# MODULARITY VERSUS CONNECTIONISM: TWO DIFFERENT VIEWS ON THE ARCHITECTURE OF THE MIND

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## Introduction

Issues such as comprehension and production of language have deserved special attention from many areas of human knowledge. Perhaps it can be said that the modular and the connectionist theses of cognitive science somehow reflect two well-known opposite poles, namely, the innate view (related to nature, to what has been called *the black box*, the rationalist, nativist view) versus the experiential, behavioristic view (related to nurture, to *the tabula rasa*, the empiricist, environmentalist view) of the organization of the mind. Steinberg (1993:135), for example, speculating about where language ideas come from explains:

> There have been two basic answers to the question of how ideas (as knowledge) get into our minds. The Empiricist believes that ideas come through experience. The Rationalist, however, believes that basic ideas are already present in the mind at birth. The dispute then revolves around what is in our minds at birth and what role experience (of the world and of our minds) is to have.

Truly, science has evolved greatly specially in this era of artificial intelligence, and the human race has received great contributions from the humanistic sciences. Besides, the question in science is much more complex than this dichotomous dilemma. However, this basic, fundamental polarization has served as a starting point and as a guide to research, specially in linguistics, psycholinguistics, and cognitive science. The purpose of this brief paper, thus, is to make considerations on some of the differences between the modular and the connectionist views of how human beings process information.

## Modularity

The issue of modularity will presently be discussed in relation to Fodor's view called *The Modularity of Mind*. According to this MIT (Massachusetts Institute of Technology) scholar who makes use of advanced findings in artificial intelligence and neuropsychology, the human mind possesses different psychological faculties. Fodor investigates which mental processes, which psychological faculties are modular, pointing out the properties that modular cognitive systems most probably have due to their modularity. Fodor claims that there are two types of cognitive systems: those that are nonmodular, called central systems or central processes and those that are modular, called modules.

In terms of the nonmodular systems, also understood as horizontal faculties, Fodor (1983:11) explains that they are characteristic of faculty psychologies in general. These cognitive processes are not content specific, and they 'exhibit the interaction of such faculties as, e.g., memory, imagination, attention, sensibility, perception, and so forth'. Fodor explicitly takes out from his study these nonmodular central systems (Scliar-Cabral 1991), as they are the creative, interactive processes, such as thought and problem-solving, which cross content domains, thus being horizontal faculties. He says, 'the more global ... a cognitive process is, the less anybody understands it. *Very* global processes, like analogical reasoning, aren't understood at all' (Fodor 1983:107, emphasis in the original text). He explains that these systems make use of analogy, which is a process that transfers information among cognitive domains, so they cannot be modular.

Being horizontal, domain-general and interactive, central processes differ from those psychological faculties which are vertical, modular, localized and domain-specific (the ones Fodor concentrates his attention on). By vertical faculties (this term being taken from Gall's theory of vertical functions) Fodor means those faculties which are domain-specific and computationally autonomous, that is, these processing systems are isolate, content-specific, independent subsystems which do not make use of other aspects of cognition. Vertical faculties have significant and specialized, unique roles, concerning different processing systems. Modular cognitive systems are also innately specified and hardwired, that is, they are 'associated with specific, localized, and elaborately structured neural systems'(Fodor, 1983:37).

These faculties are autonomous or non-interactive in the sense that their processes occur independently of other aspects of cognition; they perform functions related only to the specificity of their domain. Bock & Kroch (1989:176) mention recent parsing theories as examples of the autonomous processing position, and say that 'From these perspectives, neither the processing systems nor the information they manipulate share significant features with other cognitive, perceptual, or motor systems'.

Concerning the vertical type of psychological faculties or cognitive mechanisms, Fodor considers certain subsidiary systems the candidates for modularity. He refers to these as input systems, input analyzers or interface systems, which roughly correspond to each of the traditional sensory/ perceptual modes (hearing, sight, touch, taste, smell) and includes one more for language. Fodor believes that minds and computers are basically symbol-manipulating devices and he analogizes cognitive processes with the way computers operate. The role of input systems is to get information into the central processors. They are modules because their properties are essentially those of vertical faculties. It is my intention now to present the most important features of input systems, as Fodor understands them.

Encapsulation of information is the key aspect of the modularity thesis. This property means that at each autonomous phase of processing, only specific kinds of information are available for decision-making, and not all of the information represented in the mind. As Fodor (ibid p.70) puts it,

> The point is this: to the extent that input systems are informationally encapsulated, of all the information that might *in principle* bear upon a problem of perceptual analysis only a small portion (perhaps only quite a small and stereotyped portion) is actually admitted for consideration... input systems don't function in the general sense. Rather, they function to provide very special kinds of representations of very specialized inputs...[italics in the original text]

Fodor explains that we do not make use of everything we know about language, for instance, in order to understand an utterance. According to him, background information is relevant only to the extent it confirms our perceptual identification.

Two other characteristics of input systems are that they are fast and their operation is mandatory. For example, it takes us time to solve problems, as this is a central process, but we can quickly identify visual stimuli or sentences in a language we understand, since these are very fast psychological processes. Likewise, input mechanisms are mandatory in the sense that they are automatic: they are automatically triggered by the stimuli they encounter. Fodor explains that we cannot understand speech as noise even if we would like to.

Another feature of input systems is that the access to the mental representations that these systems compute is limited. This means that human beings do not have equal access to all levels of representations. There is a relative inaccessibility of intermediate levels of input analysis. Only quite high-level representations are retained and the lower-levels of input analysis are somewhat inacessible, or not available for report of the information they encode. To illustrate this point, Fodor says that when we hear a sentence, the choice of words is quickly lost, and we store only the gist of what was said, not the exact words heard.

There are many other pertinent issues concerning modularity which are taken up by Fodor, but the points mentioned above seem to suffice for now, as my intention has been to briefly point out the main aspects of Fodor's modularity thesis. I hope I have made it clear that modularity is a theory of mind which refers to the vertical, autonomous or non-interactive, encapsulated psychological faculties, the input systems. Fodor's view of modularity fits into the symbolic paradigm of cognitive science, which concerns representations or the transformation of symbols according to rules: the computer, as a symbolic device, executes symbolic manipulations specified by rules.

Recent researchers have corroborated the modularity thesis, with some adjustments to Fodor's view. Linebarger (1989), for example, shows neuropsychological evidence for linguistic modularity, analyzing data from patients with language disorders. Dr. Michel Paradis (lecture at the *Seminário Internacional de Psicolingüística*, at the Federal University of Santa Catarina - UFSC, in January 1993) also favors modularity. His concept of modularity, however, refers to neuro-functional modularity of the systems, shown by results of experiments in language pathology. For Paradis all these various neural-functional modules are individual and separable; nevertheless, they are interdependent, in other words, they do communicate with each other.

## Connectionism

Now I intend to give a general view of connectionism and show the main differences in relation to Fodor's view of modularity. Whereas modularity relates to vertical, autonomous, non-interactive, localized psychological faculties, to rule-based processing, carried out in a step-by-step or serial procedure, connectionism refers to the horizontal, interactive, non-modular cognitive systems, to parallel nonlinear dynamic processing (Sokolik, 1990; Bechtel & Abrahamsen, 1991). The connectionist approach to modeling cognition — derived from the fields of psychology and neurology — has emerged as an alternative view to the symbolic application to cognition and it reflects recent thinking about cognition, based on the neural-networks of the brain (Bechtel & Abrahamsen, 1991). As Anderson (1995:224-5) points out, contrary to symbolic, localist representations of memory, distributed representations 'assume that a memory record does not reside in any single neural element but rather is represented by a pattern of activation over a set of neural elements'.

Unlike modules, which are domain specific and informationally encapsulated, the elements of a connectionist network, called units or nodes, are simple, neuron-like and highly inter-connected and their activity may be excitatory or inhibitory, depending on the weight of their connections (Bechtel & Abrahamsen, 1991; McLaughlin, 1990). The weight, which can be positive or negative, ranging from **-1** to **+1**, specifies the strength or importance of the connection between two units. If the connection is excitatory, it has a positive weight, and it is the excitatory connection that increases the activity of the unit (Bechtel & Abrahamsen, 1991).

Even though both symbolic and connectionist systems may be considered computational systems, their conceptions of what computations involve differ (Bechtel & Abrahamsen, 1991). In the symbolic paradigm, computation refers to the transformation of symbols according to rules: the computer performs symbolic manipulations which are made specific by rules, written on the program. The computations in a connectionist system, on the other hand, concern causal processes, and this system does not consider stored symbols or rules (ibid). These models have highly interconnected networks, and knowledge is acquired through experience (Schumann, 1990), or as McLaughlin (1990:624) explains:

> For the connectionists, learning takes place through the strengthening and weakening of interconnections in response to examples encountered in the input. There is no need for learners to appreciate the significance of specific syntactic forms or to make an inductive leap to abstract rules. Instead, learning consists of a network of units that enable the learner to produce rule-like behavior, but the rules themselves exist only as association strengths distributed across the entire network.

The architecture of connectionist models (also called parallel distributed processing or neural networks) relate to the structural and functional characteristics of the human brain (Sokolik 1990; Bechtel & Abrahamsen, 1991). Contrary to modularity theorists who favor an innately specified computational system, connectionists advocate that the structure of the computational system is formed by some degree of learning process. Connectionist networks — which are described by mathematical equations — do not manipulate symbols. The fundamental feature of these systems is that there is a network of elementary units or nodes, and each one of these nodes is activated up to a certain point. The units are connected to each other, and active units excite or inhibit other units. The network is understood as being dynamic because when it receives initial input, it excites or inhibits its units. Units get inputs from other units or from the environment. Then they compute a function that specifies what output they will send to other units.

Fodor and Pylyshyn (1988) criticize connectionism in the sense that it may be considered a drawback in terms of studies in cognition. They consider connectionism a return to associationism, which is an approach to learning and mental functioning that takes into account dynamic relations such as attraction, repulsion, assimilation, etc and the co-occurrence of mental and environmental relations. These critics suggest that a model of cognition must make use of symbols, variables and similar devices in order to encode and manipulate information. They also say that the model must account for symbolic representations such as hypothesis-testing and analogizing. They consider connectionism as an inadequate form of representational systems: for these two authors an adequate model for cognitive processes cannot be envisaged without symbolic representations.

Sokolik (1990) explains that connectionist ideas are not new. The difference is that now attempts have been made to apply connectionist principles to several fields of interest. In the area of language acquisition, for example, these models have been designed to test grammatical tasks such as the production of English past tense verbs, or recognition of gender of French nouns. If we take into account neurological constraints on language learning and the parallel processing which characterizes brain function, Parallel Distributed Processing seems to provide a more plausible explanation to show why children learn a second language more readily than adults, compared to the concept of rule-driven language systems (Sokolik 1990).

Concerning second language acquisition (SLA) research, Larsen-Freeman (1993) points to the contrast between the nativist Universal Grammar (UG) approach and the environmentalist connectionist/parallel distributed processing models, considering them two different and relevant theoretical perspectives on the explanation of the learning process. For the nativists, 'learning depends upon a significant, specialized innate capacity for language acquisition' and for the behaviorists/environmentalists, 'the learner's experience is more important than innate capacity' (ibid141).

MacLaughlin (1990) says that connectionism tries to give an explicit and verifiable account of the organization of linguistic knowledge in the brain; however, he sees the need for an integration of clearly defined representational and processing perspectives. Likewise, Hatch et al. (1990) explain that although connectionist models are attractive to second language learning as they assign teaching an important role, these models do not give us a substantial, integrated model. These authors suggest that an adequate theory of second language acquisition research should integrate modules and interconnections.

## Concluding remarks

To conclude this brief paper, it seems relevant to emphasize the fact that according to proponents of connectionism, this approach is not a return to associationism, but indicates advances in cognitive science. I believe in Hatch et al's and McLaughlin's view that connecting modules, thus integrating aspects of modularity and connectionism, may be a possible alternative for future research in the area of cognition. Still, as Steinberg (1993:152) notes,

> It would not be surprising, then, if a neutral observer were to remain unconvinced one way or another on this Rationalist-Empiricist [and I add the Modularity-Connectionist] grand debate. This debate, which has gone unresolved for thousands of years, may well continue for thousands more.

In spite of the contrasting principles of modularity and connectionism briefly outlined in this paper, it seems that still a lot of questions remain unsolved in terms of how human beings process information and learn languages. Just as Psycholinguistics has greatly evolved as a science and has offered great contributions to studies in Second Language Acquisition, the study of different theoretical perspectives (such as the two views briefly presented here) may contribute to make teachers more aware of the complexity of foreign language learning. To conclude this paper on the two theoretical and conflicting views presented here, I would like to quote Cook & Seidlhofer (1995:4)'s account on the complexity of language.

> Language is viewed in various theories as a generic inheritance, a mathematical system, a social fact, the expression of individual identity, the expression of cultural identity, the outcome of dialogic interaction, a social semiotic, the intuitions of native speakers, the sum of attested data, a collection of memorized chunks, a rule-governed discrete combinatory system, or electrical activation in a distributed network. But to do justice to language, we do not have to express allegiance to one or some of these competing- and aspiringly hegemonic-views. We do not have to choose. Language can be all of these things at once.

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