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CHAPTER ONE

The allocation system: Using signal detection processes to regulate representations in a multimodular mind

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IMPLICATIONS OF A MULTIMODULAR MIND

An aspect of evolutionary psychology that seems to distress a number of people is the degree of modularization it implies. The concept of a multimodular mind can be difficult to accept. To be more precise, many sensible people readily accept that evolutionary theory is relevant to the study of the mind, and even that the evolutionary process is an important consideration in understanding how the mind was designed, but balk at the implication – drawn by most pre-eminent theorists in evolutionary psychology – that the mind is therefore composed of a large number of relatively specialised cognitive adaptations, or modules (Buss, 1995, 1999; Pinker, 1997; Tooby & Cosmides, 1992).

The reason for positing a large number of specialized mental abilities lies at the very foundations of evolutionary thinking. The evolutionary process must be enabled by a selection pressure – some aspect of the environment that poses a survival or reproductive problem for the species in question. Evolution happens by positive and negative feedback in relation to how well individuals (actually, genes that produce phenotypic traits that exist as part of individuals) solve that problem (assuming there is some variation in problem solutions). Since we are talking about specific problems, the better solutions will be specific and tailored to that problem domain (see Cosmides & Tooby, 1987, 1994); one cannot have a single solution for problems as diverse as finding food, courting mates, learning a language, and bipedal locomotion.

Although there are debates about the nature of the processes and devices (Karmiloff-Smith, 1992; Sterelny, 1995), the mind must contain some form of specialisations specific to these problem domains. Thus, it is proposed that there is a learned taste aversion module, a “cheater-detection” module, a “jealousy” module, a “theory of minds” module, “bluffing-detection” and “double-cross detection” modules, and so on. (Tooby & Cosmides, 1992; also see Francis Steen’s compendium for a tentative attempt at documenting the major categories of modules: http://cogweb.english.ucsb.edu/EP/Adaptations.html.)

Although this process of module discovery appears to be ongoing, there already are concerns that evolutionary psychologists are creating a Frankensteinian mind. Some (Murphy & Stich, 2000; Samuels, 1998; Sperber, 1994) have referred to this evolutionary view of the mind as the “*massive* modularity” hypothesis (italics added), an expression that seems to capture this concern quite well. Other, less restrained writers, have taken to calling evolutionary psychology “the new phrenology.” Some of this discomfort is likely to be the result of the sheer magnitude of the transition from traditional psychological models to evolutionary approaches. Behaviourist models of the entire mind contain a small handful of extremely general associative modules. Early computational models of the mental abilities tend to have a similarly small number of modules (e.g., the Atkinson & Shiffrin (1968, 1971) model of memory, which prior to later modifications, had three basic modules: sensory memory, short term memory, and long-term memory). Even the model proposed by Fodor (1983), which in many ways introduced the idea of mental modules, restricted itself to highly encapsulated modules at the interfaces between the external world and the (still general-purpose) central functions of the mind. In the context of these historical roots, the evolutionary vision of the mind is truly a radical step.

Another indication of the profound nature of this viewpoint shift is that some early critics of evolutionary approaches seemed to miss entirely the implications of multimodularity and criticized domain-specific abilities for not being able to explain phenomena outside that domain. Cosmides’ theory on reasoning about social contracts was considered to be falsified if it failed to account for improved reasoning of any kind, with any other type of content:

> …contrary to the prediction of social exchange theory, facilitation in the selection task can be readily obtained with unfamiliar regulations that do not involve social exchange, any type of ‘rationed benefit’, or even any social situation at all.
>
> (Cheng & Holyoak, 1989, p. 299)

> We ourselves have found, however, that the facilitation effect [in selection tasks] is not only produced by conditionals relating benefits and costs as Cosmides describes.
>
> (Manktelow & Over, 1990, p. 156)

> Intriguing as this theory is, it is incorrect as it stands, since, as several authors have pointed out…, many of the best established facilitatory contexts do not involve costs and benefits that are socially exchanged.
>
> (Garnham & Oakhill, 1994, pp. 140-141)

Actually, the existence of a cognitive adaptation for dealing with social exchanges in no way precludes the existence of other cognitive adaptations for reasoning about other types of contents. In fact, it actually implies that there *must* be other reasoning procedures, given any similar selection pressures over human evolutionary history that involved making inferences about any other aspects of the world.

As some people grasp the "massiveness" of the multi-modular mind model, they have tried to dismiss the basic idea using an argument of incredulity (see Samuels, 1998); claiming that the implications of multimodularity are simply too outrageous to be true. Although this "too massive" objection is a weak rhetorical argument (Dawkins, 1987), is does help to reveal some points that do deservedly require serious attention. One of the most important of these points is that the existence of a large number of modules necessitates some form of coordinating superstructure; a regulation of the modules that determines which modules are invoked as which times. In short, a multimodular mind requires some procedural government of modules.

The government of a multimodular mind can be usefully viewed as being a process just as much about the external world as it is about modules. The primary task of this process is to categorise situations that arise in the environment into the various domains in which particular inference procedures (modules) are invoked. As pointed out by Samuels, Stich, and Tremoulet (1999), "perhaps the most natural hypothesis is that there is a mechanism in the mind (or maybe more than one) whose job it is to determine which of the many reasoning modules and heuristics that are available in a Massive Modular mind get called on to deal with a given problem." Samuels, et al. call this device the "allocation mechanism". I shall adopt this label, but with a modification: this allocation process is almost certainly a multifaceted system, and as such it is probably misleading to refer to it as a mechanism (e.g., just as one does not usually refer to a "visual mechanism" but rather the visual system). I will, therefore, refer to the *allocation system*.

This paper will also use certain other conventions in terminology. Cosmides and Tooby (1997, 2002) have used the term "multimodular" (as opposed to massively modular) to describe the general structure of the mind from an evolutionary viewpoint. Also, this paper is concerned more with the information entering and being processed within this mental allocation system, and I will refer to the output of the allocation process as different *representations* of information. That is, what the allocation system does is impute specific representational forms onto environmental situations (based on incoming information), so that each situation can be processed within a module suitable for such situations. (Admittedly, this description glosses over some complex processes, e.g., how representation, categorization, and the movement of these neurally instantiated representations to their appropriate modules, but it will have to suffice at this point).

How does this allocation system work? In terms of a computational analysis (Marr, 1982), what is the computational problem that this system must solve? The situation that exists is a more-or-less continuous series of categorization tasks, all under situations of incomplete information, based on the properties of situations (cues) that are used as information (signals) for categorization. One of the most straightforward and widely used conceptualizations for such perceptual cue/category relationships (in situations with incomplete information) is signal detection theory (SDT). SDT has been applied across many situations in which a categorization decision must be made based on cues with less than perfect cue validity and other situations of incomplete information.

PRIMER ON SIGNAL DETECTION THEORY

Signal detection involves the perception of some information from the environment (the signal) and a decision process for categorizing that information as either being or not being the target signal (detection; Green & Swets, 1966). The issue in signal detection is not just whether the signal actually exists (it may or may not), but also whether observer detects it (they may or may not). Therefore, there are four possible states of affairs:

1. "Hit" (correct acceptance) = the signal is present, and it is detected.
2. "False Alarm" (incorrect acceptance) = the signal is absent, but it is detected.
3. "Miss" (incorrect rejection) = the signal is present, but it is not detected.
4. "Correct Rejection" = the signal is absent, and it is not detected.

So long as the information is incomplete in some ways, due to limits in the sensitivity to the signal, environmental and/or neural noise, or infidelity of the signal itself, all four of these outcomes will be possible. In real-world settings there is nearly always some amount of insensitivity, noise, or corruption in the signal, meaning there is always a distribution of ways the signal (or absence of a signal) may appear to an observer. An observer must therefore set a criterion (also called a cutting score, or *C*) for making decisions about whether the signal has occurred or not. As can be seen in Figure 1, any given criterion results in errors (misses and false alarms); the task of the criterion generally is to minimize the effects of these errors, and a natural place to put

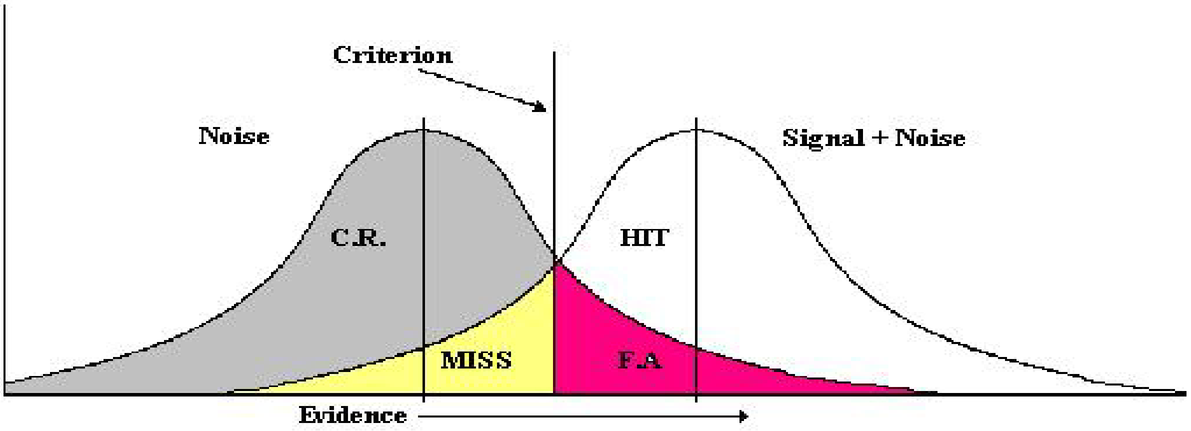

Figure 1.1 Generalized model of a signal detection situation. A judgement that there is only noise when there is, in fact, only noise (left-hand distribution) is a "Correct Rejection" (CR), whereas a judgement that there is a signal when there is actually a signal (right-hand distribution) is a "Hit". Errors can occur when either no signal is judged to exit even though a signal does exist (a "Miss") or a signal is judged to exist although there actually is no signal (a "False Alarm"; FA).

the criterion is at the point that minimizes both the miss rates and the false alarm rates. A criterion can be adaptively adjusted from this point, however, changing what is called the *criterion bias*, based on the relative costs of "miss" errors and "false alarm" errors. Placing the criterion in different locations changes the likelihood of these two errors, which are linked to one another in an inverse relationship (e.g., as in Neyman-Pearsonian statistical hypothesis testing theory, in which Type I and Type II errors are parallels to misses and false alarms).

It is important to note here that in most applications of Signal Detection Theory (SDT) the categorization itself is the crucial event that leads very directly to a decision and the end of the process. One reason for the focus on signal detection decisions as the end-points of the process is that most signal detection tasks are for fairly specific tasks. The topics most strongly associated with Signal Detection Theory are narrowly defined areas of decision making; from the original conception of Signal Detection Theory (identifying sonar objects as being either ships or non-ships), to specific aspects of memory and attention (e.g, Posner, Snyder & Davidson, 1980), to specific aspects of language (e.g., Katsuki, Speaks, Penner & Bilger, 1984), to taste and smell (e.g., Jamieson, 1981; Doty, 1992), and to jury decision making (Mowen & Linder, 1986). In each of these areas, the decision frame has already been constructed around a rather specific issue (also see Pastore & Scheirer, 1974 for a general discussion of Signal Detection Theory applications).

Even in understanding the behaviours of other animals, in which signal detection has also been useful, the animal signals have typically been signals of specific things (e.g., alarm calls, mate attraction, warning coloration, etc.;

e.g. Cheney & Seyfarth, 1990; Marler, 1996). Similarly, the detection of a signal has usually been directly linked to some specific behavioural response. Signal detection models in the animal world, however, more often involve the idea of detection errors that are caused not by random noise or insensitivity, but by other agents (i.e., other animals). Take, for example, the situation of a predator (say, a hawk) scanning the landscape for prey. A "hit" for the predator is a correct sighting of prey, and a "correct rejection" is a correct rejection of non-prey objects. The predator can be induced to commit miss errors, however, by prey that mimic the appearances of foul tasking animals (Gould & Marler, 1987; one could also view this as a false alarm on the part of the predator, if considering the categorisation dimension of "foul tasting things to avoid"). Alternatively, some prey animals induce misses in predators by using camouflage with their surroundings so that the predators simply do not detect the prey's presence as such.

THE ALLOCATION SYSTEM

The ideas proposed herein are designed to outline an allocation system envisioned as a part of the multi-modular mind generally (Fig. 1.2), but will, by necessity focus on specific topical areas in describing and giving examples of this system's functioning. This focus is made for several reasons. First, specific areas (social relationships and judgments under uncertainty) have been loci of evolutionarily informed research, providing sufficient and relevant background research. Second, these are areas with particularly interesting properties: like the predator/prey example earlier, signals sent by other people may be intentionally made clearer or noisier to suit the sender's goals. Finally, I think it would be premature to attempt anything near a complete model of all aspects of the allocation system. At present, the goal is simply to develop a general framework.

The general form of the allocation task is to determine which type of representation is most appropriate for understanding a given situation, based on the perceived properties of that situation. In complex situations (such as most real-world settings), there are multiple cues to the nature of the situation, each of which is due to particular properties of that situation (analogous to multiple cues to visual depth; Holway & Boring, 1941). It is supposed, therefore, that the allocation system is structured to take advantage of these multiple cues by utilizing signal detection mechanisms for particular cues, each of which contributes –but is not alone sufficient– to trigger the allocation of a particular representation. So, for example, a social exchange situation (as described by Cosmides & Tooby, 1992), would involve all or some of the cues of another person's wanting something you possess, of them having something you want, of the relative values of both these items (and if their exchange would result in a net benefit for both parties), and how likely it is that you would receive what you want in the absence of action. Once represented as a social exchange, a similar signal detection procedure could be evoked by cues of deception or dishonesty; the much-discussed "cheater detection module." Other situations that could potentially be mentally represented may involve some – but not all – of these same situational cues (e.g., perceiving a threat involves another person wanting something you possess and cues as to the nil likelihood of them receiving it without any action, but critically does involve a reciprocal benefit for both parties). And, of course, other situations will additionally involve other detectable situational cues (e.g., a threat does involve cues of a cost being implemented in the absence of the items being given over).

Some possible representations for social interaction situations include as a social exchange, a hazard, a threat, or as a sexual opportunity. Recent studies have provided evidence that these different representations not only exist but that specific social interactions can be categorised into different representations based on how people are induced to consider that interaction. Fiddick

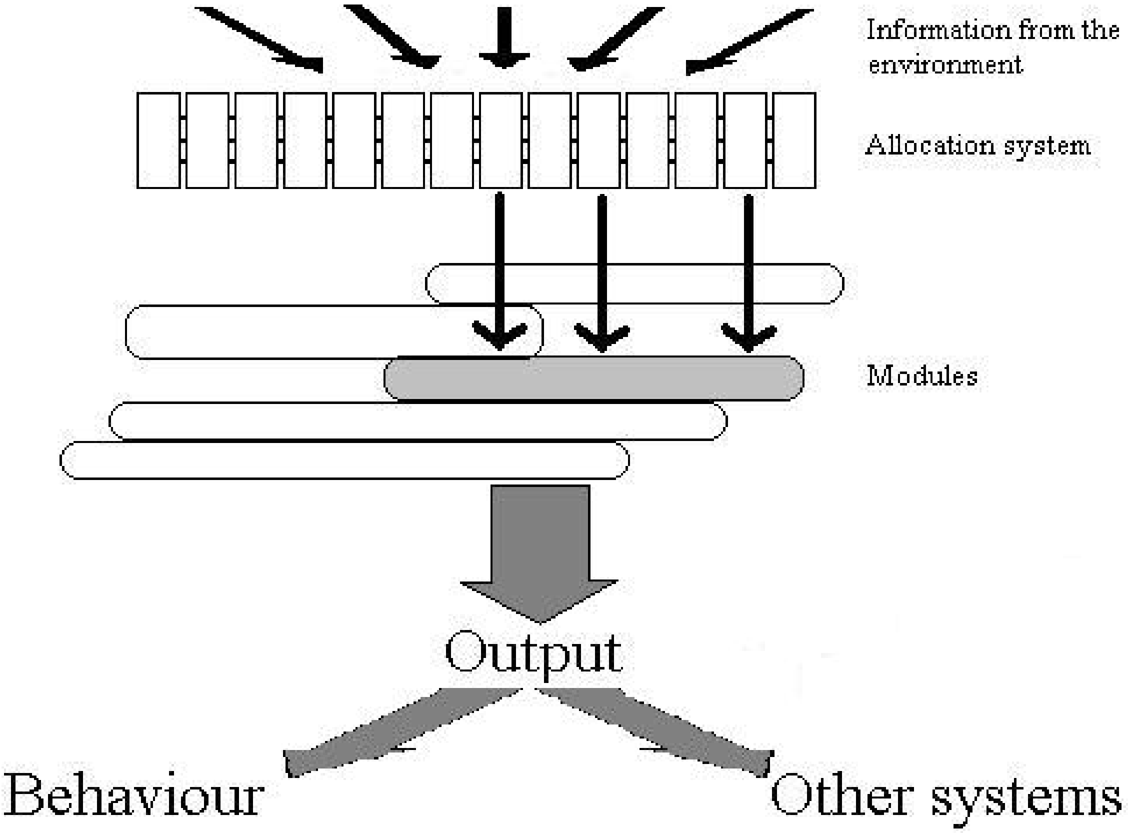

Figure 1.2 Rough sketch of a multimodular mind. Informational cues from the external environment are received by the multiple signal detection devices, operating in parallel and constituting the allocation system (rectangles). A particular combination of signals being detected will invoke a specific modular ability (elongated ovals), thereby fitting the environmental situation into a specific representation. The output of modular activities may take the form of either behaviour or information (signals) sent to other systems or modules.

(1998; Fiddick, Cosmides, & Tooby, 2000) has been able to induce research participants into representing ambiguous social interactions as social exchanges, threats, or precautions, demonstrating dissociations of these categories. Similarly, Brase & Miller (under review) found that a sexual harassment statement framed with a punitive consequence ("If you spend the night with me, then I won't eliminate your position.") was judged by the majority of people (86 per cent) to be a threat. A sexual harassment statement in the same context but framed with a rewarding consequence ("If you spend the night with me, then I will give you a promotion.") was judged by the majority of people (69 per cent) to be a social exchange.

How information is represented has also been a major topic of evolutionarily based research in the area of judgments under uncertainty. Although curious examples of frequency formats leading to facilitation in statistical judgments have been around for some time (Tversky & Kahneman, 1983), evolutionary explanations have helped to explain the reason and nature of this effect (Cosmides & Tooby, 1996; Gigerenzer, 1991b). Specifically, it has been proposed that the human mind is designed by the evolutionary history of our species to be sensitive to the frequencies of events, as opposed to statements given in other numerical formats. Furthermore, these results have been taken even further by Brase, Cosmides, & Tooby (1998), who showed that our statistical judgment abilities are not just tuned to frequency formats (as opposed to, for example, single event probabilities), but also tuned to particular ways of parsing (or "individuating") the world. In short, the mind not only represents statistical information in frequencies, it preferentially represents that frequency information in terms of whole object, events, and locations (as opposed to aspects of objects, partial events, or idiosyncratic views of locations).

Samuels, et al. (1999) also discussed the evolutionary views on judgments under uncertainty, leading them to propose the term "allocation" system that is adopted here. They led them to wrestle with an implication of this allocation system: the implied existence of misallocations.

MISALLOCATIONS AND MISREPRESENTATIONS

In terms of how the results of the allocation system are experienced, signal detection incidents of misses or false alarms --in social interactions—can be experienced as misinterpreted situations, social *faux pas*, and embarrassing misunderstandings (the fodder for hundreds of television situation comedy episodes). These same errors, when they occur in statistical judgment situations, have led to questions about the nature of human rationality (or irrationality). When information about a situation is misallocated by person *X*'s allocation system it is then misrepresented in person *X*'s mind. From this it follows that the representation of that situation as held by others is missing in *X*'s mind. The result is that person *X* does not behave appropriately. He commits a social error, or a statistical error, or some other type of error.

Samuels, et al. (1999) talk about "misallocation" as a way to explain errors and apparent irrationality in reasoning, however, their insightful analysis is only a partial accounting of misallocation possibilities. Just as there are a large number of possible ways that a computer (or a car, or human organs, or any complex system) can manifest systematic errors, there are a number of ways that misallocation errors can come about. The following sections outline several ways in which misallocations, and subsequent misrepresentations, can occur.

Initial base-rate biases

Information will be allocated more frequently to representations that correspond to higher frequency situations (Note that here, as in subsequent sections, the term "bias" is being used in relation to signal detection theory and does not necessarily imply irrationality). Indeed, certain representations appear to be more likely to be evoked than others, and these inequalities of representations can be general to all people, or specific to certain contexts (such as particular cultures). General base-rate biases can exist simply because the size and spread of distributions for various situation types are different. If events that evoke representation A are significantly more common than events that evoke representation B, then all other things being equal there should be a bias towards selecting representation A in unclear situations (for example, there should be a bias to represent a small object flying overhead as a "bird" rather than a "bat", a bias to represent a doctor as male (the basis for a well known riddle), and a bias to represent a couple as a pair of heterosexuals).

The idea that certain representations are more easily evoked than others has been recognized in social psychology for quite a while, under the label of "chronically accessible schemas" (Bargh & Pratto, 1986; Higgins, King, & Mavin, 1982). A chronically accessible schema is a particular way of representing events that is used by a person in a habitual manner, such as when a person represents all social events as being related to race-relations (or politics, or sex, or ethnicity, or any other specific frame of reference). These schemata can be based on a combination of prior predispositions, objecttively observed base-rates, and prior subjective representations of events (e.g., within a subjective Bayesian model).

The availability heuristic proposed by Tversky & Kahneman (1973) can also be understood as being a result of this base-rate bias. The availability heuristic is the use of one's phenomenal experience of how easy it is to recall a type of event occurring as a source of information for making probability judgments about that event. Systematic errors occur due to the availability heuristic, because subjective experiences of an event occurring do not always accurately reflect the actual prevalence of those events (for example, subjective experience appears to be influenced by exposures via television; O'Guinn & Shrum, 1997). Thus, people tend to overestimate the probability of plane crashes, terrorist acts, and school shootings, while underestimating the number of heart failures, automobile accidents, and broken collarbones. If, however, one takes into account the idea that the human mind is not designed to differentiate between electronic reports of exotic events in far-off locations and interpersonal communication about local events, then the availability heuristic is really a product of media technology corrupting an otherwise well operating cognitive module. Specifically, the availability heuristic shows errors because initial base-rate settings are led to deviate from the true state of the world.

Context biases

Situational information can bias the allocation system towards one representation, which can in some cases cause misrepresentations of specific aspects or particular incidents. For example, walking down a dark street in a seedy part of town provides contextual cues that could lead to a criterion bias in detecting signals for a threat representation of others' actions (e.g., if someone crosses the street to help you and you initially represent them as coming to attack you). A merchant in a store may have a bias towards interpreting situations as being social exchanges; a person in a singles bar may have a bias towards interpreting any social contact as a sexual overture. These context-sensitive criterion biases are overlayed on general base-rate biases.

There have been some interesting findings in social psychology that fit within the idea of situational information being used as cues that create context biases. One of these findings is the *weapons effect*, in which the mere presence of a weapon (usually a gun or a knife) leads participants to be more aggressive (Berkowitz & LePage, 1967; Berkowitz, 1993). Although there is no clear reason for people to become more aggressive because a weapon is present (and, indeed, an argument can be made for the reverse), there seems to be a just such an effect. The weapons effect can be understood as a case of the weapon providing a context bias. A weapon, by definition, is a tool for aggressive purposes, and the presence of such a tool therefore constitutes an environmental cue that aggressive behaviour is possible or anticipated. Subsequent aggressive behaviour could result from either counter-aggression or defensive aggression. A effect similar to the weapons effect has recently been documented: Payne (2001) found that priming white participants with images of black faces led to faster identification of guns and higher false-positive rates in identifying objects as guns.

A second set of relevant findings in social psychology is the general phenomenon of labelling effects. By telling someone that they have –or that others have–a particular characteristic (e.g., helpfulness, social deviance, discriminating taste), it is possible to increase the associated behaviours or the associated reactions to those characteristics (Cialdini, 2001). In these situations, the information given to the target person is specifically designed by the experimenter to create a context bias. Notably, these labelling effects are also notoriously short-lived; as soon as the target person is in a new situation the labelling effect tends to dissipate.

More recently, Cosmides, Tooby, Montaldi, and Thrall (1999) reported that the personalities of others was used as a context variable in reasoning about a social situation. Their participants were told that they would interact with one of two (fictional) persons, and they were given a character-defining story involving that person. The social interaction that participants engaged in was a social exchange setting, and the participants' task was to search the prior actions of the fictional person for any indications of "cheating" on social exchanges. For the fictional person who was characterised as exceptionally honest, her prior activities (where cheating could have occurred) were typically not scrutinised at all, whereas the prior actions of the not-as-honest fictional person was searched through in the same manner as in similar research tasks with no personality information.

Personality biases

People may have personality differences that thereby cause them to differ in their likelihood of forming various representations of situations. Some people are more fearful than others, some people are more attentive and concerned about precautions, and some people see a wider array of situations as involving sexual innuendo. Whereas it is not a radical step to claim that personality differences in extroversion, neuroticism or social deviance can have pervasive implications in terms of manifested behaviours, it may be quite interesting to consider the idea that these personality based differences in behaviour can be understood as driven by biases in allocations to various situational representations. Thompson (1978) actually documented a relationship between individual difference variables (personality, age, and sex) and how people perceive social cues, using a signal detection theory framework (specifically, multiple linear regression analyses using the demographic variables was able to predict both sensitivity and response bias).

It is possible that at the extremes of these individual differences lie insights into some of the notoriously difficult to diagnose mental disorders. Paranoid Personality Disorder (a pervasive and unwarranted tendency to interpret the actions of others as deliberately demeaning, or threatening) can be well described as a severe criterion bias towards detecting threats. Obsessive-compulsive personality disorder (preoccupation with orderliness, perfectionsm and mental and interpersonal control, at expense of flexibility, openness, and efficiency) can be described as a severe bias towards detecting (and applying) precautions.

With some latitude, I will consider sex differences under personality. Sex differences have been a major topic in evolutionary psychology (Buss, 1999), probably because relevant predictions derived from evolutionary theory are clear, robust, and of some natural interest. In line with general evolutionary predictions and findings that men are more interested in sexual opportunities than women, Abbey (1982; see also Abbey, Ross, McDuffie & McAuslan, 1996) found a difference between men and women in the representation of social interactions between the sexes. Both men and women in their study were shown the same videotape of a man and woman interacting, but men were significantly more likely to perceive that the woman was sexually intersted in the man (i.e., the men were more likely to form a representation of the social interaction as involving sexual overtures).

Formulation errors

Samuels, et al (1999) coined the term "formulation errors" in reference to the particular misallocation phenomenon they noted: failures of certain forms of environmental inputs to register as the normatively appropriate representaions. In particular, their discussion focussed on statistical formats and the fact that frequency information seems to more effectively tap into intuitive statstical competencies than do single event probabilities. The formulation error is an error in that both frequency counts and probabilities convey information that is largely interchangeable within the context of many statistical tasks, yet the mind seems to be competent and rational only when the information is formulated in particular ways (Brase et al., 1998). Another example might be useful here: our visual system has a wonderful ability to maintain colour constancy under varying conditions of natural lighting (our perceptions of colours remain fairly constant regardless of if it is dawn, full light, dusk, sunset, etc.; Jameson & Hurvich, 1989; Lucassen & Walvaren, 1996). It is possible to perceive breakdowns of this colour constancy ability, however, by looking at colours under artificial lighting conditions (such as sodium vapour lamps). This phenomenon can similarly be described as a formulation error of the information fed into the visual system; this system was not designed over evolutionary history to be able to do things like maintain colour constancy under sodium vapour lamp illumination. Thus, there is an analogous set of implications: the visual system is in some ways very poorly designed (for some aspects of the modern visual world) and the stat-istical decision making system is in some ways very poorly designed (for some aspects of modern probability expression). The key in both these examples is that the visual or statistical incompetence derives from the fact that the relevant system is being called upon to perform an evolutionarily novel task.

Similarly, some other instances of apparent incompetence and irrationality (e.g., estimating the frequency of ----ing words versus the frequency of -----n- words; Tversky & Kahneman, 1973) can be understood as formulation errors (in this case, the fact that the human mind does not code the frequencies of *everything*, and some access to the frequency of linguistic morphemes such as "-ing" may be possible, whereas access to the frequency of "'n' in the sixth position of the word" is almost certainly not a part of our language abilities). Contrary to the implication that some readings of Samuels et al (1999) might indicate, a multi-modular mind is by no means perfectly competent (nor, obviously is it perfect in performance) in the sense of being able to do anything in the world. Instead, it is satisfactorily competent in those things that it was designed to do.

Instigated errors

There is also the possibility of manipulation by the person who sends a signal out for others to receive. From this perspective, the signal sender may systematically alter his or her output in order to promote certain representations in the minds of others, and thus more effectively achieve their own desired outcome (Dawkins & Krebs, 1978). For example, a person may internally represent a situation as a threat ("If anyone touches my car I will beat them up"), but attempt to send out a message that is more palatable to others and more likely to achieve his desired result (e.g., as a precaution: "If you touch my car, I can't be responsible for what happens to you" or a social exchange: "If you don't touch my car, then I won't have to beat you up"). Another example might be someone who injects sexual overtures into interactions to get preferential treatment that would otherwise not be forthcoming (see, for example, Sarah Hrdy's work on female evolved strategies for resource extraction; Hrdy, 1997, 1999).

Intentional manipulation/suspension of allocation

Finally, there are many indications that the allocation system is not entirely transparent or beyond conscious control. The meta-awareness, and even willful control, of an allocation system can be argued as an explanation for how metaphors are both created and understood. A metaphor, on this account, is a way of understanding some aspect of the world that does not fit easily into some already established representational set by purposefully allocating it into some representation that is clearly not correct but useful in that the allocation into a representational framework allows further understanding of this aspect of the world. Along these lines, Gigerenzer (1991b) has proposed the idea of "Tools to Theories" metaphors; that the statistical techniques that psychologists use for research analysis purposes can be traced as the origin points for several theoretical accounts of mental processes (including, in the present case, Signal Detection Theory). Successful and popular metaphors are those that prove very useful in promoting a further understanding of the target phenomenon. This understanding of the world that metaphors can bring people, however, in no way guarantees that their understanding will be correct. Gentner & Gentner (1983), for example, found that the metaphors students used for understanding the nature of electricity (i.e., either electricity as running water or electricity as rats running through tubes) led to misrepresentations of the true nature of electricity that were consistent with the particular metaphor used.

Another phenomenon that can be understood in terms of the functioning of the allocation system is the development of "abstract" representations of information. For example, higher mathematics, formal logic, and probability theory are all abstract systems of representation that do not appear to be naturally or intuitively present in the human mind (i.e., they require extensive training to acquire). The successful acquisition of these abstract representational systems appears to be a process of more-or-less willful suspension of the usual allocation system processes. If one looks at how these abstract concepts are learned, it is possible to discern the development of this suspension process. Formal logic, for instance, is typically taught by beginning with statements that happen to be allocated and represented in such a way that the logically correct implications are usually drawn, but then the rules of formal logic are set out for how that implication should be derived. By successive modelling, students learn to consciously apply the formal logic rules instead of using the initial representational-based inferences. Some of the classically successful aids in learning formal logic are also based on this idea (e.g. Venn diagrams take the abstract formal logic and map it by metaphor onto a physical representation of space). Finally, once the abstract representation has been successfully acquired, it is customarily necessary to invent some form of notation to communicate these abstract representations without falling back into more mentally convenient representational sets (e.g., $X \in Y \geq Z$).

THE STRUCTURE OF THE ALLOCATION SYSTEM

An implication of using signal detection processes for shunting situations into their correct mental representations is that a multimodular mind must therefore have multiple signal detection processes in place. Specifically, assume for the sake of argument that each signal detection process is designed to exactly categorise a situation or leave it uncategorized. In this case, there would be as many signal detection processes as there are modules. It is almost certain that this is not the true state of the allocation system; each representation is hypothesised to be evoked by multiple, converging signals, and there are also several ways of reducing the number of signal detection processes needed. Given, say, 10 signal detection processes, there are 2^{10} (1,024) possible combinations of signals. It may also be the case that the correct rejection and miss outcomes of some signal detection processes lead to "default" categorisations. Regardless of these basic considerations, however, a lot of signal detection processes are required.

Having many signal detection processes is arguably not such a bad thing. Presumably these processes are operating in parallel with each other (see earlier discussion on multiple cues leading to allocation decisions), and more signal detection processes can yield a more reliable, accurate, and rapid government of modules. Furthermore, having a large number of signal detection processes involved leads to a robust design. The relative simplicity and redundancy of the signal detection process ensures that if a small number of the signal detection processes become corrupted (e.g., by stroke or head trauma), it is quite likely that some of the remaining signal detection processes can compensate for the loss. In other words, it is a somewhat fail-safe system in that the removal of a signal detection element (or even several) is not fatal for whole system. Another benefit of a large collection of relatively similar signal detection processes is that it provides a blueprint for the construction of the mechanisms during developmental (see Keil, 1981, 1990, 1991 regarding the ontological repetition of modules, and Dawkins, 1987 regarding simple rules for the development of body plans). The ability to construct a large component of the mental architecture from relatively few genetic directions in turn provides for great efficiency in genetic coding (e.g. pleitropic DNA sequences). Finally, this in turn helps resolve a periodically emerging criticism regarding the relationship between genetic coding and the brain: how can only 30-50000 human genes (many of which must be committed to other parts of the body) provide a multimodularly detailed blueprint for billions of neurons in the brain? While many people have answered this criticism in general terms – that genes do not code for physical aspects in a one-to-one manner– the elaboration here has an added benefit of providing an explicit route by which a few genes can produce many neural structures.

There is one area of ambiguity regarding the structure of the allocation system and a mulitmodular mind that I will not go into much detail in trying to resolve, and that is the exact definition of a "module." There are a number of different definitions of a module, as well as a number of alternative names for what I have referred to here as modules (Darwinian algorithms, cognitive adaptations, instincts, mental organs; see Fodor, 1983, 2000; Tooby & Cosmides, 1992). Whole books have been written regarding how to best characterize human psychological adaptations (Bock & Cardew, 1997). The primary difficulty thus far appears to be that there is no one, single level at which all "modules" occur. Consider, for instance, vision. One might say that we have a module for vision, but it can also be argued that we have a whole array of modules for colour perception, motion detection, colour constancy, line orientation, face recognition, and so on. Going the other direction, our ability to see is a fundamental subcomponent of other abilities that have themselves been called modules (e.g., evaluating physical attractiveness or inferring mental states from the actions of others). So is "vision" one module, a whole collection of modules, or a fraction of some other module? Until we develop a terminology system that clearly and validly distinguishes among the different levels of "lower-order" to "higher-order" cognitive abilities, we appear to be stuck with general terms that encompass all these various kinds of modules. So for example, the ability to engage in social exchanges, something that itself has been called an adaptation or a module, is actually an ability that invokes multiple "modules": a cheater detection module, a cost-evaluation module, a benefit-evaluation module, a theory-of-minds module, and probably others (Cosmides & Tooby, 1992). Atkinson and Wheeler spend another whole chapter on this issue (see Chapter 3), and the present chapter will not delve any further into this issue. This chapter is actually only indirectly about modules, and more precisely is about the allocation of representations for information so that it can be directed to modules. Perhaps a better understanding of the allocation system can actually aid in our developing understanding of how to properly conceptualize modules.

Although I have taken an evolutionary, multimodular approach to the structure of the human mind, the task of representing incoming information as belonging to various categories so that it can be routed to appropriate cognitive processes is a task that nearly any conception of the human mind must properly address. If the choices for representations were not social exchanges, threats, hazards, and sexual opportunities, they could be induction and deduction, or deontic logic and descriptive logic, or information gain and expected utility. The allocation problem exists regardless of whether or not one's view of the mind ignores evolutionary considerations (e.g. the pragmatic reasoning schemas theory [Cheng & Holyoak, 1985, 1989] requires some allocation system), and the problem exists regardless of whether one adheres to the "massive" modularity thesis or to a much less aggressive view of modularity. The relative merits and validity of these different views are tremendously important issues, as they relate to the fundamental nature and structure of the human mind, but as such they are beyond this small chapter.

SETTING PARAMETERS IN SOCIAL SITUATIONS

Signal detection of objects in the physical world usually involves a mix of constant and variable (or "open") parameters. For example, detecting the letter "R" will involve about the same, fairly constant pattern of lines, curves, and spaces no matter where one is, who is around, or what time of day it is. The ease with which an "R" is detected does, however, change depending on whether the letter is embedded within a word (e.g., "WORD") or a nonword (e.g., “WYRZ”; this is known as the word superiority effect, see Reicher, 1969). Signal detection of social interaction types similarly involve both constant and variable parameters. Certain properties of a social exchange situation, for example, are constant across time, place, and person: items are intercontingently exchanged such that both parties experience a net benefit. A social exchange with one particular person at one point in time, however, is not entirely the same as a social exchange with a different person at a different time (Cosmides et al. 1999). One of the keys to effective representations of social interactions is an ability to facultatively adjust the signal detection parameters depending on the individuals with whom you are interacting. In other words, a key to effective social interactions is a memory for individuals. Our memory for individuals is, in fact, quite good (Farah, Wilson, Drain, & Tanaka, 1998), and this is a necessary prerequisite. The additional step taken here is that those memories for individuals are fed into the signal detection processes (e.g. in the modelling of the utilities of the possible outcomes), such that the signal detection parameters are adjusted to be reflective of that other person’s traits. Specifically, it should be possible within the allocation system to adaptively adjust the criterion (cutting score) based on the particulars of a situation, to reflect the ambient costs and benefits of the possible outcomes of that situation. (Other aspects of the allocation system, such as the category distributions, may also be adjustable, but probably in an ontogenetic manner.)

One possible problem in this proposal is that we encounter hundreds of thousands of people in our daily lives. It would be impractical and computationally impossible to maintain signal detection parameters for every different individual. And, of course, we don’t. One of the characteristics of the social world that the human mind constructs is that it is filled not just with people but with various categories of people. People are categorised according to their gender, their ethnicity, their race, their views, and other dimensions that are perceived to be relevant. The characteristics associated with each of these categories of people are stereotypes, and the use of stereotypes in the everyday world has serious implications in terms of prejudice and discrimination. These stereotypes, however, which could in this context be considered as template models of mental states for categories of individuals, also enable facultative adjustments to the process of categorising social interactions into different representations. Recent research (Levin, 2000) has actually shown that people categorise new individuals (of a different race) as members of a racial group before they are categorised as individuals. Other research (Haselton & Buss, 2000) has explored the apparently significant extent to which people infer the wants, beliefs, and desires of others based just on the other person’s sex. An open question is the extent to which it is possible to react to other individuals without tapping into some form of social categorisation for that individual (i.e., whether or not there is a completely generic template model for considering individuals with no known gender, race, or other categorizable features).

OTHER IMPLICATIONS

There are some interesting implications of this allocation and representation system. The first two implications noted here are relevant for proponents of cultural relativism. First the bad news: this system broadly presumes a set of universal representational categories. It may be the case that certain specific representational categories will not exist in certain specific cultures (for various historical, social, or other reasons), but the system demands that there be a full set of categories from which the existing representational categories derive. In other words, the representational system is an element of human nature. So what is the good news? This system also provides a way for wide and superficially "fundamental" differences across cultures. The key is that there may be tremendous latitude in when and/or how the different representations are elicited. For instance, there may be a universal representation of a social exchange as the exchange of items that are differentially valued such that both parties realise a net gain, but the key element of what things are "valuable" and what things are not is apparently very open to social learning.

Another implication of this system is for the construction of human memory. It has been documented repeatedly over the years that human memory is far from veridical. We not only forget things that happened, but we remember things that did not happen (Bartlett, 1932/1967, Loftus, 1975, 1980, Roediger & McDermot, 2000). A vexing element of this research area is that people presumably see situations in a relatively veridical manner (i.e. without gross omissions and hallucinations), yet memories retrieved just a few hours after an event can be distorted. It almost appears that the way in which memories are stored even for brief periods is somehow defective. Consider, though, what happens to memories in the context of our allocation system. Once an event has been allocated a certain representation (for instance, as a threat), any deficient elements for that type of representation are sought out (are there weapons, menacing movements, escape routes?). Instead of simply perceiving the situation as one of billions of scenes from our lifetime, it is perceived representationally as a particular type of situation. Furthermore, different situations are assigned different representations, leading to both additions and omissions in memory that are systematic by representational type but almost chaotic if viewed in temporal order.

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