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Integrating and extending the distributed approach in cognitive science

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This special issue is a refreshing contrast to the intuitively influential notion of language as an internal system. This internal approach to language is going strong in some segments of the cognitive sciences. As an assumption, internalism drives much empirical work on language, and it is the basis of prominent theories of language – its nature (e.g. an internalised computational system), its evolution (e.g. a single still-unknown mutation), and its function (e.g. thinking, not communication).

Radical fundamentalist versions of these theories are no longer in the mainstream, however, despite the attention they may garner by forceful exposition (e.g. Chomsky 2011a). A fuller canvassing of the cognitive sciences – obviously outside the scope of the current presentation – would probably reveal that *most* researchers, even those who study aspects of language isolated in individual participants, would allow for an intrinsic social characteristic to language. I would go so far as to guess that they would place this social character on explanatory par with other structural or information-processing features that are studied in the lab.[1] And despite what is averred by Chomsky (2011a)[2], this social character in human cognition has been proposed in many domains, from vision (Balcetis & Lassiter 2010) to memory (Barnier et al. 2008). Humans are intrinsically social *in a way* that distinguishes them from any other primate species, and this sociality seems to be weaved into many cognitive processes (Castiello et al. 2010; Tomasello 2009).

But "social" is not the same thing as "distributed," by the content of this issue.[3] The latter may subsume the former. The distributed approach discussed in this special issue is not "simply" social – it does not just propose an added static feature of any synchronic language context (as noted in Jennings & Thompson this issue). The approach instead regards this social characteristic as just one part of a broader *dynamic distributed process* that constitutes language, through different kinds of inter-individual coordination at many levels of spatial and temporal scale (Cowley this issue; Fusaroli & Tylén this issue).

But some key aspects of a distributed approach to language *are* social. At least at the dyadic (or small-group) level, coordination does appear to be intrinsically social, and is thus definitive of the (evolved) human linguistic context. Many universal structural properties have been proposed for language, but this dynamic social one is especially important: All human beings learn language in a dynamic social context (Clark & Clark 1977); extracting an infant from this social context probably precludes the emergence of language (Candland 1995); and importantly, linguistic exposure in a non-coordinative medium does not lead to language learning, even by children (Sachs et al. 1981). The distributed account takes this dynamic social coordination as explanatorily central to the dyadic context. It would also embrace this level of analysis as crucial to understanding the ecology in which language evolved, and in which it occurs today. Though others may take the internalised, structural characteristics as being "clearly, the most fascinating and important aspect of language" (to paraphrase), this sort of assertion is a matter of taste, not of convincing argument, and certainly not of evidence.

These continuing disagreements about language as being internal or distributed are partly driven by the choice of evidence marshaled in support of one or the other. For example, those who focus on internalised language structures might choose auxiliary inversion as revealing interesting constraints on instances of language. By showing the structural character of this property, one could then argue that it cannot be accounted for readily by other theories, such as the distributed one. And because these (internalised) structural aspects are so central (as it is asserted in this context), then distributed, social (or other) accounts are hobbled by (at least one) fundamental explanatory limitation (see, e.g. Crain & Pietroski 2001 vs. Reali & Christiansen 2005; see also Lidz et al. 2003 for anther structural example).

Yet the special issue offers provocative possibilities that buck this trend. In this issue, there are passages in which researchers adopting the distributed approach propose ways of rethinking structural examples like those referenced above. Jennings and Thompson (this issue) proffer a potential relation between patterns of language usage they call *engendering*, hypothesising conditions under which distributed coordination between individuals, extended over time, brings about interesting structural aspects of language, such as center-embedding.[4] While certainly conjectural at this point (as admitted by the authors), this frames a very interesting agenda. It thus offers a glimpse of bridges that can be drawn between the distributed logic, and "internalist" mainstream cognitive science. In the following work, I have three primary goals. The first two are to discuss the contents of this issue, and extend and reinforce the ideas of a distributed approach to language. A third goal is to briefly consider where the approach may go to strengthen its influence in cognitive science. In sum:

1. The distributed approach is compatible with theoretical constructs in internalist and other mainstream theories (like the lexicon), and can be integrated with many variants of these internal conceptions of language (reinforcing the debate between Donald and Cowley, and to some extent Clark, this issue).
2. The distributed approach permits a new synthesis of processes that live at very different time scales, from dyads to populations. This provides an exciting and comprehensive perspective on language that encourages interdisciplinary interaction (reinforcing the discussions in Ross; Fusaroli and Tylén; and Jennings and Thompson).
3. The distributed approach could be strengthened by extending two avenues of computational and empirical investigation.

1.   Lexicons and all that: The status of theoretical entities

One point of contention that may continue to separate existing distributed proposals is the "psychological reality"[5] of constructs found in internalist theories, such as the "mental lexicon." This supposed neural repository of words and their various properties (dependent upon one's theory) is now central to a number of accounts of syntax, from usage-based theories (e.g. Tomasello 2005), to lexicon-driven generative accounts (e.g. Sadock 1991). As discussed in Cowley (this issue), Donald (2001) also hypothesises a mental lexicon as central to human language. Apparently, therefore, he too supports this internalist conception by ascribing the lexical level of analysis to particular neurophysiological hardware.

As Donald (this issue) discusses in his response to Cowley, he rejects this classical perspective. Rather, his position is that the mental lexicon is a broad and dissociable set of neural access points to a semantic network. This large-scale, multimodal network in which words may serve as access links to sparse assemblages of episodic information brings about particular functional relationships between phonetic (or inscriptive, etc.) patterns and particular events and things in the environment (for a definitive proposal, see Barsalou 2008). One such example is "simple ostension" even though more complex symbol relations are possible (as discussed in the oft-cited Deacon 1997). So the human neural system is *behaving as if* it contains a repository of labels with functional relations, which is a certain kind of capacity that emerges out of the lexical network. And Donald (this issue) notes that the neuropsychological evidence about breakdown suggests this theoretical construct is not of coincidental usefulness, even if it is approximate.[6]

Still, if one posits that particular "lexicon-like" internalizations of language are a fundamental part of the story, does this vitiate the distributed account? It may not, because words "… come from an increasingly innovative cultural matrix," and

"[t]he skills needed to exploit such tools must also be developed in culture, and assimilated by means of an extended learning process." (Donald this issue) Even if distributed theorists briefly entertained some form of "psychological reality" for theoretical constructs like lexicons or (the subject of Jennings & Thompson this issue) some engendered patterning of sequential lexical items (i.e. syntax), to my mind, this does not seem to challenge either of two important assumptions urged by the distributed account: that first, language should ultimately be conceived of in its social/distributed context (Enfield 2010), and that it is usefully conceived of as a dynamic multi-scale process (Cowley this issue).[7]

These two overarching assumptions about language can be reconciled with classical conceptions of the lexicon and syntax. It can be argued that events leading to a lexicon and syntax are "distributedly" evolved (on a very long timescale), "distributedly" sustained (in socially-embedded language learning), and "distributedly" employed (in real, physical encounters: Jennings & Thompson this issue). I am not suggesting that the distributed account would deny the importance of individual constraints. I am simply suggesting that there may be ways to integrate it with internalist conceptions that need not challenge either agenda fundamentally. Indeed, this approach might lead internalist theorists to show more interest in social coordination and the dynamics of distributed language. Additionally, by doing so, the distributed approach may shed light on the validity of these various theoretical entities and processes. Perhaps, as Cowley (this issue) describes, the solution is to understand how semantic knowledge is undergirded by a rich linguistic memory tied to shared cultural events, and by deep interconnections between it and perception-action systems (see, e.g. Binder & Desai 2011). As I describe further below, integrating theories of the individual cogniser with theories of distributed processes would appear to offer a promising agenda.

2.   Cascades across levels: From dyads to populations

The previous section briefly discussed the status of internalist theoretical entities in a distributed account. I argued that, to some extent, the distributed account is robust to a broad array of conceptions about how the mind/brain is involved. Short of the most radical internalist conceptions (e.g. language is a "system of thought," Chomsky 2011b), the distributed account, as Donald suggests, need not give up even good-old-fashioned concepts from linguistics and psycholinguistics (like the lexicon).[8] Still, the natural question becomes how the episodes of "colloquy" (Jennings & Thompson this issue) cascade through distributed networks of people, extending over space and time, and in the words of Ross: "Humans may be individually cleverer than other animals, but the overwhelming source of their

ecological dominance is the fact that their discoveries of new levers of environmental control are not forgotten across generations." (this issue)

This "ratchet effect" (Tomasello 1999) is well-known and some versions of this process are discussed in many contexts, including Donald (1991) and several places in the current issue.[9] Everything I am doing now and that you are doing now as a reader requires a bedrock of constraints and conditions wrought by a long process of distributed, mutual influence among people. Our (mostly) shared vocabulary, the extended training we receive in academic writing, and so on, requires a long-standing cultural edifice that is "transmitted" from generation to generation. Many of the papers of the special issue discuss this and provide more interesting examples than I could provide, so I will not belabor the point. There is also dynamic coordination on a more local temporal level. My current behaviour (and yours) is influenced by more coeval processes – dynamic influences of the audience (Brennan et al. 2010) and social memories, expectations, and concerns (e.g. Horton & Gerrig 2005) and so on – that (partly, at least) render our interpretation (and evaluation) of each other's behaviours. So the cognitive processes of an individual person, when placed in the context of this broader academic agenda (from its emergence to its current enactment), can only be a limited part of the explanatory picture. The special issue is compelling in this regard.

But how does this distributed process work, exactly? What are some examples of *kinds* of coordinative processes, and the change they can bring about? Ross (this issue) uses game theory in enlightening discussion of how coordination unfolds at different spatial and temporal scales. Beyond simply signaling/messaging, Ross discusses two kinds of coordination that are compelling as sources of structure. In the first case, team coordination reflects the "recruitment by agents of coalitions to accomplish joint projects." In the second, intergenerational change is a "second-order coevolutionary dynamic," through which innovations are not only preserved, but may create new opportunities for innovations as a new cognitive foundation for each passing generation. Both kinds of dynamic coordination have been studied recently in the cognitive science of group decision-making and language evolution.

In the case of group dynamics, Goldstone and colleagues (see Goldstone et al. 2008) have looked at collective group behaviour under differing conditions, such as different individual strategies or task constraints. For example, imitation within a group may sometimes hinder group performance, while innovation may serve to help the group explore new vistas of decision-making abilities. Their results, so far, suggest there is a trade-off. This work seems to be consistent with the economic empirical work described by Ross (this issue). In addition, the emergence of symbolic communication has been shown to be preserved in groups when they are able to mutually interact a pair at a time. This works even if they don't work as a team but only as loosely interconnected pairs of people who engage in mutual exchange (Fay et al. 2010).

As for intergenerational transmission, the very elegant work of Kirby and colleagues (2008) and recent iterative learning approaches to language evolution (Kalish et al. 2007; Kirby et al. 2007) show that basic learning processes that extend over generational time can accumulate systematic structures (of a simulated linguistic sort). This occurs because subtle changes in the behaviour of one generation are preserved in the next, leading to a cumulative effect after many generations, and bringing about systematic forms of behaviour (in, e.g. a simulated language). So, while not explicitly framed in the mathematics of game theory, as Ross (this issue) discusses, it is certainly within the scope of thorough experimental and computational work to explore how coordination contributes to sources of emergence. As I discuss further below, importing game theoretic ideas about collective behaviour into cognitive science – where we do spend more time thinking about the "mechanisms" of individual agents – may lend new understanding to how the ratcheting effect works for language at larger scales.

This integration would represent an account that resembles that of Fusaroli and Tylén (this issue). In their helpful review of recent work on symbol emergence in coordination, we get a picture of how processes of individual cognisers function in local contexts and also across different timescales (e.g. collaboration) to bring about stable symbolic processes (e.g. stable shared referential vocabularies). As discussed in their article, this same ratcheting process may lead to the emergence of linguistic structures and symbolic innovations in larger groups. Thus, the integration of the coordination dynamics discussed by Ross (this issue) and the local (then cascading) coordinative dynamics model of Fusaroli and Tylén (this issue) provides insights that may lead to new experimental work on how language is coordinated between dyads and then, over long periods of time, becomes quasi-stable in a population of speakers with shared symbols.

3.   Quick summary

A reader sympathetic to the distributed approach can perceive rich relationships across the current articles. Here is a quick summary, from my perspective.[10] Proposed cognitive processes are crucial to our conception of higher-order coordination, because that coordination is only possible because of the mimetic basis of our cognitive abilities (Donald).[11] They are likely to derive partly from motor control (Clark) in a rich physical environment that gives rise to sequential capacities (Jennings & Thompson). Meanwhile, simultaneously but at a slower time scale, a subset of these proposed processes bring off successful coordination using mechanisms such as mimesis, rich linguistic memory, and integration with perception-action systems. Language thus emerges as a dynamic, distributed and

non-localizable system (Cowley 2011). As these processes unfold, generational change can engender particular structural innovations (Jennings & Thompson) that arise in various forms at different scales of organization, from dyadic collaboration (Fusaroli & Tylén) to larger-scale intergenerational shifts (Ross).

4.   Where to from here?

These (mostly) verbalised ideas are interesting and important. But beyond verbalised (or purely formal) theories, if a perspective is to be influential, the scientific rubber must meet the road.[12] Accordingly, I now suggest that a few agendas may be taken on by researchers interested in a strong version of this account. Here are some possibilities, motivated by the very reviews contained in the articles of the special issue. The agendas are, of course, part of ongoing research in cognitive science. The idea is that they should be pursued in full.

While those taking a distributed view have already begun to explore agent-based modeling (see, Belpaeme et al. 2009; Lopes et al. 2008), they may have focused too narrowly on the physical grounding of linguistic symbols.[13] Further, game theoretic explorations, as Ross acknowledges, typically cannot incorporate individual cognitive processes and strategies that are readily observable in individual behaviour. In order to understand the impact these processes have on the dynamics of team coordination and intergenerational transmission, agent-based modeling in which agents are endowed with richer conceptions from cognitive science may provide new vistas of exploration. Put simply, *different* cognitive constraints may "ratchet" skills *differently*. The individual-level constraints interact with the larger spatial and temporal scales of populations. Simulation provides the means of exploring this interaction.

This has, of course, been pursued in the domain of language evolution and artificial-life simulations (e.g. see Cangelosi & Parisi 2000 and Nolfi & Mirolli, 2010 for reviews), but it could also become a flagship toolkit of distributed theorists. This would permit distributed accounts to have explicitness in the essential aspects of the theories being proposed. They also provide existence proofs of how distributed coordination in groups brings about differences in structure. For example, in some recent collaboration with Gary Lupyan (Dale & Lupyan in press; see also Lupyan & Dale 2010) we have observed that group size can impact learning patterns in a population. Very large groups highlight adult language learning, because large groups will engage in more trade, cross-cultural interaction, etc. than smaller groups. This may correspondingly influence the structure of the language that group speaks (i.e. more regularization). In short, social network size can engender differences in language structure. This basic idea is discussed in Fusaroli and Tylén

(this issue) as well, and agent-based modeling permits a demonstration that, given a basic representation of proposed variables of importance, what is expected falls out of a simulation. Human verbal intuitions have been shown to be limited in numerous scientific contexts, and these simulations allow the intuitive rubber to hit the computational road.[14]

Agent-based modeling can also be used to establish how time-scales are integrated. One key feature of the distributed approach is its emphasis on language as a multi-scale phenomenon (Cowley this issue). To understand behaviour at various scales, and how they produce patterns of cross-scale influence, one needs a context where variables can be explicitly specified, so that one can unveil the expected (or perhaps even some unexpected) outcomes. Simulation affords such opportunities. This would also extend the exciting simulation and robotics work on symbol grounding, which has been influential in guiding the thinking of distributed theorists (e.g. those cited above; and see Steels 2007 for discussion).

In this commentary, I have occasionally emphasised that the exact nature of the underlying cognitive processes is an important part of our understanding of how language works. This is because larger-scale coordinative dynamics are partly constrained by the "computational psychophysics" that are centered on individuals. What do proposed processes of individual cognisers do when they are collected in groups and allowed to interact over thousands or millions of iterations? The agent-based modeling context thus allows an integration of accessible empirical evidence from individualistic cognitive science, and mutually inform ideas of distributed processes at different scales. An interesting example of this agenda is Barr's (2004) agent-based simulation with processes that are "socially attentive" and others that are not, and exploring what conditions are required to engender spatially-distributed dialects in simulated language. In short, the big picture this special issue lays out across its contributions (summarised above) could be, in principle, instantiated in a single simulation.

The final point that needs to be mentioned is that language learning is a crucial aspect of understanding the evolution of social coordination. Though there is *some* mention of this in the special issue, the *fundamental* issue of how learning constrains evolutionary change was less central than I had anticipated. Others have argued that a crucial window onto our language evolution is provided by careful study of the language acquisition context (e.g. Christiansen & Chater 2008). Oller (2000), through what he calls a "natural logic" approach, assumes that language learning is tied to our hypotheses about how language sprang from our primate ancestors long ago. This approach utilises the constraints imposed by biological learning and evolution as observed in ourselves and close relatives, and what can be (very reasonably and even minimally) guessed about ancient conditions. The approach focuses on how perceptuo-motor processes of infants are embedded in

their social context, and how they unfold in intra- and interpersonal feedback loops that support language (Warlaumont et al. 2010). This requires again an integration of the cognitive and biomechanical constraints of individual infants, and the coordination shaped by the rich interaction in dyads. This has been discussed by several other researchers (e.g. Murray & Trevarthen 1985, as cited by Fusaroli & Tylén this issue; also Cowley 2004; Trevarthen 2009). Understanding what distributed language does over different scales of time *requires* an understanding of how languages are learned. Or, at the very least, it needs to be integrated with this knowledge in order to be convincing. Oddly, many rigidly individualistic conceptions of language, such as the generative linguistic account, shamelessly ignore these data (e.g. by deeming the primary linguistic context too error-ridden and noisy). The distributed approach does not suffer from this flaw.

Overall, the content of this special issue is interesting, compelling, and important. Some parts of these papers are challenging, offering diverse vocabulary for concepts that recast our ideas of language (from "engendering" to "reenacting"). But, as Cowley (this issue) describes, overcoming "scientization" of commonplace misconceptions of language (such as the classical lexicon that both Donald & Cowley deride) will require challenging new ideas about how cognitive processes, conversation, cultures, and languages, mutually shape each other across long spans of time. The special issue succeeds in shaking these conventional foundations. I hope to have provided reinforcement of these ideas, and perhaps some new ones that can serve both the authors and their readers.

Notes

1.   There are a variety of "mainstream" perspectives in the cognitive science of language, and all of them at this point are "internalist" in nature, in that they attribute to the individual a level of linguistic representation which is denied by the distributed theorist, who sees language primarily as a stable property of populations.

2.   "The observation about social context is uncontroversial with regard to communication. It is true, a virtual tautology, that the study of communication takes into account social context. It is also uncontroversial that the study of the mechanisms that we put to use typically ignores social context, and quite rightly so: for example, the classic work of David Hubel and Torsten Wiesel on the neurophysiology of vision (Hubel & Wiesel 1959), or of Elizabeth Spelke, Renée Baillargeon, and others on object recognition and constancy (e.g. Spelke 1985, 1990; Baillergeon, Spelke, & Wasserman 1985), or Shimon Ullman's Rigidity Principle (Ullman 1979a, b), or in fact virtually all of the fundamental work that aims to determine the properties of the modules of cognition, at whatever level of inquiry it is conducted." (Chomsky 2011a, p. 266)

3.   For example, "social" may refer to "airbone synapses" between people, as Steffensen (2011) has called direct interpersonal interaction. As discussed later in this commentary, other types

of distributed patterns likely occur, such as intergenerational change (Ross this issue), which is not "social," commonly construed.

4.   In fact, center-embedding and related recursive aspects of language have also been a focal point of debate in cognitive science (e.g. Smolensky 1988; Christiansen & Chater 1999; see also Rączaszek-Leonardi 2010).

5.   For a much earlier debate on attributing so-called "psychological reality" to constructs in theories of language processing, see Fodor & Bever (1965) and papers that cite it.

6.   It is important to note that Donald's strong expression about clinical aphasiology is perhaps too strong – evidence accumulating in the past 20 years has actually revealed that distinctions among these conditions are more approximate and fluid, with breakdown of various functions not so pure as textbook examples of aphasia specify. Donald (this issue) appears to acknowledge this, but the strength of the evidence in this regard is important to emphasise (see, e.g. Wilshire 2008).

7.   It does appear that distributed theorists are concerned with *how much* these two levels explain (individual vs. distributed) and to what extent one is subservient to the other (e.g. individual languaging being, to a great extent, a function of the larger-scale dynamics unfolding at the dyadic, group, and population levels). Unfortunately, how this explanatory mitigation could be accomplished is outside the scope of the current discussion but an important point to pursue (Rączaszek-Leonardi personal communication).

8.   Importantly, there may be *other* reasons to give them up (e.g. Elman 2009), though many of these arguments are based on *internalist* considerations (i.e. more plausible tales at the representational level).

9.   The ratchet effect has been proposed to underlie the cumulative evolution of behavioural or technological abilities in populations: "Individual and group inventions are mastered relatively faithfully by conspecifics, including youngsters, which enables them to remain in their new and improved form within the group until something better comes along." (Tomasello 1999, p. 512)

10.   For the sake of full disclosure, this author's perspective is perhaps more mainstream. Internalist ideas are still powerful guiding hypotheses for huge volumes of research on language. This research has produced countless systematic findings about individual "languagers" that have yet to be explained by the distributed account. Perhaps, rather than a pure "internalist" perspective, one dubbed "active internalist" perspective best approximates this author's opinion. In this framework, the intrinsic dynamics of a system are deemed central to explanation, but are modeled as coupled to the broader social context (see, Yoshimi in press).

11.   A cautionary tale can be derived from other sciences in which "privilege" is granted to some level or other (e.g. Mitchell 2003), and may help distributed theorists avoid their own version of "level chauvinism." Just as one can argue that distributed, cultural processes engender our cognitive abilities, one could argue that our cognitive abilities also support those cultural and distributed processes. They are mutually influencing and sustaining. They can also individually be the *emphasis* of analysis, given the standard agenda in science of fixing some variables and not others to shed light on the whole system. In short, there is an important role for individualistic explorations, perhaps as much as there is a role for exploring the effects of their interpersonal distribution, because each informs the other.

12.   It is also important to avoid what Chemero (2009) calls "Hegelian arguments," in which one discards a whole scientific framework by philosophical argument. Instead, he argues, one should develop "guides to discovery" for generating new *scientific research*: new models, new predictions, new empirical findings, and so on.

13.   And indeed, when one looks at the simulations cited here, they often include individual agents *representing* symbolic forms, suggesting that the simulations adopt a weaker version of the distributed account.

14.   And there is readily available software to do this, from MATLAB to Avida (Adamansky & Komosinski 2009).

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