Modularity
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1 Introduction

Modularity of mind is the notion that a mind may, at least in part, be composed of innate neural structures or mental modules which have distinct, established, and evolutionarily developed functions. However, different definitions of "module" have been proposed by different authors. In this paper, Marr's Modular design and Fodor's Modular Hypothesis are discussed.

2 Marr's Modular Design

- David Marr (1982) was particularly interested in something he termed as **the principle of modular design** and, he advanced the argument in terms of the example of a computer programmer who is designing a large and complex computer program.
- The central idea is to break down the overall endeavor into manageable sub-projects where each sub-project maps onto a particular component (or module).
- the program may be divided into separate modules or sub-routines that can be developed independently of the program.

- Indeed, with very large software packages, each sub-routine will have it's own dedicated set of programmers who collectively work to develop it.
- Although **Marr** wrote with respect to implementing large and complex programs, his points should be taken as applying, by analogy to the evolution of intellectual capabilities.

2.1 Advantages of Marr's Modular Design

- According to him, there are clear advantages in having a complex system evolve along the lines of independent specialized sub-processes.
- One particular advantage of having a system evolve like this is that it becomes resistant to damage:
  - If the system is composed of the independent interconnected components; then damage to one component may not have catastrophic consequences for the operations of other components.
  - Consider, if a program comprises of just one monolithic set of instructions then a change in any one instruction would have consequences for all ensuing instructions.
  - On the contrary, if the program is composed of independent routines, then it is possible to see that damage to only one components not lead to problems with other components.

2.2 Inferences from Marr's Modular Design

- According to this view, **sensory transduction** associated with each sense organ eventuates in information being transformed into a common perceptual code $\rightarrow$ information presented in any modality is rendered into the same code
- This code is then operated on "in sequence, by the faculties of perception, imagination, reason & memory" and each of these faculties effected its own intrinsic operations upon input representations irrespective of the nature or type of those representations (Marshall, 1984). For Example, various sensory organs give us a different kind of information which gets converted to **common perception code.** Then this common perceptual code is worked on by the higher cognitive abilities like memory, languages, reasoning, etc.

- Linguistic operation for the particular kind of information will happen independently of the perceptual processing or independent of the memory operation that will happen.
- Finally, Marr (1982) was also particularly taken with this principle of modular design because it allowed for a degree of operational independence across the different core components.
- The idea is that within a complex information processing system, the different modules can be getting on with their own tasks quite independently of what is going on in the other parts of the system.

3 Fodor's Modularity Hypothesis

- Jerry Fodor (1983) began by discussing what he called **Faculty Psychology** $\rightarrow$ a loosely held set of beliefs that maintains that the mind is composed of many different sort of special-purpose components.
- According to Marshall (1984), the bases of the ideas given by these psychologists may be traced back to the ancient Greek philosopher Aristotle.
- Aristotle's Framework for thinking starts with the considerations of the five senses (sight, sound, touch, smell & taste) which map onto the respective sense organs; which eventually do the sensory encoding or sensory transduction.
- Eventually, these are the senses which do the sensory encoding of whatever information is coming in; and in sensory transduction which is basically converting of the sensory information to a form that can be processed by the brain.
- Fodor proposed 2 kinds of faculties/abilities that human mind will have $\rightarrow$ Horizontal Faculties and Vertical Faculties; which are discussed in next subsections.

3.1 Horizontal Faculties

- Fodor (1983) labeled the faculties of perception, imagination, reason and memory as horizontal faculties.

- These reflect general competencies (whatever brain generally does on all kinds of information) cut across different domains. For instance, cognitive abilities may be conceived as containing a memory component and, therefore, memory can be interpreted as a horizontal faculty.
- For example, write a paragraph on one word requires memory related to that word. Similarly performing complex arithmetic problems require storing the solution of simple arithmetic sub-portion of the sub-problems in memory.
- Memory can therefore be construed as a horizontal faculty to the extent as similar memory constraints apply to other quite unrelated competencies, such as trying to learn a poem off by heart.
- According to Fodor (1983), horizontal faculties are defined with respect to what they do and are not defined in terms of what they operate on. For example, same more constraints may apply to letters, numbers, pictures, etc.

3.2 Vertical Faculties

- Jerry Fodor cited the work of **Francis Joseph Gall (1758 - 1828)**. Gall's idea was that the mind is composed of distinct mental organ, with each mental organ defined with respect to a specific content domain,
  - For instance, there is a mental organ that underlies musical ability and a different mental organ that underlies mathematical ability and so on & so forth.
- So, vertical faculties are defined in terms of what they operate on.
- Gall took the argument further & proposed that each of these different mental faculties or organs could be identified with the unique region of the brain; i.e. He firmly believed that individual intellectual abilities, such as being musically adept; were directly linked with particular brain regions $\rightarrow$ that there are really distinct areas of the brain that embody a special purpose mechanism for music or math.
- This view formed the basis of Gall's Phrenology, where particular bumps on the head could be interpreted as being associated with particular regions of the brain.

- Each of these regions embodied a particular intellectual capability & the prominence of the bump was indicative to the size of the underlying brain region; i.e. the size corresponded to how well developed the corresponding cognitive function was.
- In positing the vertical faculties, Gall provided a critique of the traditional view of horizontal faculties (Fodor, 1983).
- The notion of general faculties for memory, perception, etc. was dismissed in favor pf a framework for thinking in which a whole battery of distant mental organ are posited, each one of which has particular characteristics with respect to memory, perception, etc.
- Gall's vertical faculties do not share $\rightarrow$ and hence do not compete for $\rightarrow$ horizontal resources such as memory, attention, intelligence, judgement, etc.
- So, the conflict between general purpose $\rightarrow$ versus specialised faculties.

3.3 Fodor's Modules

- With the publication of Fodor's **The Modularity Of Mind (1983)** a quite different meaning of modules was introduced.
- Fodor (1983) distinguished between sensory transducers, input systems and central processors.
- In order to understand these, we have to consider:
  - **The Proximal Stimulus:** the stimulation of the sense organs
  - **The Distal Stimulus:** the actual external object responsible for the sensory stimulation.
- For example: the distal stimulus could be a stereo system & therefore the associated proximal stimulus would be sound vibrations one receives in the ear.
- The sensory transducers are the sense organs, and are responsible for taking the proximal stimulus and converting them into a basic sensory code.
- The sensory code then acts as the input to the corresponding input system. For Fodor (1983), input systems are the modules referred to in the modularity hypothesis.

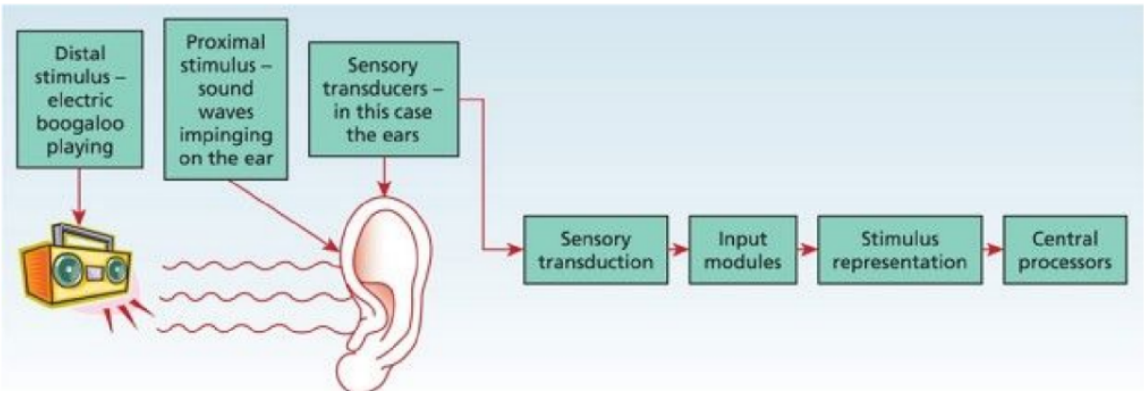

Figure 1: **A schematic representation of the core ideas behind the modularity of mind thesis**

- Modules operate as the interface between the sensory transducers and the central processors. These modules deliver to the central processors; the best first guess of what the distal stimulus is, which gave rise to the stimulation.
- The final decision, about what the distal stimulus may actually be, is made by the central processors. Central Processors are concerned with the fixation of belief and planning of intelligent action.
- The fixation of perceptual belief is the act of making a final decision about the distal stimulus.

- All the really interesting things about thinking, believing & feeling are taken care by the central processors.
- Fodor (2000) also claimed that the operation of central processors remains essentially unknown. This Black Box Persists.
- Fodor's modules are **domain specific**. There are many more modules than sense organs, so the visual system may contain more than one module; each of which takes on a different job: i.e. separate module exist for colour perception, for analysis of shape and the analysis of three dimensional spatial relations.

- Similarly, within the domain of language processing, the possibility exists that different modules are used for encoding different sorts of linguistic input. For example, separate modules for visual and spoken language.

- A recent take on the same has been ventured by Coltheart (1999) who stated that **a cognitive system is domain specific, if it only responds to stimuli of a particular class.** and he speculates; there might exist a module responsible purely for face recognition and that comes into play only when confronted with faces & for no other visual objects.

4 References

[1] **Cognitive Psychology By Philip T. Quinlan, Ben J. Dyson**

[2] **Modularity And Cognition By Max Coltheart**