
MODULAR VERSUS INTERACTIVE
MODELS OF INFORMATION PROCESSING¹

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Introduction

This review article is an attempt to contribute to the discussion about reading-related matters. More specifically, this paper discusses a serial model of information processing as put forth a while ago by the American linguist Jerry Fodor in his book *The Modularity of Mind* (1983)². The choice of an argument that seems settled at this point has to do with the feeling that by discussing how theoretical views underlying different approaches to reading pedagogy in a first language were originally devised, we can get a more accurate view of what processes are

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²FODOR, J. A. *The modularity of mind*. Cambridge, Mass.: MIT Press, 1983.

ultimately involved in our present attempts to teach foreign language reading skills.

The debate about foreign language reading pedagogy has recently been intensified among professionals working at the tertiary level of formal education in Brazil. Most of the discussion revolves around the reasons offered by Brazilian researchers for adopting an interactive model of reading and to accommodate within it a broader view of language as socially constructed phenomena³. Therefore this paper aims to make a contribution as a critical review of one among the possible models of reading: the linear model as proposed by Fodor.

The choice of Fodor's account of what happens when we process linguistic information stems from the need for an applied linguist to investigate and write about relevant theoretical issues concerning her practice. Fodor's book belongs to this last class, if for no other reason, because much of the reading classes in the western societies heavily relies on modular frameworks (consider, for example, the fact that in the US the *Phonics*⁴ method is advertised daily on TV). Thus his account deserves a closer examination.

The discussion that follows has a basic two-part organization. First, the topics dealt with in the book will be reported and next, an appraisal of

³MOITA-LOPES, L. P. da. *Oficina de lingüística aplicada*. Campinas: Mercado de Letras, 1996; SANTOS, M. A preliminary investigation of Brazilian EFL readers. In: LEFFA, V. (ed.) *Autonomy in language learning*. Porto Alegre: Editora da Universidade, Universidade Federal do Rio Grande do Sul, 1994. p.251-59; MOTTA-ROTH, D. O processamento de sentido na leitura de textos em inglês como língua estrangeira. *LETRAS*, 1:92-102, 1991; MOTTA-ROTH, D. & V. HEBERLE. Critical discourse analysis and the language learner's autonomy: Possible ways to relate both areas of study. In: LEFFA, V. (ed.), 1994. p.237-46.

⁴The advertisement purports to call teachers' attention to the great success this method has attained in teaching reading through developing students awareness of the phonological representation of letters. I may be providing a reductionistic comparison but the method is presented as solely relying on the putting together of letters. Something like what we popularly call in Brazil 'Ivo viu a uva'.

Fodor's account in the light of later developments in the field will be offered.

Fodor's language processing model

The Modularity of Mind brings a perspective on language processing which has had an impact on the area of neurolinguistic studies in that it attempts to offer a detailed view of how language is processed in the human mind. In arguing for a serial processing model, Fodor claims that the human mind consists of a set of modular or specialized psychological faculties or systems. These modular systems would sequentially process the information a) provided by the environment at independent levels (in the case of language: visual input, letters, words, phrases, sentences, etc.), and b) perceived through six sensory/perceptual modes: the five traditional senses and language. Fodor presents modular cognitive systems, like memory, for example, as kinds of vertical faculties: content specific, innately specified (not through learning), autonomous (not sharing horizontal interfaces with other cognitive systems), 'not assembled' (different domains demand different faculties); and 'hardwired' (corresponding to neural structure) (p.37)⁵.

The first of the five parts in the book gives an account of four alternative views of the mind. Firstly, the Neocartesian view of the mind argues for a specialized 'organ' for language ('Language Acquisition Device' for Chomsky) which has two basic characteristics: innateness and

⁵ Unless otherwise indicated, references containing page numbers refer to *The modularity of mind*.

species specificity. This device would be in charge of processing and breaking the linguistic input received by the child from his/her immediate environment into patterns in order to set the unspecified parameters of a Universal Grammar. In this approach, the human mind would be conceived as a diversified structure, with different organs for different functions (for language, music, etc.).

Within the second perspective, known as the Faculty Psychology, a language faculty is recognized through its effects, that is, a language faculty would be any mechanism that can be said to be responsible for the development and use of language. One variant, the Horizontal Faculty Psychology, considers the various faculties, such as memory or attention as invariant among the different areas of knowledge. If a person has good memory for music then s/he will have as good a memory for geography or chemistry. All cognitive processes would require a particular interaction of these different faculties.

A third account of the organization of the mind would be the Vertical Version of Faculty Psychology. In this case, the psychological processes would vary along the topics of concern. Thus a person could have a great memory for music but a terrible memory for chemistry. Fodor tends to accept this account as the most appropriate to represent cognitive processes.

Finally, from a rather different perspective, Associationists see faculties as built out of basic units called 'ideas' (for mentalist associationists) or 'reflexes' (for behaviorist associationists) (p.27). These ideas/reflexes would be associated one with another as a function of the representation of the person's experience. This experience would

determine which ideas would get associated, and with which intensity or strength this association would be established. Basically this associationist relation among ideas would mirror the events experienced by the person, so that spatiotemporal proximity in the environmental events would determine greater speed or facility in recovering their correspondent ideas.

Mind and machine as analogous cognitive mechanisms

The second part of the book comprehends the discussion about a functional taxonomy of cognitive mechanisms, through the analogy with idealized computing machines (Turing Machines). Minds and Turing Machines hold similarities since they are both symbolic systems that operate through rules, i.e., mental representations that are processed by a formalization of an operation such as inference. They differ, however, in that Turing Machines are simple devices, comprehending very limited primitive machine operations and, most important of all, machines are closed computational systems while human minds, besides being complex devices, are affected by the environment. Exactly because of that, and because Fodor wants the analogy to hold, Turing Machines have to be put in contact with the external world. In this sense, the human that operates the machine serves the function of a subsidiary computational system, providing the computer with information about

the world in a 'language' that the machine can understand. Fodor calls these subsidiary systems input systems.

The flow that information would follow along the processing mechanisms could be represented as a one-direction sequence:

transducer > input systems > central processors

The 'transducer' would be responsible for the analogy with the human senses; 'input systems' would be responsible for the inference performing systems, arranging the representations of the world in an organized way; 'central processors' would be the semantic memory or the cognition that encompasses all the knowledge stored in the mind. The central processes would be responsible for our beliefs, our evaluations of the world against our background information. Fodor concludes this taxonomy, establishing the basic similarity between the linguistic and the perceptual systems: both encode information about the world in a way appropriate for the use of the systems that are supposed to operate this information (it would be like a monolingual English-speaker processing information in English or a Brazilian, in Portuguese).

Input systems as modules

The third part of *The Modularity of Mind* discusses the properties of input systems as modules. Input systems are modular as long as they exhibit some properties among a set of nine. Of these nine properties, five seem to be more representative of modular systems.

First, input systems are (1) domain specific, i.e., different computational mechanisms are specialized in processing different kinds of information received from the transducer systems (like voices by the hearing sense or temperature by the touch). Due to this specificity, input systems have constraints upon the type of information (received from the transducers) that they can process.

Next, input systems are conceived as being (2) mandatory and (3) fast, i.e., they are highly automatic and therefore do not depend on conscious judgment. They also have limited central access to the mental representations that input systems compute: perceptual processing has a bottom-up flow, therefore it cannot have access to the central processors.

Input systems are also (4) informationally encapsulated, i.e., the analysis of linguistic information is carried out at different levels - phonetic, phonological, lexical, syntactic, etc. Since Fodor argues that input systems operate in a sequential bottom-up flow, he does not support the idea of an exchange of information between these different levels of representations (in distinction to interactive models). For him, input systems do not suffer influence from cognition, they operate within their own processing limits, having access to and consulting a limited range of information.

Finally, Fodor believes these systems to have a (5) fixed neural architecture which would map out the functions of input systems. This seems to reinforce the notion of encapsulation. If we think that a specific region of the brain is responsible for the processing of a certain kind of information and if this processing is encapsulated, then it seems

reasonable that we have in the brain a delimitation of the regions where the different systems operate. A final question concerning these properties is posed: 'Do the properties of being modular entail being an input system (or vice versa) or can there be other cognitive mechanisms that are also modular?' The fourth part of the book is set to discuss the above question.

A basic difference between input/ modular systems and other cognitive systems like the 'central systems' (p.103) is that the latter have access to a wider range of information processed from different sources (different input systems) and pertaining to more than one cognitive domain. These two properties are basic in differentiating these central systems from modular ones. These central systems are responsible for correcting or confirming the representations that input systems provide based on the information they receive from the transducers about the environment. This operation to adequate representations to the outside world are considered by Fodor as 'the fixation of perceptual belief' (p.102), comprehending operations of thought and problem-solving. For him, input systems are hardwired, encapsulated, domain specific. Alternatively, central systems, being responsible for the fixation of belief (thought and problem-solving), allow for a flow of information from and to all sources using practically any area of the brain that might help in the thinking process; it will deal with any type of information, i.e., from any domain; and it will consult any range or level of information in thinking.

In the concluding section of the book, one last question is dealt with: the 'epistemic boundedness'. 'Boundedness' refers to a constraint in relation to a certain premise or condition. 'Epistemic' relates to knowledge. The mind is 'epistemically bounded' if it has constraints on the possible ideas that it can produce or comprehend. Fodor tends to accept this boundedness mainly for spatiotemporal reasons that impose limits on the sort of information we can have access to in processing the representation of an environment stimulus: no one can know everything all the time (p.121). 'Epistemic Boundedness' is intrinsically related to innateness and species specificity, two premises of Fodor's thesis. These two basic tenets are directly related to Chomsky's ideas about a universal grammar: there is a language acquisition device built in the brain of the new-born child, which is general enough and ready to map down the parameters of a given language. Thus, from this perspective, among the four alternative views of the mind discussed in the first section, Fodor seems to align himself with the Neocartesians.

Fodor's account in the light of later developments

An interesting aspect in Fodor's book is his account of the Associationist theoretical apparatus because of the similarities it presents with Connectionism. In his account of associationism, Fodor seems to

address issues pertaining to the connectionist perspective, although this similarity is not stated explicitly. Fodor quotes an associationist's opinion that rejects the idea of 'memory' as a faculty in charge of keeping hold of past experiences, which might be seen as an evidence of the similarity between associationism and connectionism. Thus, instead of memory, there would be only particular *connections* (my italics) between certain mental events and others in such a way that Associationist models would seem to operate without rules, only using the aid of a 'fundamental power' — 'the capacity to form associations' (p. 28-9). This can be thought of as another point in common with connectionist models which are neither symbolic nor do they operate through rules⁶. Connectionist models operate, instead, as in Associationism, through an 'association' between input-output pairs.

Another aspect of confluence would be the Empiricist basis for the psychological theory conceived as underlying associationism (p.33) and connectionism — 'a revival of behaviorism'⁷. Also a very clear link between both accounts, specifically between connectionists and computational associationists is their use of an analogy between the mind and the computer processing mode. Gasser⁸ states that connectionism is a computational model constructed over 'simple neuron-like processing units' that use 'fluid patterns of activation' along sections of a network of representations of the world. This description seems to correspond to Fodor's views on computational associationism

⁶GASSER, M. Connectionism and universals of second language acquisition. *Studies in Second Language Acquisition*, 12:179-99, 1990. p.184.

⁷Idem, p.179-83.

⁸Ibidem, p.179-80.

as constructed out of associations of basic operations. In any case, the modular model is in opposition to associationist/ connectionist models, which are also called *interactive* models because they allow interaction or exchange of information between different levels. In reading, for example, connectionist/ interactive processing of visual information of a text also relies on the reader's background knowledge (as in cloze tests), rejecting a basic premise of modularity: the encapsulation of input processing mechanisms. Maybe because of that, Fodor has been one of the main voices to criticize these empiricist models⁹.

Some questions are open to debate in Fodor's work and a number of them might have been the focus of lengthier and more ingenious discussions, but one of these questions is worth mentioning here: the disconnection between input processes and the semantic component. Firstly, in relation to where the semantic component lies, Fodor seems to suggest that it is regulated by the central processors when he writes that these processes are responsible for the 'fixation of beliefs' (p.102) and that these central systems have access to different levels of information and to background knowledge. Fodor does not develop the idea of the semantic component either (1) because, in being within the central processes, it is not accessible to scientific investigations¹⁰; or (2) because

⁹FODOR, J. A., & Z. W. Pylyshyn. Connectionism and cognitive architecture: A critical analysis. *Cognition*, 28:3-71, 1988.

¹⁰SCLIAR-CABRAL, L. *Introdução à psicolingüística*. São Paulo: Ática, 1991. p.54.

pertaining to the central processes, the semantic component would be only accessible to non-modular horizontal faculties, and therefore, not relevant to the discussion of his modularity thesis. Anyway, this point is worth discussing since there are other opposing views. Top-down models, for example, claim that the central processes would be present at all levels. In Frank Smith's approach to the reading process¹¹, for example, even the lowest levels, like the processing of visual input, would be under the influence of higher cognitive levels like the semantic memory, requiring the brain to make decisions.

Another aspect of this disconnection between input systems and central processes refers to the conception of a modular system that operates in a serial, one-way direction, without acknowledging or getting affected by higher levels of processing, which in itself is not entirely convincing. Models which allow a greater interaction or a flow of information seem more appropriate. Let's consider the case of cloze tests for a moment. In such tests, the absence of a certain item is 'compensated for' with knowledge of the surrounding context: the words that collocate with the missing one, the sentence, the paragraph, and even the whole text in which the missing word appears. Or in oral communication, kinetics many times compensate for failures in production or lack of aural comprehension.

Fodor's model seems to give too strong a version of mental vertical processing with encapsulated modular systems. Even though I do not totally agree with connectionist accounts of mental structure due to its non-symbolic representations, I believe in a psychological model that

¹¹SMITH, F. *Reading*. Cambridge: Cambridge University Press, 1978. p.17.

accepts a flux of communication among the different domains of knowledge. A model that has specialized input systems with access to other levels of processing. One-way serial models do not seem to be able to account for the complexity of cognitive processes.

In reading, for example, top-down models fail to acknowledge important empirical evidence adequately¹², relying strongly on 'prediction' as represented by Goodman's well-known idea of reading as 'a psycholinguistic guessing game'¹³. In the other extreme, bottom-up processing models like the one put forth by Gough¹⁴, assume that 'all letters in the visual field must be accounted for individually by the reader prior to the assignment of meaning to any string of letters'. A very common criticism to this view is that one must understand the meaning of the word in order to recognize it as a word since there is no special faculty that processes linguistic graphic input apart from other objects' visual input¹⁵. Both extreme versions of serial processes do not seem broad enough to encompass all the cognitive operations involved in reading. Grabe¹⁶ favors interactive models, arguing that both lower and higher-level processing skills are very important for good reading; accurate and automatic access to vocabulary is decisive for fluent reading in ESL; furthermore, students' individual differences and preferences in approaching text might be respected if, for example, we

¹²GRABE, W. Reassessing the term "interactive". In: P. L. Carrel, J. Devine & D. E. Eskey (eds.). *Interactive approaches to second language reading*. Cambridge: Cambridge University Press. p. 56-70, 1988. p.58.

¹³GOODMAN, K. S. Reading: A psycholinguistic guessing game. *Journal of the Reading Specialist*, 6(1):126-35, 1976.

¹⁴SAMUELS, S. J., & M. L. Kamil. Models of the reading process. In: P. D. Pearson (ed.), *Handbook of reading research*. N. Y.: Longman. p. 185-224, 1984. p.187.

¹⁵Idem note 11, p.58-59.

¹⁶Idem note 12.

allow for a lack of vocabulary to be compensated for by generic knowledge of the world and vice-versa.

In addition, if we do not accept that input systems can receive influence from higher levels responsible for our beliefs, how are we going to accommodate functional grammars such as the one proposed by Halliday¹⁷ that claims that language results from and determines social relations? The answer appears to lie within models that conceive language from a social perspective, as resulting from the social interactions we take part in throughout our lives, as subjects of a social structure that determines our language acquisition. For Halliday¹⁸, language is a system of meanings realized by form that we have at our disposal and whose different elements we choose to use according to the communicative event. Although Halliday does not venture into a psycholinguistic debate, we can assume that in the functional grammar he advocates meaning and form are part of an indivisible two-sided unit of language. Such position would oppose a model that divides form and meaning as belonging to two different kinds of processing systems: a modular input system (form) and a central horizontal system (meaning). Not to mention that intentionality and ideology are completely cast out from bottom-up machine models in their analogy with computers.

¹⁷HALLIDAY, M. A. K. & HASAN, R. *Language, context, and text: Aspects of language in a social-semiotic perspective*. Oxford: Oxford University Press, 1985.

¹⁸HALLIDAY, M. A. K. *An introduction to functional grammar*. London: Edward Arnold, p.xiv, 1985.

Concluding remarks

In this closing section of the paper, the basic question underlying the discussion of Fodor's model can be elaborated as: To what extent the modular analogy can hold without our having a reductionistic view of the complexity of the human mind? Or maybe we could ask how a psycholinguistic model can totally disconsider the social environment that produces the input that will be processed by the input systems. When discussing the taxonomy for the input system, Fodor signals that he also feels the need to insert his processing unit — in this case a machine — into an environment. To construct his modular theory over an analogy between the human mind and a machine, he needs to endow the Turing Machine with the property of being able to receive input from the outside. However, his analogy is not perfect. It is difficult to accept a model of the human mind that only receives input from outside in a syntactic way, without receiving feedback from the semantic memory, regardless of the information stored in long-term memory. (Going further on this line of argumentation, it would be difficult to reconcile Fodor's view with the highly recognized psychoanalytical discussion of perception of reality around the concept of symbolic representations of previous experiences.) It seems more reasonable that, in processing the stimuli provided by the environment through the transducer, input systems represent 'reality' in certain ways in accordance with the whole semantic memory one has stored along his/her life. It is well-known that a scientific theory that attempts at accounting for everything, ends up accounting for nothing, but at this point of the 'nature vs. nurture' debate in

psycholinguistics, the nurture side seems to be winning in its attempt to account for cognitive processes in a more comprehensive way. As this paper attempted to show, at present the best choice for reading pedagogy is to adopt interactive models of information processing and to adequate the interactive perspective to the view of language as text, i.e., as a socio-semiotic unit of analysis in communication¹⁹.

One last word about Fodor's book. In spite of the author's emphasis on its being of a different nature from modular systems, the semantic component, its origins and processing, should have received a special part dedicated to the discussion of the topic. Also, *The Modularity of Mind* does not succeed in being simple and clear in its language. Fodor uses too many words for saying simple things and too difficult words to say complex things. Readers would profit more from the text if it were written in a more accessible language, if more examples were given to illustrate 'unspecific' terms²⁰ as, for example, 'system' or 'process'. But, despite these points of divergence, *The Modularity of Mind* is an extremely relevant reading for researchers working with reading as a way to inform their choices of information processing models.

¹⁹ For example, note 3, p.139.

²⁰ WINTER, E. O. On unspecific/ specific as fundamental organiser of written texts. Conferência apresentada no ELR, Birmingham: University of Birmingham, Inglaterra, 1989.