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Narrow and Broad Faculties in System 1 and System 2: Toward Consensus in the Debate on Modularity

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Abstract

Research on learning, the structure of attained knowledge, and the use of this competence in performance has repeatedly returned to longstanding proposals about how to better understand proficient use of knowledge and how humans acquire it. The following article takes up an exchange between Chiappe & Gardner (2011) and Barrett & Kurzban (2012) on the concept of modularity, one of these proposals. Despite the disagreements expressed, a careful reading of the contributions shows that they also left us with lines of discussion that will eventually sort out the relevant hypotheses and integrate findings for future research. These lines of work will contribute to a clearer understanding of an updated version of the modularity hypothesis that is also compatible with evolutionary science perspectives on learning. How might the categories of domain-specific and domain-general correspond to the distinction between competence and performance and to that of narrow faculty and broad faculty?

Keywords

functional specialization – faculty of language – intelligence – evolution of language

1 Introduction: Points on Which We Might Be Able to Find Common Ground

In thinking about the interacting components and processes of any complex psychological faculty, research has considered how they could be reliably described in componential terms. This approach has put forward proposals

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that conceive of the overall structure of the mind/brain as modular in some way and to some degree, the alternate hypothesis being that at some higher level of the nervous system cognitive organization is thoroughly equipotential and homogeneous.

Given that some version of modularity can be taken as a hallmark property of evolved biological systems, the study of competence, ability and learning from this point of view has tried to distinguish among the different claims that have been presented over the years. The claims about competence, ability and learning have thus tried to make contact with relevant research in evolutionary science. So far, various competing versions have been examined and debated. One approach to the discussion could be to provisionally set aside competing definitions and commitments and to start with the presentation of cognitive structure as componential in a neutral sense. In the language sciences, again without committing ourselves to the idea of domain-specificity, could there be a sense (shared in common among all theories) in which phonology and syntax, for example, correspond to two different kinds of linguistic knowledge – two components? On one view they would be domain-specific "components"; on the other, the "components" could be considered as networks of competence[1] subserved by domain-general capabilities. On a separate but related comparison, could some form of functional specialization be accepted in the case of the different kinds of central nervous system processing for tactile, visual and auditory cognition (linguistic aspects aside)?

Over the years an interesting trend in the discussion has appeared, among proponents of the first view, to distance themselves from the very use of the term modularity. Prominent researchers have recently commented on this shift in terminology, pointing to some of the extravagant claims by the author most associated with the term, Jerry Fodor; that they had cast a veil of confusion over ongoing work. Two examples stand out: a vaguely formulated theory of radical concept nativism[2] and his attempt to discredit advances in research on natural selection.

1 In this paper a "competence" is a "knowledge structure."

2 Models of learning that include *procedures* are necessary for both new simple and new complex concepts. A reasonable nativist explanation accepts the existence of a limited set of innately given conceptual primitives as well as the participation of a suite of acquisition mechanisms (Margolis and Lawrence, 2011). Better understanding of the interaction of domain-specific and domain-general mechanisms in the formation of conceptual structure will be informed by research on: rich input of relevant positive evidence, simple but consistent immersion, implicit associative learning, communicative-based learning accompanied by provision of instructive examples, explicit instruction and reflection on negative evidence, deliberate hypothesis testing, and so forth.

As distracting as these claims came to be, in particular the deepening skepticism over the years about the concepts of adaptation and descent with modification, one idea still deserves thoughtful consideration, that there are two dimensions of mental heterogeneity: the specialized modules themselves and the so-called "central systems," that not all cognitive domains are innately and narrowly constrained, encapsulated in regard to input and shallow in output, and developmentally pre-programmed to be domain-specific. Looking back on this idea, that the input mechanisms of perception (of the "periphery") were a good example of modular type design should not have implied that central cognition as a whole would be thoroughly domain-general. Rather, research on the higher-order knowledge structures has pointed to examples of specialized domains within higher-order faculties. In comparison to Fodor's more controversial claims, we could grant that such was a minor defect in the original formulation. On the other hand, regarding the widely criticized concept of encapsulation, Fodor from the beginning left the door open to admitting degrees (1983: 64–74, 1985: 2–4): simply, that the contribution of top-down information to the computations of specialized bottom-up processes, for example, is not completely unconstrained, as it is conceived of in holistic and integrativist type models. Especially for higher-order domain-specific modules, interactivity must be extensive, but they are not open to unlimited penetration.

For now, to begin to sort out the different perspectives for the purposes of this discussion, we can defer for another occasion a discussion of the radical holistic theories. Among working researchers in cognitive science, holistic proposals favor a domain-general architecture throughout rejecting any participation of specialized modules in higher-order cognition. In popular culture and in the non-scientific academic departments there is a vague affinity with this view expressed in the increasingly dominant *tabula rasa* view associated with the limitless possibilities of an unconstrained plasticity, outright rejection of evolutionary psychology and the various post-modern theories of strong relativism.[3] Nevertheless, and importantly for the present discussion, it would be unfair to hold the former, colleagues in the cognitive sciences, responsible for the social media enthusiasm for unlimited malleability.

3 The deep skepticism about natural selection may be related to recent anti-evolutionary science reaction from within humanities departments (in particular different iterations of cultural studies). A related source is the more traditional opposition of transparently ideological motivation, uncomfortable with the perceived individualistic (as opposed to collectivist) implications of concepts such as fitness, competition, inheritance and human nature, most famously traced to the 1930s in the theories of biologist Trofim Lysenko.

On another level, the debate on the core questions is not about nativism, *per se*, whether or not biological endowment is a factor to consider in describing cognition. Today, the strongest neo-behaviorist theory accepts, by logical necessity, that the advanced learning capacity of modern humans is rooted in one kind or another of biological species-specific inheritance. Rather, the outstanding question is one of comprehensive integration or some version of componentiality. Is our unrivalled creative capacity exclusively connectionist, associative and domain-general all the way up to the top and down to the bottom, or is there some degree of domain-specific differentiation and specialization? On the question of "inheritance" there is actually a more varied panorama of theoretical proposals, depending on assumptions (two, for starters). Given a wide provisional acceptance of some version of nativism, as outlined above:

– Are the domain-general capabilities of modern humans descendent from ancestral capabilities of a domain-general type, or are they unique emergences in our species, of sudden appearance?
– Likewise, are the present-day domain-specific capabilities (gradually) evolved cognitive structures, or are some, or all, of the defining competencies of modern humans unique and sudden emergences with no ancestral antecedents?

With this provisional framing of the discussion, one exchange on the relevant concepts has offered a productive assessment and tentative roadmap for possible convergence for the differentiation and specialization proposal: referencing the positive contributions of Fodor, to what extent, how and in what way "massive" is modularity? The exchange between Chiappe (2000), Chiappe & Gardner (2011) and Barrett & Kurzban (2006, 2012) and subsequent commentary by other authors was just such a promising beginning. The purpose of the present modest proposal is that the exchange of views on the problems mentioned above should pick up where it left off.

2 Competencies and Abilities of Type 1 and Type 2

In parallel, by coincidence, early reports from our project on child bilingualism took notice of the componential aspect of language proficiency (ability). As the exploratory study began with a description of performance in the academic realm at the ability level, focused specifically on literacy learning, previous studies that came to form part of the conceptual framework (Francis, 1997) naturally emphasized components within larger networks. On the one hand, the literature pointed to different patterns of interaction among linguistic and non-linguistic domains, contrasting academic literacy-related language abilities and abilities of face-to-face conversation, and on the other, comparing first language (L1) and second language (L2) competencies. The contrasts and comparisons seemed to reveal network structures of different kinds (Chireac & Francis, 2016; Chireac et al., 2019). A review by Bialystok and Cummins (1991), precisely about the very same realm of language ability (academic-L1-L2), called attention to the concept of modularity as being relevant, in this case from proposals by Jackendoff (1987).

Considering the idea of "levels," proficiency/ability appeared as a coherent category more or less equivalent to the traditional category of "performance" or "language use." In later work, the distinction drawn between faculties described as "narrow" and "broad" (Fitch et al., 2005; Pinker & Jackendoff, 2005) was extended to problems of studying language use in the learning of the literacy-related abilities. This extension could be taken as following the same distinction, more or less, between "competence" and "performance." In the case of a language ability such as reading in which the linguistic domains interface with the visual system, among other systems, literacy research has tried to specify the relevant interconnections. The larger, overarching, system then serves as an analogy for study of the interfaces among the components within the domain of the faculty-narrow (e.g., morphosyntax and phonology). This turned out to be the proposal in Francis (2012, 2013, 2017)[4] following the evidence of semi-autonomy of the higher-order proficiencies (requiring discourse-level coherence, logical and chronological organization, causal relation, and mastery of concepts) in relation to the linguistic subsystems of the bilingual learners. This contrast, in our view, parallels the same contrast described in the literature as System 2 and System 1, respectively.[5]

4 Because of the separate representation (not bound to the linguistic modules) of key System 2 proficiencies, access to them via the (also) separate language representations of the bilingual or second language (L2) learner is not blocked by acute sociolinguistic restriction or beginner level L2 grammatical competence. The access might be marginally deflected, because the systems are interactive, but it remains open and productive (Francis, 2012: 79–140). Similarly in Grammatical-Specific Language Impairment, conceptual structure and other higher-order capacities remain spared and accessible. As pointed out by Kinsella (2009: 105–107), the analogy to the FL(n) also suggests a modular architecture internally to its own structures. Following from the evidence of modular architecture within the larger FL(b), where such componential structure is more obvious, the proposal for research is that the FL(n) itself is internally diverse and heterogeneous. According to Kinsella (pp. 72–81), the complexity of (narrow) linguistic competence rules out a single domain-specific mechanism.

5 Given that the results of our study confirmed models in the field of literacy and bilingualism that had referenced versions of the modularity hypothesis, the final report continued, in its turn, to present it as the best approximation among candidate explanations to a proposal for further research. Such is still the current status of this line of investigation in the field of literacy, one that will require a new generation of more robust methods to decisively confirm

The early studies by Stanovich and associates on the psycholinguistics of reading contributed to a framework for subsequent work on describing higher-order cognition. Converging evidence pointed to a conclusion: that reading depends on specific mechanisms in word-level recognition, for example, that effective phonological access is an integral constituent of word identification. The metaphor of "encapsulation" came to be useful in describing how top-down information (e.g. background concepts, reader expectation, cultural knowledge) is not the driving force that supports efficient sentence-level decoding. That for accurate word identification and parsing of phrases, domain-specific processing does not entertain, in an unconstrained manner, top-down effects of context. Effective comprehension, in turn, is maximized by a modular-type process, by automaticity, that exploits the high-fidelity and high-reliability input from the orthography and its link to phonology. For writing, for example, the physical signal is less ambiguous than for speech. Higher-order computation in reading benefits from decoding that exhibits speed, delivering accurate representations to open-ended inferencing. In fact, a characteristic of reading difficulty is the over-reliance on top-down expectancy for word identification, implemented by the reader as a compensatory strategy (Stanovich, 2000: 209–236). The extended lexical entry, if we could name it, that in addition to linking the semantic, grammatical and phonological (natural/inherited) subcomponents is now linked to an orthographic sub-component, will be reliably accessed if the representations and interconnections are of high quality. If they are of high quality, decoding is fast and accurate, just the kind of input that comprehension requires. Even for morphosyllabic writing, phonology cannot be bypassed or blocked in silent text reading by meaning-based components of characters because it is one of the biologically constitutive modules of primary linguistic competence with which orthographic knowledge interfaces (Packard, 2000).

Here, another departure from Fodor's schema comes to the fore, that of skills and competencies that appear as modular but which are acquired. In these cases, the properties of domain-specificity and componentiality are manifested in "central" type capabilities. We will examine two possible examples from abilities that arguably require the participation of learned skills of the higher-order type.

Similar to the observation in our descriptive and exploratory study of bilingualism and academic language use, the above cited studies of literacy

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or discount tentative conclusions about specialization, specificity and cognitive-general domains. The most complete summary of the framework for reading research begins with Perfetti (1999) and Stanovich (2000).

observed analogous or parallel differentiations: (1) between implicit acquisition and explicit learning, the latter associated with formal teaching, and (2) between attainments that do not correlate with higher-order abilities and those that do show correlations with more analytic and controlled information processing characteristic of the higher-order abilities. Stanovich and Toplak (2012) recommend that the categories System 1 and System 2 be thought of rather as Types 1 & 2 to avoid the suggestion that the respective features each form part of a singular or self-contained "system." Following upon (1) and (2), to which we can add the distinction between context-dependent and context-reduced processing, System 2 proficiencies require the resources of working memory and the functions of general intelligence (Evans and Stanovich, 2013). In contrast, System 1 proficiencies emerge independently of estimates of general intelligence (g). System 2 proficiencies vary among normally developing individuals; those associated with System 1 do not in the same way.

With the idea of convergence in mind, theme of this paper, it is necessary to gather together the threads from the above findings. The difficult research problem will be that of proposing a plausible evolutionary account for all of the underlying capacities alluded to so far.

3 The Internal Diversity of Knowledge and Ability

Returning to the analogy presented in the previous section regarding the components and interfaces of language, we could propose that the specialized modules, *specific* to linguistic competence, conform the Faculty of Language (narrow), FL(n). For the larger category of language abilities, the FL(n) engages the required competencies and skills (both domain-specific and domain-general) of the FL(broad). In the outer ring, literacy (including both reading and writing) could perhaps be considered to form part of an "extended FL(b)." Following Curtis (2013), Kinsella (2009) and Pinker & Jackendoff (2005), there are then two layers of modularity:

(1) the dissociation between language (its narrow domain) and other realms of cognition, the fundamental one being the relationship of mutual autonomy between the FL(n) and conceptual structure (Gleitman & Papafragou, 2013). Then,

(2) the linguistic (narrow) faculty itself could be viewed as internally componential, a first division perhaps marking off the subsystem of phonology from morphosyntax. Jackendoff (2002) singles out the lexicon as straddling language and thought, bringing into interface conceptual structure (CS) with the linguistic sub-systems. Following from (1), it is precisely

> the model of a relationship of mutual autonomy that helps explain the complex interaction (networks of correspondence, Falk, 2001) between concepts and language as well as among the language subsystems of bilingual ability.

A similar kind of evolutionarily motivated layering of competence components and their interfaces may be applicable to other complex cognitive abilities. The obvious candidate for work on this question is the faculty that appears to share domains in common with hypothetically homologous language (Mithen, 2006: 246–265). Which specialized and music-specific modules might constitute the narrow Faculty of Music? Two candidates come forward from research on musicality, domain-specific components for the content and processing of: rhythm (as in beat perception), and tonal pitch space (Honing et al. 2015). The most common congenital musical disorder (approximately 1.5% of subjects tested in large scale studies) affects the ability to perceive out of tune singing (one's own and that of others) and off-key notes in conventional melodies, and to recognize familiar tunes without the aid of lyrics. This type of *amusia* is shown to be highly heritable and most patients self-report the disability. Importantly, speech perception is spared (Peretz & Vuvan, 2017). The converse disorder reveals intact tonal competence by spontaneous performance of in-tune singing (i.e., variations on melodies), including octave sensitivity, in the presence of severe aphasia (El Mogharbel et al., 2003). A model that also makes reference to the common evolutionary origin of music and language, differing in some respects from the above view, is the *resource-sharing framework*. While music and language depend on their respective, separate, domain-specific representations,[6] shared neural resources such as processing operations are not specialized (Patel, 2012).

4 Evolution of Cognitive Architecture

At first glance, the exchange between Chiappe & Gardner and Barrett & Kurzban appears to reflect a sharp controversy on the application of the concepts of modularity to learning and knowledge, to research in evolutionary psychology (EP) and to the mechanisms of natural selection. But in contrast to the recent growing confusion in many university departments on these

6 In the resource-sharing framework, "representation" appears as parallel to the term "competence," a knowledge structure (see Note #1). Thus, representation/competence is conceived of as different from processing mechanism, a distinction that future research will hopefully clarify.

points, the authors have made a contribution to clarity by charting the lines of future discussion.

5 Functional Specialization

Barrett & Kurzban (2006) set the stage with an argument for massive modularity (MM). There should be wide agreement at least on one understanding of this idea: to start just with the domain-specific modules of the FL(n) together with their external links would make cognition already massively modular; and that would be only starting. Citing Fodor, they clarify that the specialized modules should be considered as massively interactive as well, that "encapsulated" cannot mean impenetrable. On the second point, all agree, as we took note of in the original formulation of "encapsulation." While appearing to take issue with Chiappe (2000) regarding his view that it is difficult to account for interactivity across the board from a "strictly modular" perspective, Barrett & Kurzban, correctly, point out that findings of top-down effect are entirely consistent with the modularity hypothesis (p. 632). There seems to be a difference in how to precisely characterize dedicated systems and the kind of interactivity that is implemented with other domains. But this difference of concept is not clear cut, being one that I believe can be narrowed. Let us touch on the important points in the Barrett & Kurzban (2012) paper and in the next section consider areas of potential agreement and remaining divergence.

Natural selection has shaped both modular and non-modular domains, including the purported System 2 processes. While there are different ways of understanding the latter, the mechanisms in all cases evolved and should be taken as mind/brain adaptations. Here we are reminded again of the false dichotomy between (innate) "evolved" and "learned." Proposals from EP have to try to account for the higher-level executive systems, not only for the narrowly specialized components. Thus, the concepts of System 2 and domain-general are not dismissed outright as some strong versions of MM might be tempted to do. Importantly, even some strong versions seem to hedge on an outright dismissal; weaker versions of MM seem to lean toward the acceptance of the idea of domain-general if it can be properly described.

A crucial requirement is that adaptations need a persistent signal of some kind from the environment, recurrent features of problems that natural selection can solve. In this regard, the question of specifying the factor of novelty as a motor for adaptation needs to be taken seriously. Precisely what aspects of new environmental challenges display recurring features? Barrett & Kurzban do not discount novelty, rather they suggest ways to redefine it for this purpose, for example by referring to novel "tokens of types" or identifying some aspect of an evolutionary environment that presented a changing, but tractable, signal. Here, nevertheless, they stop short of accepting a sharply defined dual-process taxonomy. Maybe System 2 can be taken as a provisional working category in need of finer distinction; for example: widely recognized open-ended domains could be reanalyzed in terms of formal properties that specific mechanisms can compute (2006, p. 634). Thus, they would not be, in fact, open-ended as assumed. These procedures could apply to domains and operations that are typically considered as cognitive-general and non-specialized. This point of discussion might be related to Barrett and Kurzban's suggestion to widen the conception of modular beyond the original formulation making use of an overarching category, that of functional specialization.

6 Dual-Process

Barrett & Kurzban's (2012) paper was a reply to a critique by Chiappe & Gardner (2011). The overall theme of the critique is that the conception of modularity by the leading current in EP is too broad; that it defines specialization and domain-specificity in a way that tries to include too much. As alluded to above, content-independent domains taken as non-specialized, such as logical inference and working memory, are defined in terms of a restricted input domain; for example as in Barrett & Kurzban (2006: 634). Thus, with this overly broad conception of specialization, versions of massive modularity suggest that the concept of domain-general mechanism might not be useful at all and perhaps should be abandoned. Tooby & Cosmides (2015) tentatively suggest such a possibility. So to be fair, the opposing views in the debate take this point to be a pending empirical question, one side staking out a much more skeptical position on dual-process architecture than the other, which takes dual-process as the strongly favored hypothesis. While the problem of inconsistent and changing evolutionary pressures, together with the frame problem, present challenges for a natural selection explanation for System 2, for Chiappe, this is where theoretical work needs to focus on, to "specify the evolutionary factors": start by working backward from rigorous description of the contrast with System 1. In addition to the two already mentioned, the capabilities associated with analogical reasoning, hypothesis generation, higher-order information processing in working memory, inhibitory control related to cognitive decoupling, flexibility and metacognition, and creative problem solving all cluster around *g* and the acquisition devices that build CS. In the language sciences, for example, a strong proposal is that CS develops as an open-ended domain independent of the modular (linguistic in the narrow sense) components of FL(n). For reflection, analysis and decontextualized thinking, the specifically linguistic competencies interface with concepts and computation on complex higher-order information. The understanding of metaphor and other aspects of imagination entail a capacity that can confront nodes of information from a very wide range of one's conceptual network to check them for relevance (2000: 151–154).

One avenue of discussion might take up Mithen's (2006) theory that ancestral domain-specific competencies underwent demodularization. A set of modular learning devices began to evolve to become less specialized and encapsulated, and more interconnected. The culmination of the long evolution of memory systems and more sophisticated search mechanisms, coinciding with the gradual transition from a protolanguage communication system to a fully formed grammar, is evidenced in the cultural explosion and dispersal of modern humans to all continents by 20,000 years ago. Adaptations that brought together the disparate and isolated learning components, interfacing with critical advances in social aptitude, would have conferred the critical reproductive advantages. While selection pressures tend to reduce variance resulting in uniform mastery in domain-specific abilities, other evolutionary tendencies might have maintained variation in traits that are also adaptive, such as general intelligence. Such is the proposed contrast between modern day specific and general domains. The latter evolved providing survival advantages where the modularized capacities could not respond as effectively to new complexities and greater unpredictability. Selection for more advanced abilities to analyze causes and effects favored this emergence (Kaufman et al., 2011).

7 Evolutionary Scenarios

Both sides could agree that there are few alternative hypotheses for the qualitative surge in general intelligence in *H. sapiens*, co-evolving with the emergence of the fully formed language faculty, together with its extension, FL(b), all coinciding during the same period of evolutionary formation. An objection to the category *general* intelligence (singular) can be provisionally deferred by admitting two conceptions, one multicomponential and the other domain-general and internally homogeneous. As complex networks of interacting mental faculties, only the genetic inheritances corresponding to each one can account for the extraordinary attainment of modern humans far beyond that of all other species of our lineage, among extinct and surviving.[7] The explanation for the orders of magnitude divergence can be none other than one that takes biology as a foundational factor. As emergences descending from ancestral capabilities, modification by natural selection cannot, today, be discarded as the leading working theory. The emergence of the language faculty most likely depended on the evolutionary advances in conceptual structure and vice versa. Because the complexity and the remoteness of direct evidence has made progress on this line of research difficult, research cannot dismiss alternate proposals, some that do not necessarily contradict the mechanisms of natural selection. For example, saltationist hypotheses for the evolution of the FL cannot be excluded, even as they present the seemingly least favored alternative (Anderson, 2013; Kinsella, 2009; Pinker & Jackendoff, 2005). For arguments in favor, see Bolhuis et al. (2014). Conceivably, evolutionary theories associated with Minimalism, the latter, would need to posit the same saltation scenario for general intelligence during the same narrow prehistoric window.

Further consideration of the research on working memory as framed by Carruthers (2013) might contribute to a converging discussion on this point. Rejecting the view that a central workspace could be amodal and non-sensory, his proposal concludes with an account of ancestral precursors for the wide-ranging and flexible modern working memory of humans. In summary, the operations of working memory must be sensory-based (p. 145). Just taking the relevant linguistic module as an example, the content of inner speech must be bound to phonological form.[8] In general, images and conceptual information are bound to perceptual instances. The unconscious workings of cognition are thus brought up to awareness in working memory where thoughts can be brought together for combination and confrontation in an open-ended way. This is the work space where top-down executive resources direct attention to evaluation for relevance and reflection (p. 147). The inheritance in this case can be traced to the primitive, also sensory, short term memory mechanism of our hominid ancestors (pp. 157–158).

7 The argument for the "uniqueness" of human cognitive faculties can be taken too far in the direction of "absolute uniqueness," leading potentially to a priori rejection of evolutionary precursors, making it more difficult to evaluate the evidence for biological foundations, of linguistic competence for example.

8 The claim that inner speech must access phonology, interestingly, is parallel to the converging evidence, mentioned in the section on "Competencies and abilities of type 1 and 2" regarding the role of phonological working memory during silent reading of Chinese characters. In reading there is a "cognitive imperative to leverage biologically specialized systems for supporting print comprehension" (Rueckl et al., 2015: p. 15513) regardless of orthography.

This last proposal is important because as was mentioned in the Introduction, lack of decisive evidence for domain-general intelligence antecedents in the primate class implies that general intelligence emerged uniquely and abruptly in *H. sapiens*. What would such a scenario of cognitive-general emergence *sui generis* imply for theories of language evolution?

Burkhart et al. (2018) have summarized the current state of the research on the evolution of general intelligence in non-human animals, starting with the working assumption that archaic domain-general capabilities were not inextricably tied to language. While, for example, results from studies of modern primates remain mixed, findings of significant correlation among cognitive measures and, across primate species, brain and body size comparisons correlating with cognitive potential within the lineage suggest productive lines of future work. For example, research could focus on problems of tool use and food preparation related to changing environments. Russon & Begun (2007) emphasize more strongly the evidence in favor of evolving general intelligence in ancestral primates, based on the consensus view that the cognitive capacities of non-human living great apes are intermediate between other non-human primates and humans.[9] Research focused on the conditions of hominid evolution might consider a number of relevant questions, among others:

– The effects of new difficulties of survival associated with increased seasonality and dietary shift favoring the emergence of new competencies such as navigating large ranges.
– Enhanced cultural potential arising from greater social complexity and the need for greater flexibility, for example, solving problems of more complex collective living – “outwitting increasingly socially adept conspecifics” (p. 363), and
– Prolonged immaturity and cognitive development beyond infancy.

We can now take up the observation, mentioned earlier, of competence domains and processing mechanisms, of different provenance so to speak, that appear as specialized modules within ability networks. Research on literacy and advanced second language learning evidences features of this kind

9 Studies demonstrating the learning of limited communication skills by great apes in captivity have been widely commented upon. While the question of an endowment for language acquisition has been largely settled (Pika, 2008, for one perspective), the level of mastery by subjects of vocabulary-type items and their combination in simple expressions is by all measure one of remarkable achievement, in line with Russon & Begun’s evidence for the claim that non-human hominids demonstrate more advanced cognitive capability than all other non-human primates. Returning to the data of these experiments with new analytic approaches might reveal important insights into the general learning capabilities of the non-human great apes.

of organization. In reading and writing ability, the interface of orthographic knowledge with linguistic competence involves learned skills in correspondence with genetically pre-programmed domain-specific modules of the FL(n). Thus, within the broader ability structure, historically new abilities, exhibiting the properties of autonomy and automaticity thanks to successful over-learning, interact with domain-specific components. Geary (2004) and Geary & Berch (2015) call attention to this theoretical problem by distinguishing between:

– primary, core, competences and abilities that develop uniformly in children given that they rest predominantly upon evolved systems, and
– secondary competencies and their broader ability networks, the most representative being those that depend on formal instruction. Among the secondary are included skills that perform operations that appear as modular-like.

The development of primary competencies is typically associated with Age of Acquisition (AoA) effects and the problem of overcoming Poverty of Stimulus (PoS) conditions (Margolis & Lawrence, 2013). While the secondary attainments are built upon the core competencies (e.g., phonological awareness built upon phonological competence), they do not develop spontaneously. Evidence for categorizing a secondary ability would be that successful learning correlates with *g*, that AoA and PoS don't apply, and that mastery is not uniform across individual learners.

In reading ability two modular components of evolutionary adaptation, phonological competence and the modules of visual cognition, come together in an interface. But reading is served by a broader correspondence relation, part of which is not of evolutionary origin. Within the broader reading ability network, the "extended FL(b)," two recently emerged competencies are brought on-line: phonological *awareness* and orthographic knowledge. The latter two are deliberately learned, not developmentally triggered by adequate exposure alone. Phonological awareness and orthographic knowledge are mastered interactively in this case (beginning with exposure to written language), one depending on the other. This interactivity in learning is also different than the development of modular phonological competence and visual cognition; they do not depend on each other. The interaction of word decoding ability with another layer, text comprehension, we need to defer for another discussion.

An instructive comparison to the interdependence among specialized knowledge systems in literacy learning is the interaction between the initial stages of language acquisition and other innate competencies in the emergence of number concept in children. According to Spelke (2017), inherited core systems, an "approximate number system" (ANS) and capabilities for representing objects as members of kinds, are the foundation for early advances when linked to language development: in the first stage, the mastery of noun phrases, containing a determiner and a singular count noun. Children then form expressions containing terms for entities of different kinds, using conjunction, entities of two and three; soon nouns are acquired for different taxonomic levels. These expressions map onto representations from the core ANS. Developing noun phrases refer to construction of larger numbers generated from the representation of smaller numbers (pp. 156–163). Concept of number would count as a primary competency, learning of elementary mathematical operations as secondary.

Within the Faculty of Language itself we have evidence of distinctions crossing the primary and secondary ability domains that are still not well understood. Intermediate and advanced L2 learning displays some of the features of early childhood balanced bilingual competence in which automatic performance reflects a modular-type organization. In the case of L2 ability, the evolved language faculty most likely allows for bilingualism as a default setting (especially in early acquisition), but late-onset advanced L2 learning usually depends on rich input *and* instruction or sustained self-teaching leading toward mastery. As in reading, attainments from both specialized language acquisition devices and explicit learning exhibit properties of domain-specific specialization (e.g., implicit knowledge and automaticity).

More compelling is the evidence strongly suggesting autonomy (separate mental representation) of the language subsystems of L1 and L2: double dissociation in differential breakdown and systematic inhibition capability (Paradis, 2004), to give two examples. Thus, there are two kinds of System 1 competence associated with their respective processing mechanisms, both of which exhibit modular-type properties (Evans and Stanovich 2013). These include highly practiced abilities, evidence of considerable expertise that bring domains (modular and non-modular) into close correspondence in a specialized way (Newport, 2011). In turn, within the broader faculty or ability network, the two kinds of System 1 competence interact with the higher-order proficiencies of System 2 – for both reading and L2 learning especially in the tasks of comprehension.

8 Conclusion

One aspect of expanding social interaction in ancestral populations, in particular inter-community communication, should be considered in the present discussion as it is related to Barrett & Kurzban's idea of "novel tokens of a broader type" (2012) and the factor of increasing cultural complexity. In regard to increasing complexity, Kaufman (2011) posited that with challenges of a new kind and new frequency "any regularity in the environment can exert selection pressure if it poses an opportunity to the organism" (p. 313). During such a formative evolutionary epoch, we have the possible example, mentioned above, of the co-evolution of FL(n) and CS, the parallel emergence of domain-specific and domain-general capabilities. On the one hand, the modular language acquisition devices began to emerge within small scale communities in situations of a certain degree of uniformity of proto-linguistic input to these acquisition mechanisms. The relative uniformity of within-group input favored the evolution of modularized and specialized language acquisition mechanisms, precursors of the modern domain-specific FL(n) acquisition capacity. Then, if, as is likely, there existed greater linguistic diversity between communities than within, this source of recurring novelty may have favored the evolution of other kinds of learning mechanism, similar kinds but not in every way. With time, inter-community contact and communication became more frequent and encounters more complex. As communicative interchanges increased, different kinds of "pidgin," "contact-language," "bilingual mixed" and "second" language, and new kinds of "cross-cultural communication strategy" arose. Learning these varieties of language and register, on the part of (typically older) learners who had already acquired a primary language, may have required the greater participation of nascent domain-general abilities than was required for learning their primary (mainly domain-specific driven) "mother-tongue." See AUTHOR (2012, pp. 141–176, 2013, pp. 15–58) for a proposal to explain way in modern humans, L2 learning draws on System 2 type learning to a greater extent, and why there is evidence for greater variation in ultimate attainment for L2 than for L1, holding conditions of input and learning opportunity constant. A vestige of this inter-cultural communicative landscape we can observe today. The automatic and below-awareness System 1 type linguistic and pragmatic abilities that serve speakers well in their immediate speech community are progressively challenged the further speakers venture beyond their community. Successful communication requires greater access to metalinguistic awareness, deliberate and reflective use of L2 ability (typically limited to some degree) and other higher-order skills and competencies. If in language learning the System 1–System 2 distinction sometimes seems subtle, consider the difference between the ANS and typical 5th grade mathematical problem solving ability.

For the concept of module, encapsulation, implying tightly sealed off containers and pipelines, was not a good term. While sensory input and reflex-type response, at the periphery, are special, higher-order specialized function is not of the same kind. This is the level of faculties and component confederations where shared, or overlapping, functions are part of an extensive interactivity. It is here where the different approaches in research will converge on understanding how domain-specific and domain-general components form part of networks. In appearance counterintuitive, instead of starting with the most specific domain, starting with the ability-size confederation, revealed in the performance of complex tasks, might be where research can make tentative progress and then work backwards. One reason why, in the long run, this approach might be more productive is because the most difficult point around which to attain consensus appears to be how to properly describe capabilities and mechanisms that are "general." On this point "all-purpose" is not a good term either.

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