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Basic Cognitive Processes

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Lecture 08: Modularity and Cognitive Neuropsychology

What do we know so far?

- The definition of Cognitive Psychology.
- Various Possible approaches towards understanding the architecture of the mind.
- In this lecture we will see how the concept of modularity forwarded by Jerry Fodor helps us in understanding the architecture of the human mind.
- How can the field of Cognitive Neuropsychology help us understand the human mind/brain relationship?

So, What is the Mind really like?

- Let us turn to the architectural considerations of the mind.
  - Fodor (1983) would like us to discuss the functional architecture of the mind!
  - he puts forward something called the **modularity hypothesis**, i.e. the idea that the mind may be composed into smaller & discrete sub processes & modules (Fodor, 1983).

- **Marr's Modular Design**

  - Marr (1982) was particularly interested in something he termed as **the principle of modular design** & he advanced the argument in terms of the example of a computer programmer who is designing a large & complex computer program.

  - One approach to this problem has already ben discussed in the car - engine example.

  - 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 its own dedicated set of programmers who collectively work to develop it.
- Although Marr (1982) wrote with respect to implementing large & complex computer programs, his points should be taken as applying, by analogy to the evolution of intellectual capabilities.
- Acc. 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 - it exhibits **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 componential not lead to problems with other components.

- 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.

- **Other conceptions of Modularity**

  - **Fodor's (1983) modularity hypothesis**.

  - Fodor (1983) began by discussing what he called Faculty Psychology - a loosely held set of beliefs that maintains that the mind is composed of very many different sort of special - purpose components.

  - Acc. to Marshall (1984), the bases of these ideas 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.

- Acc. to this view, sensory transduction associated with each sense organ eventuates in information being transformed into a common perceptual code - 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).

- **Horizontal Faculties:** Fodor (1983) labeled the faculties of perception, imagination, reason & memory as horizontal faculties.

- these reflect general competencies that cut across different domains. For instance, cognitive abilities may be conceived as containing a memory component and, therefore, memory can be construed a a horizontal faculty.

- Remember the mental arithmetic examples (compare 17 x 3 vs. 14 x 5). the assumption is that performance in this task depends to some extent also on memory.

- Memory can therefore be construed as a horizontal faculty insofar as similar memory constraints apply to other quite unrelated competencies, such as ting to learn a poem off by heart.

- Acc. to Fodor (1983), horizontal faculties are defined with respect to what they do & are not defined in terms of what they operate on. e.g. same more constraints may apply to letters, number, pictures etc.

- **Vertical Faculties:** Another alternative is to carve up the mind into vertical strips or that of **vertical faculties.**

- 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 - 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.

Image: http://throughablogdarkly.blogspot.in/2014/03/neo-phrenology.html

- 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 of 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 - and hence do not compete for - such horizontal resources as memory, attention, intelligence, judgment, etc.

- So, the conflict between general purpose - vs specialised faculties.

- **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, let us also consider; **the proximal stimulus**: the stimulation of the sense organs and **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, & are responsible for taking the proximal stimulus and converting them into a basic sensory code.

- the 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.

- Modules operate as the interface between the sensory transducers and the central processors. they 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 & planning of intelligent action.

- the fixation of perceptual belief is the act of making a final decision about the distal stimulus.

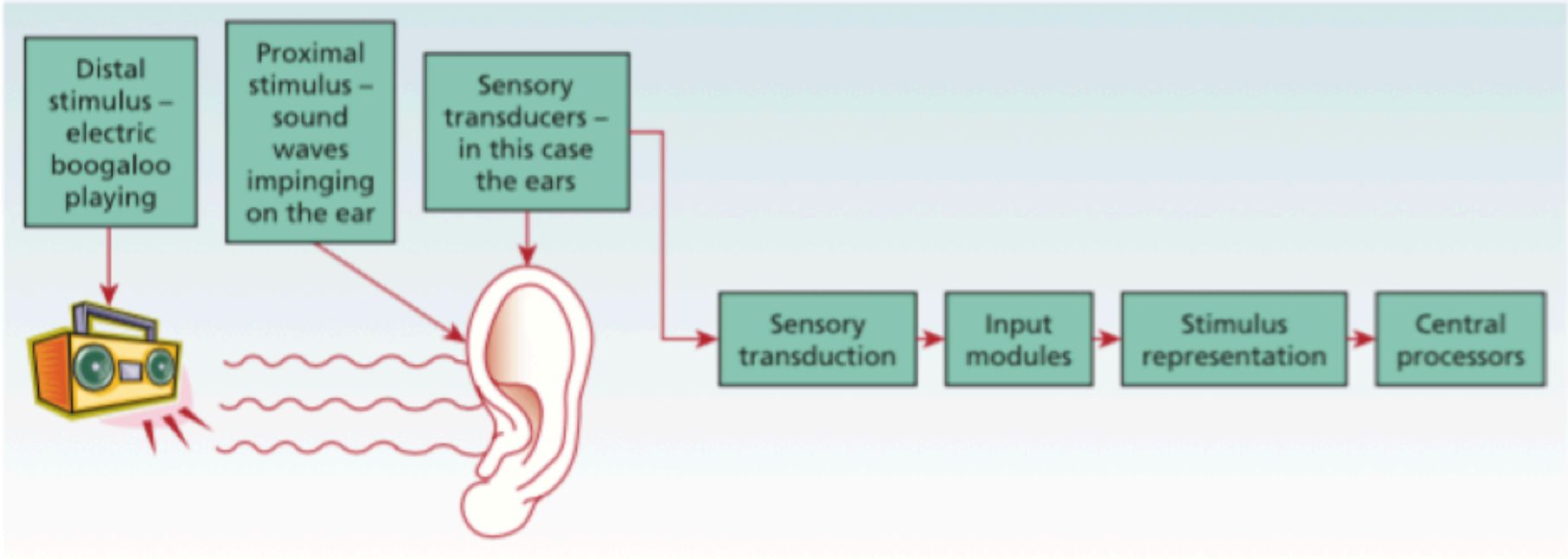

Figure 2.8 The modularity of mind thesis
A schematic representation of the core ideas behind the modularity of mind thesis.

Image: Quinlan, P. & Dyson B. (2008). Cognitive Psychology. *Prentice Hall*.

- All the really interesting things about thinking, believing & feeling are taken care of by the central processors.

- Fodor (2000) also claimed that the operation of central processors remains essentially unknown. The Black Box persists!

- **Making sense of modules!**

  - Fodor's modules are **domain specific**. there are many more modules than sense organs, so the visual system may contain more then one module; each of which takes on a different job: separate module exist for colour perception, for analysis of shape & the analysis of three dimensional spatial relations (Fodor, 1983).

  - Similarly, within the domain of language processing, Fodor, (1983) the possibility exists that different modules are used for encoding different sorts of linguistic input. Ex. separate modules for visual & 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*’. & he speculates; there might exist a module responsible purely for face recognition & that comes into play only when confronted with faces & for no other visual objects.

Modularity & Cognitive Neuropsychology

- Fodor also proposed that:
  - Modules are associated with fixed neural architecture; of the adult human brain.
  - Modules exhibit characteristics and specific break down patterns.
- Now, if we accept the above two points we are conceding that a critical dependency relations holds between the mind & the brain.
  - if the brain is damaged, it is very likely that there will be negative consequences at the cognitive level.

- **Cognitive Neuropsychology:**

  - Cognitive Neuropsychologists are concerned with the operation of disordered brains. In that the assumption is, that much can be learned about the cognitive level when brains do not function normally.

  - Evidence from brain damaged individuals can provide converging evidence for particular functional accounts and may also provide critical constraints for such accounts.

- **Developmental Cognitive Neuropsychology** is the branch of the discipline concerned with brain disorders that develop as a person ages & that lead to some form of cognitive impairment, i.e. **developmental disorders.**
    - there are also **acquired disorders** that occur during the normal course of development, through injury or illness.
    - E.g. acquired aphasia due to stroke or other illnesses.

- In adopting the cognitive neuropsychological approach, the theorist attempts to understand the cognitive deficits following brain damage, by accepting certain key assumptions.
    - for instance, Coltheart (2001) discussed the foundational assumption that the same functional architecture is assumed to operate in all normal individuals.
    - Acc. to him, cognitive neuropsychology would simply fail if 'different individuals had different functional architectures for the same cognitive domain'.
    - Remember, that if we are trying to pursue cognitive psychology, then we are attempting to establish general principles that apply across individuals; i.e. if the functional architecture is same across people.

- the logic behind cognitive neuropsychology:
  - Cognitive neuropsychology is primarily concerned with the patterns of similarities and differences between normal cognitive abilities and the abilities of those who possess a disordered/damaged brain.
  - Typically, the interest is in the performance across a whole battery of tests; where each test is designed to examine a particular cognitive operation.

- Cognitive neuropsychology is distinctive in that it is the intensive study of single cases.
    - Performance of participants with brain damage is compared to that of normal individuals (control participants).
- **Association Deficits:** When a patient performs poorly on say, two different tests. for e.g. in understanding both written & spoken words.
    - this pair of impairments is said to be associated because they arise in the same person.
    - it might be tempting to conclude that performance in both tests depends upon the operation of a single underlying module.

- **Dissociation Deficits:** Funnel (1983) reported one patient who was able to read aloud more than 90% of the words but was unable to read even the simplest of non - words correctly (‘dreed’ was read as ‘deared’).

  - In such cases the abilities are said to be dissociated, because within the same person; one is impaired but the other is intact. The deficit on the two tasks in question could also be that of degree.

- However, if we look more closely:
  - in terms of our single dissociation, we have a case of two tasks that may either arise because of the operation of two different modules each of which operates on its own pool of resources (modular) or we can think of a non -modular system that contains a single resource.
  - In explaining the single dissociation; it is easy to accept the modular explanation; but it can also be explained through a non - modular system.
    - it maybe that the two tasks are not equated in their inherent difficulty so that the single dissociation may merely reflect the different demands that the two tasks place on a single resource.

- we can assume that the dissociation shows that task A performance is unimpaired or relatively unimpaired whereas task B performance shows a substantial deficit.

- By the resource arguments this can happen if task A is an easier task than task B.

- Task A makes fewer demands on resources than does task B; so any damage that results in depletion of mental resources will have a more catastrophic consequences for task B than task A.

- **double dissociation deficits:** Firmer evidence for mental modules arises when we consider the notion of double dissociation.
    - the critical conditions for demonstrating double dissociations are two tasks A & B and two different patients I & II
        - A double dissociation arises, when patient I performs well on A & worse on B &patients II performs worse on A & well on B.

- Coltheart (2001) provided the following example: patient A is impaired in comprehending printed words but normal at comprehending spoken words; patient B is normal at comprehending printed words but impaired at comprehending spoken words.

- From this example there are seemingly good grounds for concluding that different modules underpin text & speech comprehension, respectively/

- More specifically, the double dissociation is most consistent with the idea that there is at least one module that is unique to comprehending printed words (damaged in patient A) and there is a unique module dedicated to comprehending spoken words (damaged in patient B).

- Moreover, such a double dissociation cannot be explained away in terms of resource allocation within a single non -modular system.
    - in simple terms, if task A demands fewer resources than B then; as we saw task A performance can remain intact even if task B performance is impaired.

- the reverse pattern cannot occur if the problem is assumed to lie in the allocation of resources in single non -modular system.

- Any problems in resource allocation will hurt the difficult tasks first & then the easy task; decrement on which will come out only after decrement in the difficult task.

- Colt heart (2001) however, also pointed out that this by no means definitive proof of modular architecture. for examples; double dissociations can arise in cases where different impairments to the same unified information processing system arise.

To sum up…

- In this lecture we talked about various possible architectures of the human mind.

- We talked about two conceptions of modularity (Marr & Fodor) and how they influence the approach to understanding the mind – brain relationship.

- We also talked about how the field of Cognitive Neuropsychology may help us understand the nature of interaction between the mind & the brain.

References

- Quinlan, P. & Dyson B. (2008). Cognitive Psychology. *Prentice Hall*.