Distributed cognition

Domains and dimensions

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Synthesizing the domains of investigation highlighted in current research in distributed cognition and related fields, this paper offers an initial taxonomy of the overlapping types of resources which typically contribute to distributed or extended cognitive systems. It then outlines a number of key dimensions on which to analyse both the resulting integrated systems and the components which coalesce into more or less tightly coupled interaction over the course of their formation and renegotiation.

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1. The integration and coordination of domains in distributed cognition

What are the appropriate domains of investigation for research in distributed cognition? In seeing cognitive processes — remembering, reasoning, navigating, planning and so on — as spreading (in certain circumstances) out of the head and into the changing techno-social world, this emerging framework can seem to be too loose and over-inclusive. The objects of a putative science of distributed cognition, complain Adams and Aizawa (2001: 62), would form "an unscientific motley": they note, for example, that Merlin Donald, in his groundbreaking discussion of the history of human use of 'exograms' in external symbol systems, offers rich accounts "of the development of all manner of external representations, including body decorating, grave decorating, sculpture, Stonehenge, hieroglyphics, cuneiform, maps, graphs, and musical scores", and careful analyses of the many "ways in which the processing of exograms differs from the processing of engrams" in the brain (Adams and Aizawa 2001: 58, referring to Donald 1991). And a quick survey of recent work shows the field covering human capacities to manipulate, exploit, or couple

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with (for example) other people, scrabble tiles, theatre architecture, cocktail glasses, slide-rules, incised sticks, shells, languages, moral norms, knots, codes, diagrams, fingers, monuments, software devices, rituals, rhythms and rhymes, and roads. This might seem to justify Adams and Aizawa's lament that systems composed of brains coupled with such a diverse range of putatively cognitive tools, computing devices, or memory aids "would seem to form such a motley collection that they will not form the basis for any significant scientific theorizing" (2001: 63).

I am no enemy of motley, but I accept that in response it won't always be enough for distributed cognition enthusiasts to talk of the ecological validity of multidisciplinary immersion in the idiosyncratic and messy reality of cognitive practices. Writing as such an enthusiast, I suggest that — as well as getting on with the work of producing rich case studies and weaving the results into developing sciences of the interface — we must also identify patterns and pick out the most relevant dimensions of comparison across the proliferating studies of "varied, multiplex, interlocking and criss-crossing causal mechanisms" which spread over "a wide variety of mechanistic bases" (Clark, in press). But can we yet offer even the broadest taxonomy of the domains across which cognitive systems are putatively distributed, of the key properties and dimensions on which such interactive systems vary, or even of the existing methods and approaches most effectively used so far in addressing them?

The implicit background to the following blunt and bare sketch of such a taxonomy of domains, dimensions, and methods includes a promiscuous range of variously labelled and subtly differing approaches. David Kirsh (2006: 258) offers us a succinct statement of the overall domain:

> The study of distributed cognition is very substantially the study of the variety and subtlety of coordination. One key question which the theory of distributed cognition endeavors to answer is how the elements and components in a distributed system — people, tools, forms, equipment, maps and less obvious resources — can be coordinated well enough to allow the system to accomplish its tasks.

My remarks apply most centrally to two related frameworks: 'distributed cognition' (DC) as practised by Kirsh and, for example, by Zhang and Norman (1994) and Hutchins (1995); and Andy Clark's 'extended mind' hypothesis (EM) (1997; Clark and Chalmers 1998). But they should apply in broad outline also to core examples of research under the tags 'situated' or 'enactive' or 'embedded' or 'embodied' or 'dynamical' cognition, 'active externalism', or 'vehicle externalism' (Varela, Thompson, and Rosch 1991; van Gelder 1995; Haugeland

1998; Hurley 1998; Rowlands 1999; Dennett 2000; Wilson 2004; Tribble 2005; Wheeler 2005), as well as to related work arising more from independent developments in science studies than from within the cognitive sciences (Latour 1996, 1999; Suchman 1998). In my view the DC/EM movements are in a particularly rich period of cross-tradition and cross-disciplinary interaction, and in these areas it is incumbent on philosophers and others with synthetic and eclectic tendencies to spread and blend relevant theoretical innovations and to catalyse interactions across the difficult gulfs left by specialized training and assumptions.

As Kirsh (2006: 250) notes, because "coordination is the glue of distributed cognition and it occurs at all levels of analysis", particular explanatory projects must aim at system-level approaches to the idiosyncratic interactivity of distributed cognitive systems. But he also acknowledges the occasional utility of artificial analytical separation of even tightly-coupled components, in order to make comparisons and seek generalizations across contexts, and allow the possibility of transferring lessons from any one case study. So we can offer a first brief high-level taxonomy of the overlapping types of resources which typically contribute to and coalesce into such distributed cognitive systems at various timescales.[1]

1.1 External cultural tools, artefacts, and symbol systems

Key DC/EM examples here include the instruments and procedures involved in navigation, or the physical objects and epistemic tools used in processing orders in a café, the tangle of notes and records and processing systems with which an academic paper is written, or the sketchpads without which abstract artists cannot iteratively re-imagine and create an artwork (van Leeuwen, Verstijnen, and Hekkert 1999). Taking a lead from the sociology of material culture, we can call this the study of "the cognitive life of things" (Sutton 2002a, drawing on Appadurai 1986). Of course these resources (at present, in general) do no cognitive work on their own, so it's no argument against a DC approach to emotion, for example, to complain that "the black tie I wear at the funeral isn't doing my grieving for me" (Harris 2004: 729): but then neither do brains tend to do their cognitive work in isolation, because essentially incomplete creatures like us naturally use our neural resources in part to parasitize, lean on, and incorporate those external cultural-technological resources which have become apt for incorporating (Clark 2003). The relevant external resources can include both exograms in various forms of external symbol systems, and different aspects of the nonsymbolic environment (Wilson 2004: 192–197).

1.2 Natural environmental resources

Just as many biological creatures do with *non*-cognitive external resources, organisms can reliably exploit certain kinds of world-mind constancy by functionally integrating environmental structures — such as those exploited in ongoing sensorimotor mastery of couplings between perception and action — to transform their on-board computational tasks and abilities. This creates one typical variety of more-or-less "transient extended cognitive system" (Wilson and Clark, forthcoming).

1.3 Interpersonal and social distribution or scaffolding

Often in some tight complementary fit with technological resources (as in the complex techno-social systems described by Kirsh and Hutchins), other people are more-or-less stably and reliably involved in an individual's cognitive-affective processing. This may occur in some respects among other animals, but the variety and centrality of the interpersonal resources which are integrated into human cognition is one of our most characteristic psychological features. In the case of autobiographical memory, to take a key example, we do on occasion remember alone — in some current neural, emotional, psychological, bodily, and circumstantial context — but the sharing of memories with others is also an ordinary human activity with great psychological and social significance. Sometimes such sharing of memories — like other small-group cognitive activities — is merely additive or aggregative, with each individual bringing fully-formed intact items to the collective arena, communicating them, and taking them away again unaltered: but more often perhaps the social manifestation of memories brings into being new emergent form and content through the transactive nature of collaborative recall (Sutton 2004, 2006; Wilson 2005; Campbell 2006).

1.4 Embodied capacities and skills

Thinking, remembering, feeling, counting and the like may sometimes involve embodied activities in ways which transform the cognitive task and sculpt its process. Embodied interactions with artefacts, or gesturing in characteristic ways in a social situation, or following certain bodily procedures and rituals can (on the DC/EM account) themselves be forms of cognizing, rather than the mere expressions of prior internal cognitive processing (Connerton 1989: Chapter 3; Dreyfus 2002; Anderson 2003; Sheets-Johnstone 2003; Cowart

2004). These embodied cognitive capacities are interwoven in complex ways with our use of the technological, natural, and social resources mentioned above. Although analytically distinguishable, we can also include here the kinds of thinking-in-action apparent in the exercise of certain learned skills in sport, music, and dance (Sutton forthcoming a; Sheets-Johnstone 1999; Sudnow 2001; Stevens, Malloch, McKechnie, and Steven 2003). In these cases occurrent cognitive activity can — in the right circumstances — be distributed across whole patterned sequences of allowable bodily response repertoires, coupling and coalescing dynamically in real time with complex and simultaneous changing physical, technological, and social parameters. For these reasons, expert embodied performance in these domains, and the interactions between kinaesthetic and episodic memory, is a rich and barely-tapped domain of investigation for both ethnographic and cognitive wings of the distributed cognition movements.

1.5 Internalized cognitive artefacts

The four domains discussed so far fit the DC/EM stereotype in that they take the mind beyond the brain, describing psychological states and processes as hybrids, unevenly distributed across social, technological, and biological realms. But two further significant domains of recognizably DC-/EM-styles of enquiry paradoxically enter the traditional stronghold of internalism, the brain, by offering distinctive approaches to the internal wing of extended cognitive systems. On the one hand, we may get a new grip on the nature and unique contribution of the relevant neural resources: analysis of the complex wholes made up when embodied brains couple with 'cognition-amplifiers' like objects and other people "may itself contribute important insights concering the contributions and functioning of the biological brain itself" (Wilson and Clark, forthcoming). As our independent investigations of the dynamic neural bases of memory, reasoning, action, and so on continue, they will be enriched by direct evidence of the alterations in and constraints on processing imposed by interaction with particular kinds of external symbols or social structures (Clark 2005a). This is just to underline the post-connectionist heart of the DC/EM picture: it's just because items of information are *not* in general held in stable and discrete form in the brain that we so pervasively lean on the bits of the world which we have individually and collectively made smart. Secondly, an important strand of DC/EM work — as ever, with complex historical roots in Vygotsky and elsewhere — addresses internalized versions of external or cultural resources. We use a wide range of stratagems to bootstrap,

manage, transform, and discipline our minds, and these techniques can coopt internal surrogates as worldly exograms. Both linguistic items — words, labels, phrases — and other symbols can play key cognitive roles independent of any communicative function, in freezing thoughts or condensing complex affects, or in becoming (for example) "a new [internal] target for selective attention and a new fulcrum for the control of action" (Clark 2006: 294). One rich real-world example of such complex acquired internal cognitive architectures was the baroque Renaissance art of memory, through which monks and scholars learned rhetoric and meditation and trained their wandering minds in the craft of thought (Carruthers 1998). The virtual random access systems and internal prostheses which these adepts built into their theatres of memory were extended as well as cognitive, even though they didn't happen to be outside the skull and skin (Sutton In press). Such forms of "virtuoso artificial self-manipulation" can be dramatically culturally specific and yet still a natural structuring supplement to the cognitively-incomplete biological brain, vital cognitive-affective resources with which "to drive, sculpt, and discipline the internal representational regime" (Clark 2005b: 264). Among other things, internalized cognitive artefacts — linguistic, imagistic, or other — can add an extra layer of insulating variation against the dynamics of world and mind. The context-sensitivity and openness to external influence of remembering, feeling, and thinking is itself context-sensitive: under certain conditions, we may temporarily approximate more detached cognitive agents, dynamically buffered from the world to recalibrate or renegotiate our memories, plans, or emotions.

2. Dimensions of distribution and integration

This selective tour of some domains of distributed cognition — domains which in everyday contexts are often tangled together — now needs to be supplemented with at least an initial account of what we're looking for in comparing different cases and kinds of the resulting extended cognitive systems. So far we have catalogued some differences in the nature of the extended resources which the integrating mind coopts in distributed cognitive activity. There are also a range of possible dimensions of difference in the nature of the resulting extended cognitive system. What are some typical dimensions of analysis?

As a remembering or planning or reasoning or feeling or navigating creature, I may gain quite different capacities and idiosyncrasies (and patterns of breakdown) when I hook up with specific other people or objects or environments, or when I train myself in and rely on specific learned bodily or cognitive

techniques. In many cases I just couldn't perform in the same way if I could lean on the unsupported capacities of my naked brain; and even when I *could* perform the relevant tasks 'on my own' (accessing only the internalized surrogates of these external resources), the way in which this potential performance is actualized will often shift as my openness to influences of various kinds alters.

Kirsh (2006) asks for better formalisms to understand the "principles of coordination" of the different components in a distributed system. In a related development of systems thinking, Haugeland (1998) questioned the idea of determinate interfaces between apparently separable components when a system is interconnected at sufficiently high bandwidths. And Poirier and Chicoisne (2006) focus on a set of related dimensions by which to measure the extent of emergence — understood as the failure of aggregativity — in any system. On their view, more truly distributed systems have components that are more tightly integrated or coupled, with a specific organization of bushy interactivity which makes a significant contribution to overall functioning. These dimensions of emergence are important signs of the "continuous reciprocal causation" between (for example) brain, body, and world, which is sometimes identified as the mark of dense reciprocal cognitive coupling (Clark 1997: 163–166).

Alongside these marks of distribution-as-emergence, we can also follow Wilson and Clark (forthcoming) in stressing further diachronic dimensions of variation. They point to the importance of "the durability and reliability of the extended cognitive system that results from the functional integration" of extended resources. Some distributed systems are one-offs, establishing transient and easily-dissoluble relations which are still more-or-less controllable and reliable (and which may still exhibit high degrees of emergence). Perhaps more common in human cognition is the soft assembly of transient but regularly repeatable integrated wholes involving both internal and external forms of representation: our neural resources may come, in the course of development, to be "expressly tailored to accommodate and exploit the additional representational and computational potentials introduced by, for example, the compass, the pen and paper, or the word-processing package". Wilson and Clark then characterize the more dramatic notion of the 'extended mind' as simply any cognitive extension which scores highly on these dimensions of durability and reliability, in which whatever new capacities emerge in the coupled system are "sufficiently robust and enduring as to contribute to the persisting cognitive profile" of a specific individual.

These are all extremely useful suggestions which can be mapped onto existing case studies in distributed cognition, and which all take distribution as a multidimensional matter of degree. In conjunction with the diversity of types

of relevant external resource surveyed in Section 1, these suggestions already demonstrate that — contrary to some critics (Butler 1998: 211–212; Adams and Aizawa 2001: 55–59) — the DC/ EM frameworks do not necessarily treat internal and external resources as on a par or identical. Rather, the various components in a distributed cognitive system usually complement but do not replicate each others' characteristics (Clark 1997: 220; in press). The central line of thought is thus not based on the parity between neural and environmental resources, but on their (more-or-less tight, more-or-less durable) complementarity (Menary 2006; Sutton, in press).

Once complementarity is installed as the core motivation, the DC/EM framework can be understood as investigating a range of relationships between engrams and exograms, or between agents and artefacts, relations which may be asymmetric, tangled, and dynamically reconfigured or renegotiated. This allows us to investigate particular characteristics of both sets of resources. Different non-biological external resources (technologies, media, other people, places, and so on) vary on a whole range of dimensions including not only their durability but also (for example) the medium-dependence or translatability of the information they carry, and its transmissibility across instantiations, their capacity as symbol systems, the constraints on the ways in which information can be retrieved from them, the context-dependence of their use and so on (compare Donald 1991: 315–316).

Mainstream DC/EM work has tended to treat all systems of exograms, in particular, as similarly 'classical' in format — passive, stable, and medium-independent, in contrast to active, reconstructive biological memory. But of course (as art historians and archaeologists remind us) not all external memory fields or systems are meant to be so permanent, and not all which are intended to endure actually do so (Kwint 1999; DeMarrais, Gosden, and Renfrew 2004). Future technologies may familiarize us better with external resources at least as dynamic and context-dependent as other people in our socio-cognitive world already are. But equally, historical cognitive science (Sutton, in press) can confirm the contingent and multiple nature of possible extended cognitive physiologies: if we are cyborgs *by nature*, we have never been "bound and restricted by the biological skin-bag, … the ancient fortress of skin and skull" (Clark 2003: 4–5; compare Latour 1993). So history needs to take its place alongside ethnography and developmental psychology as a key testing-ground for the whole framework (Tribble 2005; Sutton, forthcoming b). This attention to detail about the properties of exograms and other external resources stops our investigations of inner-outer relations relying on either an assumption of parity or a sharp dichotomy between fluid biology and stable culture: as Hutchins (1995:

312) argued, "it is not that some content is copied from the outside world into some internal storage medium … what used to look like internalization now appears as a gradual propagation of organized functional properties across a set of malleable media". Inner and outer realms are not pre-divided into natural and artificial, each with its own inevitable proprietary characteristics: rather, such boundaries are hard-won and fragile developmental and cultural achievements, always open to renegotiation.

And yet, finally, we also want to understand whatever diachronic stability and continuity particular embodied agents exhibit. As I go round in a complex world of varied external resources, I can move between and enter into distinctive relations with quite different artefacts and other agents. Each of us can decouple from and recouple with external resources of various kinds on a regular and continuing interactive basis. If parity considerations exclusively drove DC/EM thinking, so that features of inner and outer resources tended to be analytically collapsed into each other, then these facts would be mysterious (Butler 1998: 208–210; Grush 2003: 79–81). But highlighting the complementarity between distinct inner and outer resources of course allows for such tracking of agents over time and across their transient material and social engagements. So the last set of dimensions we need to keep open for analysis are features of the individual differences in the ways people approach various cognitive tasks, some characteristically *without* significant use of external resources. Integration with mainstream personality and social psychology here is long overdue. Even in tasks which can involve extended looping and coupling cognitive processes, we are all familiar with folk who aren't content or able to leave the information out in the world, or to use the world as its own memory. In developing Brooks's anti-representationist arguments, John Haugeland claimed that "it would be silly, for most purposes, to try to *keep track of* what shelf everything in the refrigerator is currently on; if and when you want something, just *look*" (1998: 219). But, I suggest, we all know people who *do* typically upload such information into their on-board biological memories: such individual differences in the amount and style of reliance on external resources are often glaring in the ways people plan and engage in complex activities, such as writing an academic paper, shopping for a party, or chairing a department meeting. Do I memorise the train timetable in advance, or do I just turn up to the station and see? These matters of personality and psychological style in the distribution of cognitive resources can also have considerable normative and moral weight.

There is no space here to detail just how these kinds of dimensions are indeed already under investigation, within broadly DC/EM frameworks, in a number of disciplines and traditions with their own independent histories

and methods. In developmental psychology, to finish with just one further example, the robust empirical tradition of social-interactionist research on early autobiographical memory already attends closely to the transmission of social ontologies and to both cultural and individual differences, within an overall dynamical developmental systems framework (Griffiths and Stotz 2000; Reese 2002; Sutton 2002b; Nelson and Fivush 2004). I've indicated above that, in my view, the DC/EM framework can already also draw on and in turn illuminate independent work in (for example) social ontology within philosophy, cognitive archaeology and studies of material culture, media theory, a range of historical disciplines, personality psychology, studies in the social-cognitive psychology of (for example) collaborative recall and transactive group cognition, and theories of embodied expertise and skill. Interdisciplinarity in the cognitive sciences, of course, has its pitfalls. But amidst the vast apparatus and social-institutional weight of the Kuhnian 'normal science' which is deeply embedded in more mainstream modern cognitive and neurocognitive sciences, perhaps some attention to the messy nature of our shared social and cognitive world might occasionally excuse some proliferating cross-disciplinary indulgence of the current thrills and promises within these cross-disciplinary approaches to distributed cognition.

Note

1. My scheme here owes much to that offered by Wilson and Clark (forthcoming), though mine is more elaborate and inclusive, and less fully detailed. Note that this is not a taxonomy of the dimensions which might count towards *making* a system either distributed or cognitive, along the lines of Poirier and Chicoisne's (2006) set of conditions. Here I'm just taking for granted the existence of some such systems, and in particular not addressing any concerns about relations between phenomenal consciousness and (distributed) cognition (but see for example Rowlands 2003: Chapter 10). I am entirely in sympathy with Poirier and Chicoisne's important claim that the concept of distribution is continuous or fuzzy rather than all-or-nothing, and the dimensions of variation which I identify in Section 2 are a start at a related and compatible way of identifying some further components of that fuzzy concept.

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