Distributed Cognition or Intelligence?  
Patterns of group thought within online graduate-level coursework

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Abstract  
The online design of computer-supported cooperative learning environments for graduate student education must provide considerations for typical failure modes of collaborative work. Distributed cognition is one theory describing the interaction occurring as students collaboratively build knowledge in a given subject area. This paper suggests extending this philosophical theory by hypothesizing a group of students as a nascent collective intelligence possessing a metamind, or the ability for reflective cognition. In particular, conflict between student groups is interpreted as emergence of a proto-consciousness, representative of this new metamind's theory-of-mind-model. Development of this distributed cognition is restricted both in manner and in scope due to limitations imposed by this mediating technology. The paper draws an analogy between the effects of this limitation and autistic spectrum disorders, both to typify a possible cognitive failures in online classroom activity and to suggest a direction of research in potential resolution strategies.

Introduction  
The field of distributed cognition “seeks to explicate the complex interdependencies between people and artifacts in their work activities...identifying the problems, breakdowns and the distributed problem solving processes that emerge to deal with them.” (Rogers, n.d.). As a discipline, it has received renewed focus within the past ten years, largely due to the work of ethnographic researchers in the early-to-mid 1990s, and the subsequent spread of Internet technology as a cultural mediator.

Roughly within the same ten year time frame, Asynchronous Learning Networks (ALNs) have become ubiquitous within the context of educational computer-mediated communication (Scardamalia & Bereiter, 1994; Wegerif, 1998). Grounded in Vygotsky’s social learning theories, ALNs provide a supportive mechanism by which students distributed in space and time over the length of a course can interact and build knowledge collaboratively. ALNs have found widespread application in the instantiation of computer supported cooperative learning (CSCL) environments, especially in graduate studies, where subject areas have not undergone total reification (cf Lave & Wenger, 1990) and the traditional fine-grained curricular standards of primary and secondary education do not apply.

However, their adoption in graduate study programs is still slow, as the gap between traditional classroom didactic pedagogy and the radical notion of knowledge building is wide (Scardamalia, in press). Regardless of whether a radical or gradual transition to ALNs can be made, support is necessary to assist the developing ALN-supported classroom in its growth to a fully fledged knowledge building environment. As developmental difficulties persist, diagnostics and treatments must be developed and evaluated that support authentic learning and enhanced distributed cognition.

Applied within the graduate student online course, this paper demonstrates how ALNs readily support and illuminate distributed cognitive efforts. As a majority of the interpersonal communication within the course takes the form of notes that are contained within the ALN, the generated artifacts remain both dynamic and accessible. Further, they do not exist just as static by-products, but retain their status as active elements of cognition, providing evidence of distributed cognition in action (Hewitt & Scardamalia, 1998, p. 15). This affords the ethnographic researcher the opportunity to discern and map distributed cognitive processes as they play themselves out over the course of a term.
In this paper, I propose that the observed distributed cognition within graduate coursework as supported by ALNs directly leads to the temporary construction of one or more group minds. The mature interaction between these group minds in online discussions stimulates further discussion and viewpoint maturation, simulating the inner cognitive dissonance experienced during individual critical thinking activity. This discussion leads participants to engage in reflective, metacognitive activity on their own actions (Humphrey, 1992; Suddendorf, 1999, p. 17). The mind that engages in this sort of reflective activity has been termed a metamind (Suddendorf, 1999, p. 1). Taking the group mind metaphor one step further, we can view the entire course enrolment as a collective intelligence, incorporating both the individual students' own cognitive processes and the incipient, transient group minds established as heated discussion and entrenched viewpoints develop.

Just as developmental psychology and neuroscience have been eagerly applied to remedial education, principles of remedial developmental neuroscience can be applied to nascent online collective intelligences. Developmental disorders that can be seen manifest in collective intelligences include, but are not limited to autistic spectrum disorders (ASD) and post-traumatic stress disorder (PTSD). Later in this paper I introduce ethnographic evidence to support this claim, and discuss the implications and ramifications for online design.

Theories of Distributed Cognition
As previously stated, distributed cognition is a way of modelling group interaction that expands scope of study beyond isolated examination of each individual participant's behaviour. As a theory of human interaction, it draws upon a long standing tradition of philosophical, psychological and other experimental analysis of group activity. Cole and Engeström (1993) refer to William Wundt as an early predictor of the modern-day theory. Wundt's newly-coined Völkerpsychologie (folk psychology) differed from preceding cultural histories by aiming “...not to acquire a knowledge of reality from a priori concepts, but conversely, to derive ideas from reality, [as] a psychological account of the development of mankind” (Wundt, 1916) through such techniques as “ethnography, folklore and linguistics” (Cole and Engeström, 1993, p. 2). This bold goal was not well achieved by Wundt himself, what with his text Elements of Folk Psychology drawing wild, assertive assumptions in the fields of Paleolithic cultural and middle-ages spiritual anthropology (Mead, 1919).

Cole and Engeström state that Wundt expected higher psychological functions, such as religious thought, organized society, culture and the origin of consciousness, to require “additional cognitive resources that are to be found in the sociocultural milieu.” (Cole & Engeström, 1993, p. 3). Proof of this comes later in the same lecture, where he decries both the older Spiritualist and Materialist approaches as incapable of determining the doctrine of mind without first establishing an “experiential science.” Here, he makes clear that “the study of language and linguistic development, of mythology and the history of religion and custom, ...as historical knowledge has increased, ...has approached the standpoint of psychological inquiry.” By including these other disciplines, Wundt expands the study of thought from his more well-known physiological psychological theory into the traditionally less experimental discipline of cultural anthropology.

Digging into Wundt's older Lectures on Human and Animal Psychology (1894) reveals his lack of sympathies for Spiritualist models of higher human cognition, especially Herbart's formulation that incorporates Descartes' “simple mind-substance, ... modified by the first principles of Leibniz's monadology” (p. 5). This is unfortunate, as Herbart's assertions of modularized thought and the attraction and repulsion of ideas presupposes modern supervenience theory and cognitive dissonance, though it is not directly responsible for those theories as much as Darwinism, medical psychology and psychiatry (Watson, 1978).

Research to date has struggled to define distributed cognition beyond a joint model combining elements of situated learning and social collaboration (Cole & Engeström, 1993; Hewitt & Scardamalia, 1998; Bereiter, 2002). The distributed cognitive focus on
interpersonal behaviour, as supported through internal and external knowledge artifacts, they argue, is consistent with Vygotsky’s view of knowledge acquisition as supported by “linguistic tools of thought and by the sociocultural experience of the child” (Vygotsky, 1934/1962, Ch. 4).

At least two divergent theories of distributed cognition claim common lineage from the above source. The first is closer to Vygotsky’s Chomsky-like obsession with language as the primary tool by which knowledge is constructed. Without verbal language, the argument goes, communication cannot be achieved; without communication, knowledge cannot be transferred or constructed between individuals. And without the transfer or construction of knowledge, society cannot operate. Therefore, society requires the transfer of knowledge to operate, and must necessarily include distributed cognition. Further, this distributed cognition depends on a shared set of cultural artifacts for meaning. This constitutes a Wundtian external folk psychology, also known as an external theory theory (Ravenscroft, 2004). Distributed cognition has been described as the chief process that sustains and transforms external theory theory. (Cole, n.d.)

The other theory of distributed cognition that stems from Vygotsky takes a more utilitarian, transformative view of tool use, using the general, broader definition of tool. Again from Vygotsky:

The inclusion of a tool in the process of behavior (a) introduces several new functions connected with the use of the given tool and with its control; (b) abolishes and makes unnecessary several natural processes, whose work is accomplished by the tool; and alters the course and individual features (the intensity, duration, sequence, etc.) of all the mental processes that enter into the composition of the instrumental act, replacing some functions with others (i.e., it re-creates and reorganizes the whole structure of behavior just as a technical tool re-creates the whole structure of labor operations) (1981, pp.139-140)

As the aforementioned tools are actively brought into use as part of the cognitive effort, they are no longer seen as passive participants within the cognitive process; they directly participate in the process itself. Debate over this interpretation of Vygotsky continues, but this quote and others have been used to justify the use of the term distributed cognition as arising from collective human-technology interaction.

Indeed, it is this second theory that drove ethnographic researchers such as Edwin Hutchins to help build evidence of distributed cognition. Through embedded research within the United States Navy, Hutchins richly illustrated distributed cognition within work tasks that could not be accomplished solely by the actions of a single individual, such as ship navigation (Hutchins 1995) and cockpit workload management (Hutchins & Klausen, 1996). As the tasks present in these environments involve numbers of external systems of sufficient complexity, decomposition of actions between multiple individuals is a requirement of success. By distributing elements of the process to technology in the environment, collaboration is supported. Hutchins referred to this as the “cockpit knowing its own speed” (ibid).

Like the software systems being designed by engineering teams, the examples chosen for experimental study functionally decompose well. These coordinated activities, carefully planned and “precomputed” (Rogers et al., 1992) in advance (especially in the case of naval and aviation operations), expect participants to play roles with well-defined boundaries. Scripts such as naval operations manuals and cockpit checklists clearly delineate each actor’s responsibility within the various use cases and typical scenarios, including handling of faults and errors that arise during the procedures. As not every eventuality is accounted for, these operational guidelines serve as boundaries that, if followed in times of crisis, provide maximal aversion of disaster (Cessna, 1997). Note that success is well defined; docking a battleship or landing a Boeing 747 can easily be distinguished from the failure modes.

The simplifying assumptions possible in this flavour of distributed cognition generally do not apply within the graduate-level classroom, ALN or no. As a result, research into distributed cognition within graduate studies in social sciences has been limited to a philosophical argument over pedagogy, with
primary consideration given to heavily prescriptive online design. The approach generally states that for distributed cognition to be successful within the classroom, similar scripting and prediction of behaviour must be undertaken by the teacher in curriculum planning. While this makes sense within reified areas of subject matter such as those encountered in primary and secondary school education (Scardamalia & Bereiter, 1994), the exploratory nature of most graduate study does not lend itself well to such scripting. Indeed, the development of knowledge from developmental to reified is a key aspect of limited peripheral participation theory (Lave & Wegner, 1991). Reification on a body of thought cannot reasonably be expected to complete within a single term of graduate study.

Pea (1993) picks up on the potential for misunderstanding within the admittedly broad field of distributed cognition. Starting the opposition, he actually renames the concept as distributed intelligence, claiming that “[it] is not a theory of mind, or culture, or design, or symbol systems and their impact on human thought so much as it is a heuristic framework for raising and addressing theoretical questions.” This restriction was both appropriate and necessary to frame discussion and foster further enquiry into a burgeoning field, and interestingly sidesteps the questions raised by the suggestion of an enhanced cognitive process that extends beyond the capabilities of a given individual.

The logical extreme of this objection is presented by cognitive neuroscientist Harnad: “there is no such thing as distributed cognition, only collaborative cognition” (2005, p. 1). Here we see the re-emergence of Cartesian consciousness as a prerequisite for any form of cognition, distributed or not. Harnad argues that a head-ache only has true meaning when it arises out of feeling a constricted blood vessel within a single individual’s head, and the autonomy of action that surrounds awareness of this feeling. Thus, “a corporation cannot literally have a head-ache, though its (figurative) ‘head’ (CEO) might” (ibid). After declaring that all computer-human interaction is simply computation and consultation, and that groups of people jointly using groups of computers of databases are collaborative cognition, he goes on to argue that the practical test of distributed cognition must demonstrate the kind of cognition capable of feeling a headache. For Harnad, it is not rigorous to state that this collaborative cognitive effort is distributed cognition, even if its constituent participants jointly feel a headache or pride at the outcome – unless the expression of such emotion arises directly from an autonomous, authentic, distributed cognitive process that can pass a Turing Test.

**Evidence of distributed cognition**

This paper takes the divergent (and admittedly more romantic) philosophical standpoint that, indeed, joint experience of hardship or pride is functionally equivalent to the individual human expression of these emotions. This is after Tomasello et al. (1993), who present a more compatible hypothesis of collaborative learning that should satisfy all but the most hardened Cartesians:

> [V]irtually the whole of a collaborative-learning experience involves, by definition, co-constructions in which both participants make specific efforts at intersubjectivity. Retention of the co-construction from the original learning situation, therefore, always involves to some degree retaining the partner’s perspective. The resulting cognitive representation thus involves an integration of all perspectives from the collaborative interaction, none of which is individually sufficient, into one intersubjective conceptualization that meets all the task demands simultaneously (and this may be accomplished in different ways). (501-502)

For online collaborative research activity to achieve a firmer designation as true distributed cognition, we still require evidence of group metacognition being a shared activity amongst constituent collaborators. This is visible through the analysis of extant patterns in collaborative effort.

Cole and Engeström (1993) started to explore inherent patterns in distributed cognition in their survey of research done to date, focusing primarily on activity theory. This work was furthered by Daradoumis and Marquès (2002) in a study of university students learning computer programming. This work follows from linguistic analysis of communication logs within an ALN. They start with
identification of the exchange of information in three distinct linguistic patterns (give-information exchange, elicit-information exchange, and ascertain-information exchange). Within each interchange, or member move, nuclear and satellite roles at each point in time are identified, capturing aspects of the spiral nature of participatory discussion. The sequencing of these interchanges, and the variance in roles that are played by each student, form the phrases of this extended dialogue (138-144).

How this leads to distributed cognition is then explained by drawing from Tomasello et al.'s theory: “[c]ompletion of an exchange expresses the mutual beliefs of all participants about the accomplishment of its discourse goal. This in turn implies that distribution of the cognition...is effected among group members to a degree which is at least equal to the degree, of contribution and completion of each member moves.” (144)

Of recent interest has been patterns of this type of distributed cognition in the Internet itself, especially as explored through the blogosphere. Within the past two years, social networking sites have experienced explosive growth as the fastest growing sites on the Internet, and the tracked blogosphere doubling in size every 5.5 months (Sifry 2006). As market saturation is reached, and as each new participant transitions from being a consumer to a producer of content, Web-2.0 advocates claim, culture is redefined as a populist activity. (Kroski, 2006; 'Net Neutrality,” 2006)

Despite the audacity of these broad-sweeping claims, the change is clearly revolutionary. In a recent keynote address, Downes (2005) directly espouses distributed cognition as the chief modus operandi of educators: “It is as much about the connections your students can make with those who know, and each other, and the community in social networks and communities (Downes, 2005) This redistribution of power as a “bottom-up” content channel has brought even admittedly conservative learning directors to view the change as “the end of teaching as we know it.... We are facilitating [students'] own learning” (Richardson, 2005). This follows directly from Pea’s assertion (1993) that “New resources, and changing attitudes toward the integrity of their use, change the properties of what one ‘needs to know.’”

An excellent example of distributed cognition has recently surfaced on the Internet, namely the development of an argument around the authenticity of the “Killian memos,” artifacts critical of President George W. Bush’s service in the US Coast Guard that were eventually shown to be forgeries. During the distributed argument, which functioned in structure similar to those that occur within asynchronous learning networks (Chris, 2004), elements of consciousness arose that surpassed the individual cognitive power of any single participant, nor even any singly identifiable participant-artifact pairing. Brandon (2004)’s metaphor of an exploratory frontier is particularly evocative of the mental struggle experienced during information synthesis or mental dysphoria, played out in slow motion and larger-than-life:

This (continually changing) frontier consists of the arguments and counter-arguments that are currently in play at a given time, each of which functions as a sort of vector. Unopposed, the vector moves the argument forward; met with an opposing vector in a counter-argument, the argument on that point can be stalled or moved in the opposite direction. Throughout much of the past week, new vectors have been added by both sides.... At the edge of the frontier there’s considerable floundering on both sides – both sides are struggling to find a good formulation of what they are trying to say, both are trying to filter out misinformation, both are trying to correct their misunderstandings of the facts, etc. Things get tried out and discarded because of objections; other things endure objections to move the frontier forward.

The exploratory frontier just described, then, is an instance of distributed cognitive dissonance, consistent with Festinger’s original theory of cognitive dissonance (1957). Here, the introduction of the viewpoint that the Killian memos were forgeries created a state of dissonance within the distributed knowledge artifacts on the Internet, the magnitude of which was large, given the relative importance of the implication. This lead to a heated debate, in which individuals on both sides developed increasingly refined theories. Eventually, arguments against the authenticity of the documents reached a level that overcame the resistance of the opposite side, leading
to elimination of that cognition.

As patterns of computer-mediated communication have become clearer, they lead themselves well to the sort of modular breakdown necessary to apply developmental cognitive neuropsychology to the evidence gathered. We must now turn to cognitive science to ascertain whether these representations mirror our contemporary understanding of individual cognition.

Cognitive Science, the conscious mind and mindblindness

For eliminativist-inclined cognitive neuroscientists like Haynes to be more satisfied with the concept of distributed cognition, something akin to a computational theory of distributed mind must exist. At the core of disagreement is the implication, intentional or not, that distributed cognition leads to the rise of a distributed consciousness. Rather than get into this philosophical argument as to “what” is consciousness (after Nagel), we focus instead on the “how” of its existence. This follows from investigation of biological clues supporting the theory of functional consciousness, of which access consciousness is one type.

Modern renewal of impassioned arguments surrounding theories of the origin of consciousness arguably started with Jaynes, who asserted it arose out of conflicting impulses generated by the two halves of the brain as humans evolved out of their semi-conscious ancestors (1976, p. 100ff). While he had little scientific rigour to prove his approach was correct in any sense, his work did lead to many other researchers renewing work in this area, including Block. Of interest to us is Block’s focus on access consciousness, as it relates to intra-mental relationships: “a visual state’s being conscious is … [a matter of] whether or not it and the visual information that it carries is [sic] generally available for use and guidance by the organism.” (Van Gulick, 2004).

This maps to ALNs (and, by extension, the Internet) quite clearly: each participant is conscious (by definition), and makes his or her mental state available to the ALN-organism through posts within the environment. Block built this understanding of consciousness through Fodor’s distinction of modular mental processes (ibid). By differentiating global from modular mental process, Fodor created a computational and representational theory of mind (CTM, RTM) that starts to make the skull more transparent. The strength of this argument for education lies in parallel with Vygotskyan language acquisition, as developed by Bereiter (1985):

The influence of culture, that initially may have been identifiable in particular belief, goals and rules of conduct, can now be only globally assessed on the module as a whole. There is no longer a separate representation of the context. Instead, that representation is implicit in the whole structure of person-environment relations embodied in the module. This is what situated cognition (Brown, et al., 1989) would mean in a theory based on contextual modules. It would be an emergent property of modularity rather than an attribute of the learning process itself. (613-614)

Following this, if cognition is a construct of Bereiterian contextual modules through the development of barely-sentient infants into fully conscious babies (a.k.a. ‘Machiavellian hypothesis’ of consciousness, Byrne and Whiten, 1988), then we can just about conceive of distributed cognition as a sum of contextual intelligences operating as a whole structure – in our case, from the students-ALN combination.

Interestingly, there is scientific evidence to indicate Bereiter’s model of cognition is valid within the context of developmental cognition, coming from study of the autistic mind by Baron-Cohen. Even more relevant is that it relates to a proposed Fodorian Theory of Mind Module (ToMM), as it is used in the act of “mindreading,” or “the capacity to imagine or represent states of mind that we or others might hold” (Baron-Cohen, 1995, p. 2). This mental model is depicted in Figure 1.
Briefly summarized, the model has four components. The Intentionality Detector (ID) breaks sensory input up into objects with desires or goals (“Mommy wants the food”). The Eye Direction Detector (EDD) detects eyes, determines their direction, and interprets what they see (“Daddy is looking at the door”). Combining elements from these two modules, the Shared-Attention Mechanism (SAM) creates triadic representations in a strict grammar of [Agent-Relation-(Agent-Relation-Proposition)], for example [Mommy-sees-(I-see-the-bus)] or [John-sees-(I-see-the-girl)]. The final Theory of Mind Mechanism (ToMM) generates thoughts of the grammatical form: [Agent-Attitude-”Proposition”], such as [John-believes-”it is raining”] or [Mary-thinks-”my marble is in the basket”].

Systematic and extensive biological evidence is provided for the first two systems, which I will not attempt to summarize here (32-52). Clinical research on autistic children hints at a biological basis for the latter two. This view is supported by later research into individuals who have damage to specific localized areas of the prefrontal cortex, causing executive function disorder (Russell et al., 1997). Later key studies have shown marked difference in activity within so-called “mirror neurons,” shown to play a key role in support of ToMM (Williams et al., 2001).

While we are a long ways off from curing autism, or even identifying a single cause, the theory has had immediate practical value: by identifying the link between EDD, SAM and ToMM, Baron-Cohen deduced a method of early detection of autism. By looking for a lack of gaze following, his research successfully predicted the disease’s occurrence in a screening of 16,000 British children at the age of only 18 months (Baron-Cohen, 1995, pp. 138-9). Traditionally, autism has not been identifiable until the child is at least 3 years old, and is identified only after demonstration of problems in speech development.

As older autistics can be said to possess “mindblindness” (Baron-Cohen’s term), the remedial development of their SAM and ToMM contextual modules can be said to produce global awareness of the concept of mind. It is precisely in this context that I propose distributed cognition within graduate social science study forms a metamind theory theory. As the mature students (each authentically involved in the course) discuss their own views on the course’s readings, they develop a distributed theory of mind that incorporates both each individual’s situated view (a la ID vs. EDD abstractions of the physical world), describe their understandings of how these interrelate (SAM within the context of a contributed note in an ALN).

As research in education and psychology see-saws back and forth between Kantian philosophical ideals and Wundtian hard-science experimental methodology, knowledge transfer between the two disciplines will continue to flourish. My exploration in this paper has tested the theory that “brass-instrument psychology” (Davis, 1970) through cognitive neuroscience is returning to direct applicability to the notion of distributed cognition. While developmental cognitive neuroscience may provide great insight into individual human behaviour, it cannot yet be directly be applied to group activity. There is no obvious biological analogue of sex hormone levels or myelin sheath development within distributed cognition.

Yet there are enough parallels between the theories of consciousness and neural dysfunction, especially as
applied to distributed cognition within graduate-level study as supported by ALNs to recommend further investigation. As autism is more a developmental disorder than a permanent, immutable biological one, early therapies to encourage gaze following and the development of higher cognitive ability. For example, a study could be undertaken to explore using techniques of remediation for autistic children within ALN design, helping to guide moderators in the identification of individuals and group mindblindness, with resolution through increased “mirroring” activity. Continued research along these lines should help clarify both the tangibility of distributed cognition, as well as illuminate means of its encouragement.

Conclusions
Distributed cognition has been explored in depth as a means of understanding group interaction, starting from culturally mediated folk psychology. Working through both situated and LPP theories of learning, distributed cognition moves toward a unified model, and deterministic approaches to its encouragement in online design are enlisted. Opposition to the development of the model as anything beyond a reductionist group activity was reviewed. Patterns of cognition, as explored in ALNs and the Internet point toward evidence against this theory, including elements of group cognitive dissonance and authentic knowledge building. Theories of the origin of consciousness, and the biological basis for these theories, are discussed as a means to test if distributed cognition is a necessary condition for distributed consciousness. Evidence of neurological underpinnings of theory-of-mind, parallel to the construct of folk psychology, has also been presented, along with its practical application to autistic spectrum disorders. One final connection is made to graduate study, by relating internal and external forms of theory theory, suggesting an area for further research.

References Cited


