tags can be chosen freely, and are similar to keywords. Other users can then browse through tags; a click on a tag connects a user to similarly tagged materials. Tags furthermore enable tag clouds, which graphically represent the popularity of tags, demonstrating co-occurrence relations between tags and thus jump from one tag to another.

Dcog has also been used to understand learning and communication in clinical settings and to obtain an integrated view of clinical workplace learning. It has been observed how medical actors use and connect gestural practices, along with visual and haptic structures of their own bodies and of artifacts such as technological instruments and computational devices. In so doing they co-construct complex, multimodal representations that go beyond the mental representations usually studied from a cognitive perspective of learning (Pimmer, Pachler & Genewein, 2013).[6]

Distributed cognition can also be seen through cultures and communities. Learning certain habits or following certain traditions is seen as cognition distributed over a group of people. Exploring distributed cognition through community and culture is one way to understand how it may work.

With the new research that is emerging in this field, the overarching concept of distributed cognition enhances the understanding of interactions between individual human beings, artefacts such as technologies and machines, and complex external environments. This concept has been applied to educational research in the areas of distributed leadership and distributed instruction].

Metaphors and examples

Distributed cognition is seen when using paper and pencil to do a complicated arithmetic problem. The person doing the problem may talk with a friend to clarify the problem, and then must write the partial answers on the paper in order to be able to keep track of all the steps in the calculation. In this example, the parts of distributed cognition are seen in:

- setting up the problem, in collaboration with another person,
- performing manipulation/arithmetic procedures, both in one's head and by writing down resulting partial answers.

The process of working out the answer requires not only the perception and thought of two people, it also requires the use of a tool (paper) to extend an individual's memory. So the intelligence is distributed, both between people, and a person and an object.

Another well-researched site for analyzing distributed cognition and applying the discovered insights towards the design of more optimal systems is aviation, where both cockpits and air traffic control environments have been studied as scenes that technologically and socially distribute cognition through systems of externalized representational media. It is not the cognitive performance and expertise of any one single person or machine that is important for the continued operation or the landing and takeoff of airplanes. The cognition is distributed over the personnel, sensors, and machinery both in the plane and on the ground, including but not limited to the controllers, pilots and crew as a whole.

Hutchins also examined another scene of distributed cognition within the context of navigating a US navy vessel.[7] In his book on USS Palau,[8] he explains in detail how distributed cognition is manifested through the interaction between crew members as they interpret, process, and transform information into various representational states in order to safely navigate the ship. In this functional unit, crew members (e.g. pelorus operators, bearing takers, plotters, and the ship's captain) play the role of actors who transform information into different representational states (i.e. triangulation, landmark sightings, bearings, and maps). In this context, navigation is embodied through the combined efforts of actors in the functional unit.

In his study on process, representation and task world, Mark Perry (1998) demonstrated how distributed cognition analysis can be conducted in a field study. His example was design analysis in Civil engineering. In this work, he showed how an information processing approach can be applied by carrying a detailed analysis of the background of the study - goals and resources, inputs and outputs, representations and processes, and transformational activity, “how information was transformed from the design drawings and site onto tables of measurements (different representations)” and then onto “a graphical representation” which provided a clearer demonstration of the relationship between the two data sets (Perry, 1998).

Quotes

On educational psychology:

People think in conjunction and partnership with others and with the help of culturally provided tools and implements.

— Salomon, 1997 p. xiii

On cognitive science:

Nervous systems do not form representations of the world, they can only form representations of interactions with the world.[9]

The emphasis on finding and describing "knowledge structures" that are somewhere "inside" the individual encourages us to overlook the fact that human cognition is always situated in a complex sociocultural world and cannot be unaffected by it.

— Hutchins, 1995 p. xiii

References

- Brown, Ann L., et al. “Distributed Expertise in the Classroom.” Distributed Cognitions: Psychological and Educational Considerations. Ed. Gavriel Salomon. New York: Cambridge UP, 1993. 188-28.
- Dror, I. E. & Harnad, S. (2008). Offloading Cognition onto Cognitive Technology. in I.Dror & S. Harnad (Eds.), Cognition Distributed: How Cognitive Technology Extends Our Minds (pp 1–23). Amsterdam: John Benjamins Publishing.
- Heylighen, Francis; Heath, Margaret and Van Overwalle, Frank (2003). “The Emergence of Distributed Cognition: a conceptual framework,” available on ResearchGate, https://www.researchgate.net/publication/249812898_The_Emergence_of_Distributed_Cognition_a_conceptual_framework
- *Hutchins, Edwin (1995). Cognition in the Wild. MIT Press. ISBN 0-262-58146-9.*
- Hutchins, E. (1995) "How a cockpit remembers its speeds". Cognitive Science, 19, 265-288.
- LaGrandeur, K. (1998). "Splicing Ourselves into the Machine: Electronic Communities, Systems Theory, and Composition Studies." ERIC, March, 1998: ED 410 563.
- Norman, D.A. (1993) "Things that make us smart" (Addison-Wesley).

- Perry, M. (1998, August). Process, representation and task world: distributed cognition and the organisation of information. In Exploring the contexts of information behaviour. Proceedings of the Second International Conference on Research in Information Needs, Seeking and Use in different contexts. 13/15 August 1998. Sheffield, UK (pp. 552–567).
- Perry, M. (2003) "Distributed Cognition". In J.M. Carroll (Ed.) "HCI Models, Theories, and Frameworks: Toward an Interdisciplinary Science" (Morgan Kaufmann) 193-223.
- *Roberts, John M. (1964). "The Self-Management of Cultures". In Ward H., Goodenough. Explorations in Cultural Anthropology. New York: McGraw Hill.*
- Rogers, Yvonne and Ellis, Judy. “Distributed Cognition: an alternative framework for analysing and explaining collaborative working.” Journal of Information Technology, 1994, vol 9(2), 119-128.
- *Salomon, Gavriel (1997). Distributed cognitions: Psychological and educational considerations. Cambridge University Press. ISBN 0-521-57423-4.*
- Zhang, J. (1997b). “The nature of external representations in problem solving”. Cognitive Science 21: 179-217.
- Zhang, J. & Norman, D.A. (1994) "Representations in Distributed Cognitive Tasks", Cognitive Science, 18, 87-122.
- Zhang, J., & Patel, V. L. (2006). Distributed cognition, representation, and affordance. Pragmatics & Cognition, 14(2), 333-341.

Notes

1. *Michaelian, Kourken; Sutton, John (2013-02-20). "Distributed Cognition and Memory Research: History and Current Directions". Review of Philosophy and Psychology **4** (1): 1–24. doi:10.1007/s13164-013-0131-x. ISSN 1878-5158. Retrieved 2015-11-22.*
2. *Perry, Mark. "Some simple definitions in Distributed Cognition (DCog)". Retrieved 22 November 2015.*
3. Zhang, J. & Norman, D.A. (1994) "Representations in Distributed Cognitive Tasks", Cognitive Science, 18, 87-122.
4. *Sutton, John (2006-01-01). "Distributed cognition: Domains and dimensions". Pragmatics & Cognition **14** (2): 235–247. doi:10.1075/pc.14.2.05sut.*
5. Mika,Peter.(2005)[1] "Ontologies are us: A united model of social networks and semantics" Referenced 20 March 2014

6. Pimmer, C., Pachler, N., & Genewein, U. (2013) "Reframing Clinical Workplace Learning Using the Theory of Distributed Cognition". Academic Medicine, 88(9), 1239–1245.
7. Caroll, J. M., (2003). HCI Models, Theories, and Frameworks: Toward a Multidisciplinary Science. Morgan Kaufmann.
8. Hutchins, E. (1995). Cognition in the wild. Bradford: MIT Press.
9. Hutchins, Edwin. 12-3-09. *Distributed Cognition* lecture.

Further reading

- Dror, I.E. & Harnad, S. (eds.) (2008). Cognition Distributed: How Cognitive Technology Extends Our Minds. (258 pp.) John Benjamins, Amsterdam.
- Gureckis, T.M. and Goldstone. R.L. (2006) "Thinking in Groups", Pragmatics and Cognition, 14 (2), 293-311.
- Hollan, J., Hutchins, E., & Kirsh, D. (2001) "Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research." In J. M. Carroll (Ed.) *Human-Computer Interaction in the New Millennium*, ACM Press, New York, pp. 75–94.
- Pea, R. D. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.). Distributed cognitions (pp. 47–87). New York: Cambridge University Press.
- Resnick, L, Levine, S. and Teasley, L., (Eds.), *Perspectives of socially shared cognition* (Washington, D.C.: American Psychological association, 1988).
- Ross, D., *et al.*, (Eds.), *Distributed Cognition and the Will: Individual volition in social context* (Cambridge, Mass: MIT Press, 2007).