Reviewing the Modular Versus General Debate

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Introduction

Researchers studying brain science and brain organization have been debating the theoretical structure of the brain since Fodor's *Modularity of Mind* (1983).

The debate centers around two types of organization: domain-general and domain-modular.

- **Domain-general:** A "general" organization states that the cognitive processes we use to think and behave are nonspecific; the mind is fundamentally integrated with itself so that no process is distinct (Chiappe & MacDonald, 2005). Domain-general theories often do not believe that evolution shaped psychological adaptations to solve specific problems.
- **Domain-modular:** A "modular" organization states that processes are distinct from each other; they are adaptations that evolved because they handled specific problems in efficient ways (Cosmides & Tooby, 2006). Selection pressures over time caused the mind to develop problem-solving strategies that were specific to the problem it was evolved for.

Example:

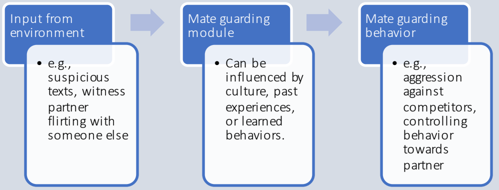
Mate-guarding is the behavioral response to feeling jealous and/or possessive over a mate (Cousins et al., 2009). It is what we do to prevent infidelity.

Domain-general theories would explain mate-guarding behavior as being the result of culture, learned behaviors, or past experiences. They can be influenced by biological predispositions, but there is not any in-built mechanism to specifically deal with threats to infidelity.

Domain-modular or "domain specific" theories go the other way around. There is an in-built mechanism to specifically deal with threats to infidelity (the input) which determines whether or not the person will mate-guard. This can be influenced by things like culture, but it is dependent upon the existence of the mate-guarding *module*.

The following graphic shows a simplified understanding of how evolved modules work.

Domain-modular organization:



If the mind is domain-modular…

- determining what and how many different modules we have could help us more accurately predict future behavior. If we consider the input in a situation, then we could make a prediction on what modules will be activated and what kind of behavior it will produce.

Support for domain-modularity

- **The efficiency problem**

Domain-modularity's specificity for information helps explain how the human brain evolved such complex processing while also remaining energetically feasible for the organism. When a system is specified for only taking in certain information, it operates more efficiently than a generalized system that requires the organism to cross-reference across domains (Cosmides & Tooby, 1992).

Example: Retinal cells are "programmed" to take in specific orientations (there are cells for individual visual properties like shape and movement) and because of this specialization, they gather information and process it incredibly fast. If every retinal cell had to process all properties of vision, it would not be able to operate as quickly as it does (Goldstein & Brockmole, 2017). This is how psychological modules are proposed to work as well.

- **Poverty of the stimulus problem**

The poverty of the stimulus argument states that mechanisms like incest avoidance are not plausibly learned through the sensory experiences of a person's individual lifetime (Frankenhuis & Ploeger, 2007). This implies that psychological norms such as incest avoidance must have some inherited, unlearned foundation. Natural selection sifts through traits by weighting those that on average end up advantageous; this process takes a multitude of generations, creating problem-solving archetypes that become cognitive modules over time (Cosmides & Tooby, 1994). Therefore, domain-modularity can reasonably explain the existence of unlearned psychological mechanisms.

Example: It would be impossible to learn the statistical reasons why incest avoidance leads to greater reproductive success over the course of one lifetime; even if it were possible, much of our lives would have to be dedicated to acquiring an aversion to it. The in-built inclination to avoid such disadvantageous behavior supports the existence of input-specific modules that drive our actions.

- **The combinatorial explosion problem**

Due to the efficiently engineered, content-specified, and inherited nature of modules, information can be combined in a non-random way to produce adaptive responses (Frankenhuis & Ploeger, 2007). On the other hand, a domain-general system has a moment-by-moment influx of information circulating through every possible cognitive avenue, generating an ever-increasing set of possible decisions an individual could make in any given situation. Not only does this seem unlikely, but it would create an organism feeling perpetually "stuck" with too many possibilities for action. Domain-modularity limits what we do by filtering all of our incoming information through its specialized domains. The processing in each domain then produces the particular output (behaviors) that it was adapted to produce.

Example: Domain modularity puts limitations on what behaviors a person is able to do, similar to how in Gibsonian ecological theory, an organism's affordances determine what actions it can energetically "afford" to do (Gibson, 1979). Although right now you are theoretically able to do a near-infinite number of actions (spin around five times, kiss the person next to you, throw your computer in the trash, etc.) the modules that are currently active in your brain are not even considering most of the actions we are capable of because they are "engineered" to only produce relevant behaviors. The engineer behind this efficient design is evolution; selective pressures would have selected for relevant over irrelevant responses, because optimal survival requires optimal energy utilization. It was likely a harsh world for the evolving human, and non-specified responses would result in a lot of energy waste.

Problems with domain-modularity

- **The creativity problem**

If every module requires specific input, then how is it that organisms often find novel solutions to problems? There would inevitably be environmental stimuli that do not match any of the built-in mechanisms (Chiappe & Gardner, 2012).

Response: Barrett and Kurzban (2006) say that although all domains have precise input criteria, some input doesn't quite key into pre-existing domains. They also make an allowance for the combination of domains; for example, novel situations like driving could be utilizing domains for spatial navigation and perception-action motor control. Foraging would also likely require the combination of multiple domains, as a variety of skills are utilized in the search and acquisition of wild resources. Although Fodor (1983) argued for the encapsulation of domains, more recent researchers say that there should be no reason why domains wouldn't work together (Pinker, 1997). If modules can combine their inputs to coordinate output, then creative decision making may involve combining domains in novel ways.

- **The general intelligence problem**

Burkart et al. (2016) agree that domain-specificity trumps generality in its efficiency and likelihood of occurring in organisms in relatively stable environments, but also reasons that it leaves little room for general intelligence. They go on to suggest that ancestral hominids may have evolved in more unpredictable environments than we think, which would support the evolution of a more generalized intelligence that could adapt to large, unexpected environmental changes.

Response: Kanazawa (2010) says that there is little reason why general intelligence could not itself be a domain. The ability to face new problems and find solutions for them would undoubtedly be a survival advantage and the amount that one can do this would surely have been selected for. A general intelligence domain would be a mechanism for tackling problems that do not fit into any other domains, and can be solved by logical reasoning. Research has supported this through showing that individuals who score higher in general intelligence also tend to perform better at evolutionarily novel tasks (technology) but do not perform better at evolutionarily "traditional" tasks (finding a mate) (Kanazawa, 2008).

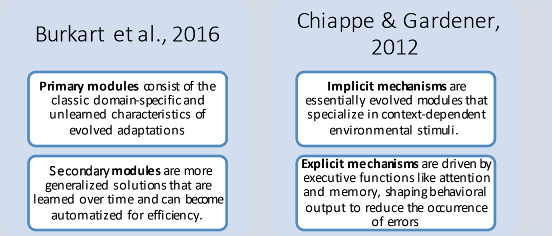
- **The predictive performance problem**

Working memory is positively correlated with both reading and math ability, but also analogical reasoning (Simms et al., 2018). Analogical reasoning involves the capacity to connect seemingly unrelated information in innovative ways, which is itself a difficult task for domain-modularity to explain. Performance on the Tower of Hanoi puzzle also has been found to predict performance on the Raven's Progressive Matrices puzzle, which require two independent calculations (Chiappe & MacDonald, 2005). If proficiency in one domain predicts proficiency in another, it may indicate that some general processing is at work.

Response: Endress (2019) proposed that independent domains may operate in similar ways because modules can duplicate its computations to be adopted by surrounding modules. There might be a computation used in the module for solving the Tower of Hanoi that has been duplicated the serve the module for solving Raven's Progressive Matrices. In this way, the performance on one can predict performance on the other while still operating as separate modules.

Alternative explanations

Burkart et al. (2016) and Chiappe and Gardener (2012) each propose organizational models that incorporate both domain modularity and domain generality. Similar to traditional Fodorian modularity, their theories involve modularity when it comes to deeper processes (primary modules/implicit mechanisms) but higher processes involve domain-general mechanisms (1983).

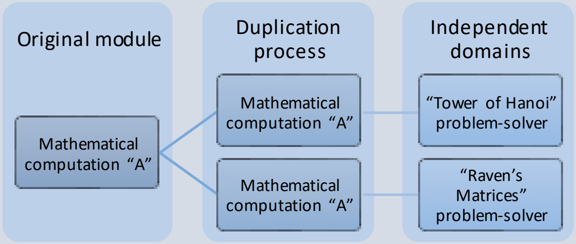


Duplication theory departs from the "best of both worlds" approach and hypothesizes a solution that not only supports domain-modularity but provides clarification for the performance-prediction problem as well (Endress, 2019).

Duplication: the mind is neither fully domain-general or domain-specific, but domain-bound. In a domain-bound system, adaptive mechanisms are duplicated across domains.

Endress (2019) states that modules act like genes in that they tend to duplicate if it is energetically possible and there is an advantage to. An example straight from evolution is the transition from dichromatic to trichromatic color vision; it was the result of opsin duplication over time.

Duplication would explain the existence of similar mechanisms existing across multiple domains, as well as how these processes can work simultaneously. If we remember how performance on the Tower of Hanoi predicts performance on Raven's Progressive Matrices, it can be hypothesized that the reason for this is the duplication of some computational strategies between the domains for solving each puzzle (Chiappe & MacDonald, 2005).



Conclusion

The current theories point to a possible fusion of both modular and general ideas, whereas hypotheses like Endress's (2019) duplication theory follow the evolutionary tradition of looking to biological systems for guidance.