

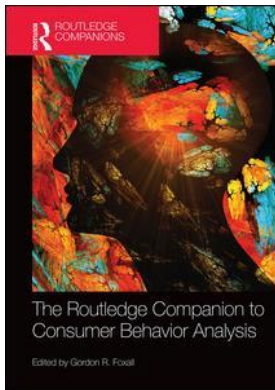
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Decision-“making” or how decisions emerge in a cyclic automatic process, parsimoniously modulated by reason

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Decision-“making” or how decisions emerge in a cyclic automatic process, parsimoniously modulated by reason

José Paulo Marques dos Santos and Luiz Moutinho

Approach

Sometimes we ask our students whether they would prefer a difficult question or an easy one. The first time that happens, the answers are unanimous: an easy one. The easy question is: given three brand categories, let's say favorite, indifferent, and unknown, why do decisions about which is preferred take significantly different times? This was an easy question to put, but the paradox is usually that easy questions have long and complex answers, if they have answers at all.

The tentative theory described in this chapter was sparked by a collateral observation in a consumer neuroscience experiment. We realized that favorite brands were statistically and significantly faster rated than indifferent or unknown brands (Santos et al., 2011). Furthermore, indifferent and unknown brands statistically and significantly belong to the same distribution. The graph in Figure 20.1 depicts these observations.

The study encompassed fictitious logos that were designed specifically for the experiment, therefore do not exist in reality, and hence were unknown to the subjects at the time of the experiment. The distinction between favorite and indifferent brands was made by means of the Pleasure–Arousal dimensions of the Pleasure, Arousal, Dominance (PAD) scale (Russell & Mehrabian, 1977).

Problems arise when we try to get an explanation for the phenomenon. The given view is that decision-making is a straightforward process, a transforming device that is fed with stimuli and which yields outputs (actions) in the end. This model largely overlaps with the computer metaphor which is the pinnacle of reason. We wonder if such a model is not a reflection of the (reasoning) method established in scientific research, i.e. are scientists contaminating their analyses with the process that they use in their studies and which precludes other possible alternatives?

In this chapter, first, we will describe the given view and how the construct decision-making contains a bias which inherently calls for the participation of reasoning. After that, we will introduce a model that does not include reliance on systematic reasoning, although it still may yield purposeful decisions and actions. This model inheres in the S–R (stimulus–response) paradigm, although it encompasses the regulatory intervention of reason, rendering it in an S–R × S–O–R hybrid. There follows an explanation of the experimental data which will be presented,

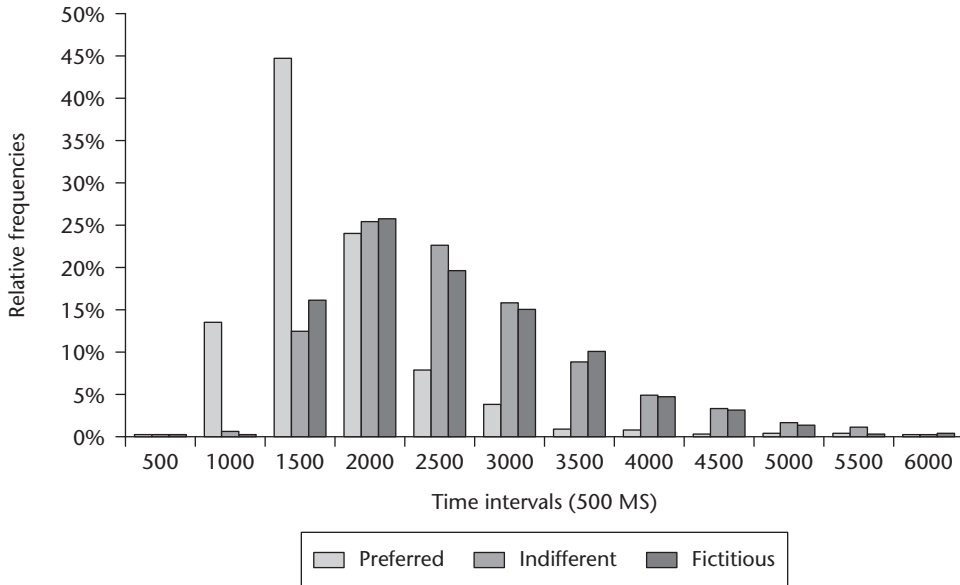


Figure 20.1 Relative frequency of response times when subjects were asked to assess assorted brand logos as preferred, indifferent, and unknown

highlighting the role of shortcuts within the decision process. Finally, we merge this model with the Behavioral Perspective Model (BPM) (Foxall, 1990/2004) and will conclude that they largely share elements and connections. Throughout this chapter, neuroscience will be a regular presence. We just do not believe in psychology apart from biology.

The given view: abridged behavioral models

Behaviorism, cognitivism, and the dual-process system

We begin by noting that most theories in psychology and in consumption studies were not constrained by physiological factors in their construction. In this respect, everything was possible then. Biological functions were not considered to have an active influence in behaviorally pertinent decisions. Rather, it seems that neurons, dendrites, axons, astrocytes, glia, etc. have a passive role where psychological processes are concerned. In economy and management, a theory or a model of international trading which did not consider the influence of the ease or difficulty of use of communication channels for commodities and services would not be accepted. How would a French wine company trade their bottles worldwide without considering the available communication structure: roads, air and maritime routes, and, nowadays, the digital highway? Recent technical improvements have enabled the study of the functioning human brain non-invasively and with sufficient spatial definition, using, for example, positron emission tomography (PET) or functional magnetic resonance imaging (fMRI). In the last five years more than 150,000 articles have been published using these techniques (source: PubMed.gov). Hence, the way opens to construct physiologically inspired models that illuminate psychological processes.

This does not mean, however, that theorists were blind to this aspect, but the fact is that, because of ethical concerns and limited availability of techniques, traditionally the brain has been

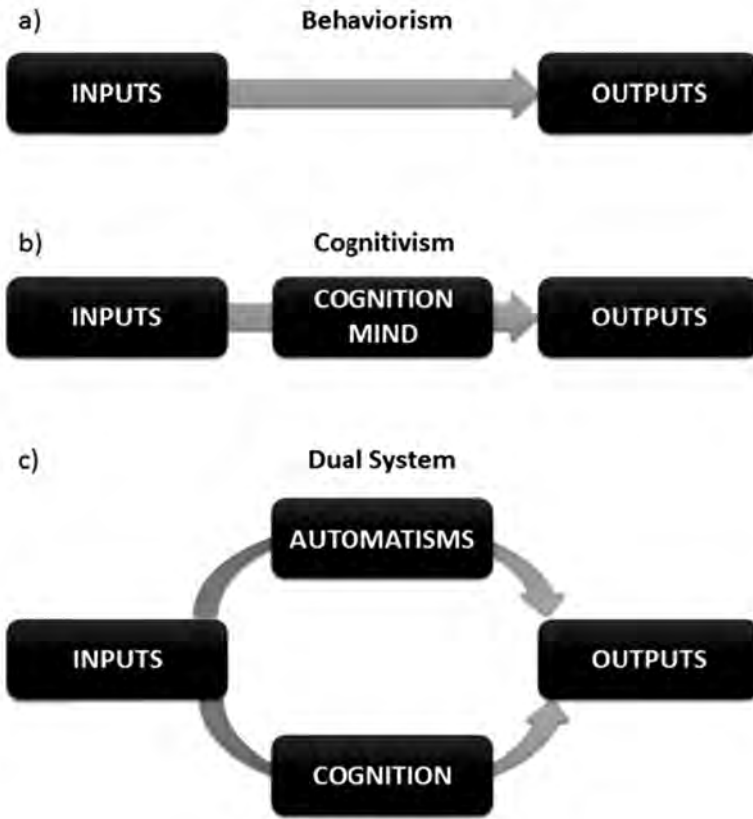


Figure 20.2 Parsimonious models of psychological processes: a) in behaviorism there are direct connections between inputs and outputs; b) in cognitivism the mediation of cognition (or a mind) is introduced between inputs and outputs; c) the dual-process system is the sum of the two previous systems with automatism and cognition competing for the output

considered a black box, placed between inputs and outputs. In summary, three abridged models have been considered, which are depicted in Figure 20.2.

Mainly derived from animal studies, some admit simple and direct connections between inputs and outputs, as behaviorists do. In this case, the brain is metaphorically a set of relays which establish temporary linkages between incoming stimuli and behavioral responses, i.e. when a certain input takes place the respective output is automatically prompted (see panel (a)) in Figure 20.2). There are stimuli (S), responses (R), and their associations, which are known as S–R models. The linkages may be acquired by heritage (e.g. genetic), or learning. For example, this is the approach taken in classical conditioning, where a behavioral response is paired with a new stimulus and is automatically performed thereafter. The critical point here is the formation of the association (linkage). This is also the case in operant conditioning (or instrumental learning), where the result of an experience may reinforce or extinguish the behavior. An important advantage of the S–R model is its simplicity, which allows its implementation in parsimonious systems, for instance in the rudimentary neural system of jellyfish, which are animals lacking cephalization (they just have a nerve net).

Others, like cognitivists, deny direct linkages and introduce the participation of some sort of intelligence, the “organism”, between stimulus and response, allowing processes like reasoning (see panel (b)) in Figure 20.2). This model is ultimately founded on Plato and Cartesian dualism and the traditional separation between body and mind, or spirit, or soul, or whatever non-biological entity it is that non-automatically transforms inputs into outputs (an extensive and deep neuro-based argument against dualism can be found in Damásio, 1994). Robert S. Woodworth created the expression S–O–R, where O represents the organism. The organism is an entity that has its own inner states, which interfere in the decision process. These states may integrate some components, like goals or values, which make the decision process much more complex and not solely stimulus-dependent. However, generally speaking, such components do not have a place in the brain and happen ethereally elsewhere. The number of components of the “organism” is open ended and their sequence and articulation may also be freely arranged. Of course S–O–R models cannot be implemented in simple neural systems. They require high processing abilities and have not been applied to species other than *Homo sapiens*. Nevertheless, this matter still is subject to dispute because some of the components, usually treated as exclusive to humans, are considered to exist in non-humans. For instance, cultures (Whiten & van Schaik, 2007) or semiotic ability (Savage-Rumbaugh et al., 1986), despite some expectations, were already matters of controversy, like the putative existence of Theory of Mind in non-human primates (Call & Tomasello, 2008). In sum, S–O–R models may exist in thinking agents.

Marketers have known for a long time that S–R models work very well, for example transferring status from celebrities by association with products and services (endorsement through classical conditioning), and S–O–R models work too. There is neural evidence for that. In an fMRI experiment, which is already a milestone in behavioral neuroscience, McClure et al. (2004) demonstrated that preference for sodas is a process determined more by cultural aspects, which are O, than by sensorial information, which is S. Specifically, when brand information was provided to subjects, they used a decision process that considered previously acquired brand meanings, a different situation from the one where brand information was not available and subjects therefore had to base their decisions just on sensory information. The two situations had distinct neural supports, and it is remarkable that cultural information overrode the information coming from stimuli. Hence, human behavior is not just a matter of exclusivity of S–R or of S–O–R, but, at least, a matter of S–R and S–O–R in coexistence.

To incorporate both models, it has been considered that the brain combines two distinct, but competing, decision processes (Evans, 2008): one grounded on intuition and automatism, and the other relying on deliberative reasoning and pondering, which are summarized in panel c) in Figure 20.2.

This proposal largely corresponds to the work of Daniel Kahneman (Nobel laureate in 2002) and Amos Tversky, who postulated the System 1 and System 2 theory of human behavior (Kahneman, 2011). System 1 is fast to respond because it relies on automatic reactions learned during past experiences; however, it is rigid, because the behavioral responses were learned for a specific context, which may not be exactly reproduced; therefore, biases may result, reflecting the organism’s response to the most similar situation, resulting in less-than-ideal behavior. System 1 is commonly connected to emotional responses and non-conscious decisions. System 2 is slow because it relies on flexible procedures, it is rule-governed, but requires time to perform calculations, and, sometimes, the optimization of the range of possible solutions; because of computational demands, it requires suitable hardware to implement it and can absorb all the faculties (e.g. attention); System 2 is commonly connected to reasoning and conscious decision-making.

Darlow and Sloman (2010) theorize about the two systems of reasoning and summarize thus (adapted from Table 1, p. 383):

- Intuition: product is conscious but process is not, automatic, driven by similarity and association, fast and parallel, unrelated to general intelligence and working memory capacity;
- Deliberation: agent is aware of both product and process, effortful and volitional, driven by more structured relational knowledge, slower and sequential, related to general intelligence and working memory capacity.

The parallels between System 1 and Intuition and between System 2 and Deliberation are obvious. Darlow and Sloman (2010) find different neural supports for each system, suggesting that the brain has more than one decision-making scheme, which means that System 1/Intuition, represented by S–R, and System 2/Deliberation, represented by S–O–R, have separated neural supports. Further, Darlow and Sloman (2010) suggest that the two systems coexist, competing to make the decision; i.e. assuming that both receive the inputs simultaneously (e.g. sensorial information), they start working in parallel on the solution(s). Because System 1/Intuition is faster, it is likely to reach a decision earlier than System 2/Deliberation, although it is not certain that it would yield the best response. When System 2/Deliberation achieves a solution, it may be different, which can lead to regret. In this case, S–R and S–O–R process in parallel, in different neural supports, in different time frames, and probably with different results. One can choose to accept System 1/Intuition, or wait for System 2/Deliberation, or even make System 2/Deliberation suppress the System 1/Intuition process (Darlow & Sloman, 2010). For example, it would not be advisable to buy a house, which is a big investment, relying only on System 1/Intuition. Some modulation of System 2/Deliberation may exist to prevent such a *faux pas*.

The brain as a generating organ

The structure of any of these models resembles a pipeline, with more or fewer branches. Woodworth (1921) states that “Stimuli are necessary to arouse the activity of the organism. Without any stimulus whatever, it seems likely that the animal would relapse into total inactivity” (p. 42). At least for humans, this condition may be sufficient, but not necessary. Humans are not constrained to react to stimuli alone. However, Woodworth (1921) continues, “It should be said, however, that stimuli, such as that of hunger, may arise within the organism itself. The stimulus may be external or internal, but some stimulus is necessary in order to release the stored energy” (p. 42). It seems, then, that the problem is with the definition of stimulus. Usually, stimuli are external to the body, but Woodworth used it broadly, encompassing external and internal origins.

But where, when, and how does the stimulus “hunger” prompt? (In contrast to the questions that our students used to choose, this is a difficult one.) Probably there are no answers at all to this difficult question, at least if one assumes boundaries between the brain and the body, or between parts of the brain . . . or between mind and brain, or between psychology and biology . . . nevertheless, the idea that something may arise inside the organism to prompt reactions has to be retained.

Woodworth (1921) also adds that “The organism, animal or human, fully obeys the law of conservation of energy” (p. 41). The idea behind the law of conservation of energy could also be extended to better understand how the brain works. When chemical engineers calculate energy balances of a chemical reactor, they consider the following generic equation, which encompasses the principles of energy conservation (first law of thermodynamics):

$$\text{Accumulation} = \text{Inputs} - \text{Outputs} + \text{Work} + \text{Heat}$$

The interesting term here is Heat. It is not just about what enters and leaves the system; it is also about what the system can generate (create) or consume (make disappear). If one adds gaseous hydrogen and oxygen and a small amount of initial energy, it will result in liquid water and much more energy. Something new is generated. If that can happen in a chemical reactor, why not in a brain? Why shall brains be confined to process inputs (sensorial information from the environment) into outputs (motor interventions over the environment)? Where does creativity take place, i.e. produce something new from . . . the inner system?

This aspect was already stressed by Raichle (2009): the brain has intrinsic activity; it is not just about processing inputs into outputs; there is activity in the resting brain. The Default Mode Network (DMN), one of the Resting State Networks (RSNs), is a brain-wide network that is active when the brain supposedly is at rest, i.e. not processing inputs into outputs (Raichle et al., 2001). The DMN deactivates when the subject passes from a resting state into performing a task, and the task involves some conscious operation like reading, calculating, assessing, recognizing, etc., i.e. whether processing or at rest, the brain is always active, independently of whether the senses are introducing external information. Activity in the DMN supports the claim that the brain does not need external stimuli to generate and yield outputs. The brain can generate information.

Reason pervasiveness in the decision pipeline . . . and some criticism

Psychologists have proposed several behavioral models, summarized in the previous sections, although these models need to be integrated with biology and updated with regard to recent advances in neuroscience. However, economic and consumption studies largely have been building up theories stressing the rational decision-making scheme, emphasizing the cognitivist perspective of human behavior (see panel (b) in Figure 20.2), disregarding the remaining models. One immediate reason is the facility to conduct controlled experiments, simplifying the huge amounts of variables that settings introduce, especially in social contexts where individuals mutually influence one another. Economic and consumption studies are social disciplines, though.

In this framework, brain function has been interpreted much like computing machines, showing the decision-making process as a pipeline: first, variables declaration; second, inputs; third, processing following an established algorithm; and finally, outputs are yielded. This approach is not recent. It is the same considered by William James by the end of the 19th century. Østergaard and Jantzen (2002) identify and characterize this perspective on how consumers should be understood. They named it “Consumer Behavior” and, historically, it became the major perspective in the late 1960s. The consumer is metaphorically a computer, and the scientific foundation of this perspective is cognitive psychology. Data is mainly gathered using questionnaires because the assumption is that the respondent (consumer) behaves rationally, i.e. processes information like an electronic device. With more or less elaborated statistical analysis, much of the market research that is done still adopts this perspective.

In economic and consumption studies, this hypothetical consumer, considered to behave, mostly, as a rational being, who is in possession of calculus abilities sufficient to process huge amounts of data and do extensive optimization, maximizing expected utility (self-interest), without time restrictions, was named the *Homo economicus*. This perspective is flawed, however. Calculative abilities are limited in humans, rarely is all the necessary data available, individuals make sacrifices in the group interest, and time is a scarce asset, especially in postmodern contexts where fragmentation impedes deliberation, pondering, reflection, and all time-exigent processes (for a characterization of postmodernity, pertinent to marketing, see Firat and Venkatesh, 1993). Nevertheless, the rational pipeline still pervades economic and consumption studies.

Even so, Lee et al. (2009) sought the rational *Homo economicus* when studying consumer decision-making, but found instead a lack of consistency in the choices, more compatible with the involvement of emotions than with the assumed prevalence of cognition. Furthermore, these authors found that emotionally chosen products were consistently preferred, whereas products cognitively chosen had increased variance, which contradicts the straight computational procedures that *Homo economicus* would use during decision-making. Henrich et al. (2001) also looked for *Homo economicus* in 15 other cultures (in Africa, Asia, Oceania, and South America). In his/her place they found humans that give, reciprocate, and contribute to the mutual interest. Yamagishi et al. (2014) finally found *Homo economicus*. In a sample of 446 subjects, these authors found 31 individuals that exclusively made self-interested decisions. These subjects are characterized by having a high IQ and by using only deliberative decision-making.

At least three Nobel laureates have cast doubt on the rational decision-maker: Herbert A. Simon, awarded in 1978, Reinhard Selten, awarded in 1994, and Daniel Kahneman, awarded in 2002. Herbert A. Simon introduced two pertinent concepts: one is the concept of “bounded rationality”, and the other is “satisficing” (Simon, 1956). Bounded rationality is the situation where the available information is limited and therefore uncertainty exists; the decision-maker has limited computation capabilities, and even so, has to decide. The concept of satisficing is in opposition to optimization. The latter requires assessment in parallel of the range of solutions to choose the one that maximizes the utility function, whereas satisficing is a sequential process that stops the search when a predefined threshold is reached. Satisficing is simple and requires limited computation and time, but optimization requires complex computation and time with increasing variables (and settings used to encompass lots of variables, mainly the social ones). Selten (2002) says:

Modern mainstream economic theory is largely based on an unrealistic picture of human decision making. Economic agents are portrayed as fully rational Bayesian maximizers of subjective utility. This view of economics is not based on empirical evidence, but rather on the simultaneous axiomization of utility and subjective probability. (. . .) However, it is wrong to assume that human beings conform to this ideal.

(p. 13)

One major concern is the lack of empirical support for such a computationally accomplished, fully informed, extremely selfish, and time-rich agent (for extensive criticism of this assumed perspective, see the contributions of Hertwig and Herzog (2009) and Gigerenzer and Gaissmaier (2011)). What can be said of theories built on such weak foundations? Cisek and Kalaska (2010) emphasize the lack of neural support for the information processing framework. The Perception → Cognition → Action framework and the S–O–R model are intrinsically the same. Both are present in linear computing devices, i.e. processing pipelines. However, it has not been possible to find these three stages in the brain. On the contrary, there is data that contradicts this theory. For example, it is assumed that the first stage, Perception, delivers representations “unified (linking diverse information into a common form available to diverse systems) and stable (reflecting the stable nature of the physical world) to be useful for building knowledge and making decisions” (p. 272) in the second stage. In fact, the visual system in the occipital cortex has specialized regions, e.g. for movement, or for colors, contradicting the assumption of unification, and attention is systematically challenging stability. So far, the existence of a cognitive processing unit in the brain has not been claimed. Nevertheless, the literature is full of references to an executive functions center, which, at best, is found dispersed through the frontal lobe. The brain should have a motor center for the execution of action plans. However, because the

data do not support the existence of such a center, the ideomotor theory is proposed, where Perception and Action are represented by the same neural structures (Iacoboni, 2009). In support of this latter theory, the mirror neuron system was discovered in monkeys (Gallese et al., 1996; Rizzolatti et al., 1996). These are neurons that fire either when one is performing an action, or when that action is observed in conspecifics (Rizzolatti & Craighero, 2004). Hence, it seems that brain neurons perform both Perception *and* Action, the two extremes of the pipeline, ruining its linearity. It seems then that the sequential multistage computer-like processing brain does not find support from neuroscience.

Introducing the setting and drafting an alternative

To a large extent (but with exceptions; see the previous section), the models considered so far have misrepresented the environment where human behavior occurs. Such an anthropocentric approach gives the impression that the individual dominates the course of events through the process of deliberation, at the expense of other aspects of the situation. In contrast, ethologists study animal behavior in their settings, considering mutual interaction. The Behavioral Perspective Model (BPM) is a theory of consumer behavior that introduces the “consumer situation” (Foxall, 2001, 2010). The consumer situation represents the deciding consumer as being equipped with his/her previous learning about the world and, significantly, immersed in a specific setting, which constrains his/her decisions. In this case, humans do not decide independently of where they are. As in ethology, the settings’ particularities mediate the processes in the brain.

At this point we would introduce some changes in the brain functioning model that reflect what has been said. Figure 20.3 includes a feedforward loop in the top that represents

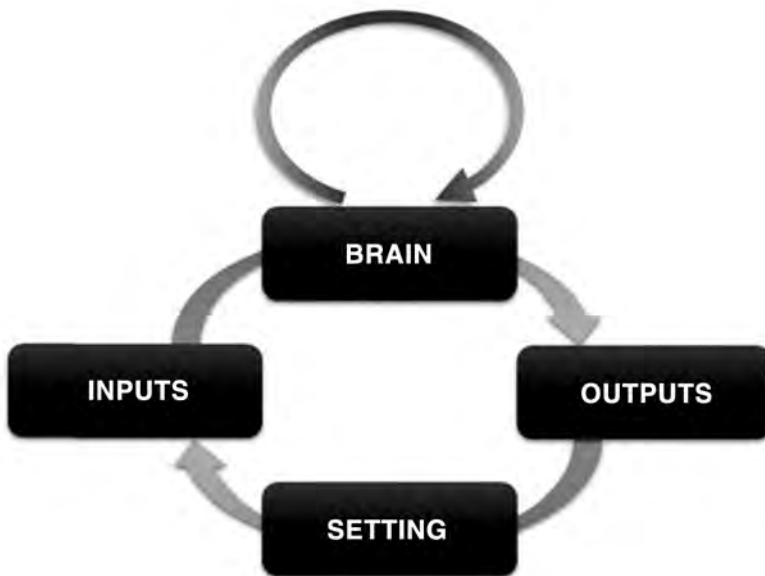


Figure 20.3 Figure of eight parsimonious model of human behavior. The top circle represents brain processes that were not prompted by input stimuli, but are generated by the brain itself. The bottom circle represents the interaction with the environment

non-stimuli-based brain productions. These are brain processes that do not depend on inputs. They are generated by the brain itself, as in reflective processes, for instance. The circle in the bottom represents the cyclic interactions that the subject has with his/her setting. The setting here is not just the things or the physical conditions that surround the individual, but his/her peers, family, friends, i.e. people that influence one's behavior.

Non-rational theories of decision-making

Inspired by the work of Herbert A. Simon and Reinhard Selten, Gigerenzer (2001) proposes non-rational decision-making theories, which are not to be confused with irrational choices. Non-rational decision-making theories are essentially non-optimizing and use instead concepts like satisficing or aspiration levels as stopping rules; they are fast, because they use little computation, and frugal, because they use limited information. Besides being non-rational, fast, and frugal, these heuristics have “ecological rationality”, in the sense that environmental contingencies are determinant in selecting the heuristics more appropriate for the situation, i.e. the structure of the information of a certain setting is used to determine the heuristic more suitable for itself, so delivering precise predictions on it. With time and experience, the individual develops a repertoire of heuristics able to solve problems in a variety of specific situations, like a toolbox. It is by adaptation to environments that this non-rational, fast, and frugal toolbox is constructed.

Gigerenzer and Gaissmaier (2011) categorize these heuristics in four groups, recognition-based decision-making, one-reason decision-making, trade-off heuristics, and social intelligence, with many specific heuristics in each group. Social intelligence is a special case because it encompasses heuristics from the three previous groups. However, social heuristics may not be used in non-social situations. Examples of social heuristics are imitation, tit-for-tat, and the social-circle heuristic.

The non-rational, fast and frugal, adaptive heuristics fit well in S–R models, because they deliver fast behavioral responses to specific situations (though lacking flexibility), demand little computational ability (so can be easily implemented in simple systems), and require previous learning. Nevertheless, Gigerenzer and Gaissmaier (2011) decline to include these heuristics in dual-process systems, because the authors claim that they can be used consciously, or not. The dual-process system makes the separation between unconscious/S–R and conscious/S–O–R and, in fact, there are heuristics that can be applied consciously and others that are not. Perhaps the individual's specific situation may have a role here. We will return to this question later, when we consider the integration of the model with biological constraints, while retaining the above-mentioned commonalities with S–R models. It has to be emphasized that these heuristics incorporate an important innovation: the non-rational, fast, and frugal toolbox is built up in close interaction with the settings. In fact, the settings are critical in the selection process, which means the end of anthropocentrism, bringing humans to the same level as non-humans in their habitats, and adapting them to the environment.

Multithreaded, competing decision processes, and modulation in the rain

Setting-prompted and self-prompted actions in the S–R model

Cisek and Kalaska (2010) propose a model for brain functioning that is largely grounded in ethology, the affordance competition hypothesis. Animals, in the real world, behave in close interaction with their setting, using it, and being influenced by it, adapting behavioral responses accordingly. This is not a pipeline, with inputs, processing, and outputs, but a continuous cyclic

interactive scheme. During this process, the brain integrates sensorial information, and also the previous experiences and knowledge that the organism has.

The visual system is split into two streams: the ventral stream and the dorsal stream (Goodale & Milner, 1992). The function of the ventral stream is vision-for-perception, identifying organisms and objects in the visual field, i.e. to answer the question “what?”. It is sensitive to details and features, and relies on long-term representations for the process of *identification*. The function of the dorsal stream is vision-for-action, delivering spatial positioning for *actions*, i.e. to answer the question “how?”. It is sensitive to spatial arrangement. It has to be noted, however, that the dorsal stream answers the question “how”, not just “where”, i.e. its role goes beyond the simple delivery of objects’ coordinates in space to make a 3D reconstruction in the brain. The dorsal stream generates spatially defined possible actions, so answering the how question: “it [the dorsal visual stream] could be extended to other systems for a range of behavioral skills such as visually guided reaching and grasping, in which close coordination is required between movements of the fingers, hands, upper limbs, head and eyes” (Goodale & Milner, 1992, p. 20).

Fusiform gyri occupy a large portion of the ventral stream. It has been suggested that these brain structures have an associative function, which is necessary in identification processes. On the one hand, it encompasses a fusiform face area (FFA), which is supposed to be a region with the specific function of decoding human faces. On the other, decoding objects is supposed to be distributed in fusiform gyri (Hanson et al., 2004). In any case, the fusiform gyri are important brain structures in the identification process, i.e. answering the question “what?”.

Nevertheless, the two streams are not independent of one another. They have complementary and interconnected workings (Milner & Goodale, 2008). Between the ventral and dorsal streams, there is the precuneus cortex. The functions attributed to this region include “visuo-spatial imagery, episodic memory retrieval and self-processing operations, namely first-person perspective taking and an experience of agency” (Cavanna & Trimble, 2006, p. 564). These functions are all pertinent to the model proposed by Cisek and Kalaska (2010), linking identification (based on one’s own knowledge) and spatial arrangement to the directing of one’s own behavior (based on one’s own perspective and agency, i.e. the faculty of the individual to be accountable for his/her own actions, initiating them and controlling their unfolding).

It is also important to note that the precuneus cortex/posterior cingulate cortex is one important hub in the Default Mode Network (Andrews-Hanna et al., 2010). As previously noted (see section “The brain as a generating organ”), the DMN is a brain network active during resting periods that deactivates when the task requires cognitive effort. There are, however, some tasks, besides resting periods, that also make the DMN active. Andrews-Hanna et al. (2010) found evidence that the two hubs of the DMN are involved both in “present self” and “future self”, i.e. “prospective, episodic decisions about one’s self (*Future Self*) to be compared to self-referential decisions concerning one’s present situation or mental state (*Present Self*)” (p. 551). Both situations, actual and future, are critical in one’s navigation system, i.e. where I am and where I may go, and therefore the precuneus cortex/posterior cingulate cortex may represent the generating component that encompasses the “what” and the “how” questions.

This structure helps organisms in answering the questions that arise during interactions with the setting: what to do, and how to do it? According to Cisek and Kalaska (2010), the dorsal stream generates a range of possible actions that the organism can take. In principle, the organism performs one action at a time (to avoid possible conflicting or mutually confounding actions), and therefore the alternative actions compete with one another and, along the stream, the range is refined. The dorsal stream comprises then, from its beginning in the visual cortex until the motor output, a successively diminishing beam of potential actions. Supposedly, it is also

responsible for the control of action execution in the posterior parietal cortex (Desmurget & Sirigu, 2009).

One may note that even very simple organisms need to eat, and that needs of this kind are powerful drivers of behavioral actions. The autonomic system/hypothalamus together with the basal ganglia, which have a determinant role in encoding habits and motor automatocities (Ashby et al., 2010), account for generating, managing, and modulating hunger-like impulses.

Until this point the organism lives in close interaction with the setting, and responds and adapts to it, without needing high cognitive functions or complex computations. It does not need evaluation systems, or optimizing procedures, but copes well with Herbert A. Simon's concept of satisficing: if one intention reaches the threshold, then the individual should stop searching and the choice is made.

Introducing the O

Whereas animals, even non-primates such as rats, may be used to study brain processes such as the ones considered so far, which are restricted to S–R decision models, it is not acceptable to continue to use such animals to study functions which are not anatomically supported within the animal brain. In this respect, Craig (2009) warned that “a rat is not a monkey is not a human” (p. 466), emphasizing specific anatomical dissimilarities that exist among these brains, which necessarily indicate the possibility of different processes in the brain. Öngür and Price (2000) dissect in detail the differences that exist among these species in the prefrontal cortex. The differences are not negligible. On a complementary evolutionary perspective it was remarked that the prefrontal cortex is one part of the human brain that underwent “disproportionate increases” which may give anatomical support to some processes unique to humans (Schoenemann, 2006). We may include in this list value-based decision-making.

Value-based decision-making is probably one of the most studied themes in neuroeconomics (Montague et al., 2006; Rangel et al., 2008) and several areas in the prefrontal cortex have been found participating in the tasks. Grabenhorst and Rolls (2011) propose a decision-making model in this part of the brain, which develops in three tiers with the corresponding anatomical supports. The parallel between this three-tiered scheme and the sequential multistage computer-like processing pipeline (deliberation) is evident:

Organization of cortical processing for computing value (in Tier 2) and making value-based decisions (in Tier 3) and interfacing to action systems. The Tier 1 brain regions up to and including the column headed by the inferior temporal visual cortex compute and represent neuronally ‘what’ stimulus or object is present, but not its reward or affective value.

(Grabenhorst & Rolls, 2011, p. 57)

As deconstructed in previous sections, there are decisions that are already “made” when the process reaches the prefrontal cortex, namely those processed by S–R models. This is the main point of disagreement with Grabenhorst and Rolls's model. Nevertheless, we recognize that S–R models sometimes do not hold the necessary assumptions (e.g. existence of previous knowledge), or, because of the intrinsic particularities of the problem (e.g. high consequences in case of failure and no time restrictions, like buying a house), are not the best suited decision processes. English, and many other languages, have a long list of adjectives to describe the individual that proceeds to act on the decision prompted by an S–R model when an S–O–R is highly recommended. Such an individual may be called crazy, unwise, imprudent, impulsive, irresponsible, negligent, reckless, hasty, rash, impetuous, etc., and even considered a pathological case.

The prefrontal cortex is probably the part of the brain best equipped for computational intensive decisions, for example the ones that require the direct comparison of several alternatives (where satisficing does not work), or the ones that integrate future planning and long-term goals (McClure et al., 2004), or even those that include multiple alternative plans (Koechlin, 2011). In these cases the final goal must be present today and all the time until the objective is met, to influence immediate and further behaviors, i.e. the prefrontal cortex has to influence more caudal areas of the brain, probably in the dorsal stream, which may account, at least partially, for the refining process of possible actions that unroll in this path (Cisek & Kalaska, 2010). Hence, the O, accounted by the prefrontal cortex, is not part of the pipeline, but may have a modulating role instead.

Why do most neuroscientific studies in decision-making imply the participation of prefrontal cortex structures? Because these studies emphasize the participation of the O, i.e. prompt the computational pipeline: subjects are explicitly instructed to act in a certain manner, think, be collaborative and not answer randomly, to press buttons to record their decisions . . . and to decide displaced from the normal settings where the decisions are usually taken (shelves in the supermarket vs. virtual shelves in the scanner room).

To return to what was said concerning the dual-process system, there is evidence that both strategies coexist in the brain at the same time, competing with one another (Darlow & Sloman, 2010; Evans, 2008; Rangel et al., 2008). How to resolve conflicts and where is that done? The anterior cingulate cortex is a candidate supposed to do it. Allman et al. (2001) summarize its multiple roles: “Functions central to intelligent behavior, that is, emotional self-control, focused problem solving, error recognition, and adaptive response to changing conditions, are juxtaposed with the emotions in this structure” (p. 107). The specific functions of error recognition and adaptive response to changing conditions enable the anterior cingulate cortex (ACC) to manage the intervention of the O over the S–R. It controls unexpected results from the actions or even errors, and hence can exert some influence in the process, skewing behavior, through the extensive net of efferences. Lesions in the ACC may impair the ability to suppress automatic motor routines, as in akinetic mutism (Paus, 2001), i.e. such patients cannot control the S–R implementations, according to the theory here unfolded. In line with this, Miller and Cohen (2001) suggest that ACC is essential for control, signaling and avoiding possible conflicting processes, which enhances its suggested role in managing the influence of the O over the S–R.

The characteristics of the ACC also help to explain some differences in the *Primates* order, supporting an evolutionary perspective. The ACCs of *Hominidae* (humans and great apes) encompass spindle cell neurons, whereas monkeys’ ACCs do not (Nimchinsky et al., 1999). Even in humans, such neurons appear after birth, by the age of four months, when the infants start to have motor coordination like holding up the head, smiling spontaneously, and tracking and reaching objects (Allman et al., 2001). This may explain why only humans, though not at all ages, can accurately perform complex behaviors that involve managing conflicting alternatives.

Imitative processes

What to do when the situation is novel, there is no previous knowledge, and the problem is complex to solve? This is a demanding situation because the organism cannot rely on previous learning to prompt a suitable heuristic to solve the circumstances where s/he is placed. In fact, S–R models are of little help here. One may use the computational pipeline: search for all necessary information, compute it and optimize the range of alternatives, and then act. But this is a slow process, there may not be enough information, the organism is eager for action . . . and the setting may change too quickly.

Pelzmann et al. (2005) give a timely example: how to choose a phone service provider? On the one hand, S–O–R models cannot solve this problem exactly because the choice of the best telecommunication provider mostly depends, today, on calls that will be made in the future. Therefore, the organism does not have all the information s/he needs to calculate the optimal solution. At most s/he will have to work with estimates, which introduce more complexity to the process and slow it even more. In any case, because of telecommunication providers' competition, the setting changes frequently, which means that the organism has to reinitiate the process over and over again, consuming lots of time. Who does that? Nobody. On the other hand, because of the changing competition setting, fixed heuristics are elusive and do not last. Here, operant conditioning is not effective since the reward/punishment schema changes too often. There is nowhere to repeat them successfully in the future and therefore, conventional S–R models also fail to provide useful answers.

Solution: imitate your peers. Imitation does not need knowledge, or previous learning, to yield suitable solutions. It is all about process, just process: do the same as others do, whatever they do, replicate it. In this respect, it is not like other S–R heuristics (which extensively rely on operant conditioning); it is quite similar to S–O–R models because its core is just process, but imitation is much faster, delivering immediate solutions. S–R heuristics are situation-locked, like a table entry: one situation prompts one heuristic. There are no arguments, or process. Although the process is very simple, imitation is like a function where the result depends on the arguments. In this respect it is similar to S–O–R, but without complex algorithms and optimization. Gigerenzer and Gaissmaier (2011) consider imitative heuristics within social heuristics, which is a special case of social intelligence. Social heuristics exist just in a social setting. Gigerenzer and Gaissmaier (2011) interpret moral behavior in the context of social intelligence, largely relying on imitation: moral behavior is not about rational conduct; on the contrary, it is unconsciously that one replicates what is agreed within the social group to gain acceptance by one's peers.

Supposedly, imitative processes have neuronal supports that, strikingly, are in the dorsal stream (superior and inferior parietal lobule) and in the prefrontal cortex (dorsal premotor cortex): the mirror neurons system (Iacoboni, 2009; Molenberghs et al., 2009). The mirror neuron system was already previously addressed in this chapter as one example of neurons that simultaneously do perception and action, i.e. a simple process to understand what is happening in the setting, which does not involve memory, projects the outcomes, and aligns one's own behavior with the environment by replicating the observed peers' conduct. The paradox is that the mirror neurons system was discovered in animals that are poor imitators: monkeys (Byrne, 2005).

At this point it is important to introduce a parenthesis and explore what imitation is. Imitation may be (pure) imitation . . . or may be emulation. For instance, whereas chimpanzees (*Pan troglodytes*) try to get the reward in the transparent puzzle-box independently of the action sequence, 3- to 4-year-old human children strictly follow the instructions (Horner & Whiten, 2005). In an emulative process the end is achieved irrespective of the means. The goal is the only thing that counts, blurring the steps that have to be taken. The organism only counts on his/her/its range of solutions (actions), which derive from his/her/its experience, to achieve the end. The instructions are disregarded. In purely imitative processes the composing stages, and their sequence or branches, and the goal, all matter. Urban and Bushman children both accurately replicate actions, even the redundant ones, in a process named “overimitation”, which is exclusive to humans, and that is critical in the accurate transmission of complex behavioral plans, as in the case of culture formation and maintenance (Nielsen & Tomaselli, 2010).

To solve the paradox, Byrne (2005) suggests that the construct “imitation” should be split into two other constructs, apparently similar but different, which he named “social mirroring”

and “learning by copying”. Learning by copying is complex and recruits specialized brain structures that only humans and probably the great apes have, and consists in the faculty of deconstructing one full process into several components, extracting the intrinsic order, and reconstructing the whole process again, and so mastering it. Depending on the intelligence of the organism, learning by copying may be pure imitation or emulation, the former requiring sufficient brain structures, and the latter functioning in somewhat stripped systems. Social mirroring is not imitation, or emulation, it is just “matching the current behavior of another with similar-looking actions of one’s own: and mutual identification requires synchrony, not creativity” (p. R499). Monkeys (and probably other social animals) perform social mirroring, like great apes and humans, which may be accomplished with the critical participation of the mirror neurons system in the superior and inferior parietal lobule and in the dorsal premotor cortex, which is then a network that implements imitative-based behavioral decisions.

Generalized model of decision-“making” in the brain

In this chapter, three different, but complementary and integrated, decision systems have been considered, each one relying on segregated, but integrated, neuronal supports: the fast intuitive system relying on previously acquired knowledge through experience where direct relations between stimuli and behavioral responses were coded; the slow deliberative system relying on working memory and computing abilities favoring processing; and the fast imitative system relying on a swift process that replicates other actions. These systems are depicted in Figure 20.4.

Starting in the most posterior areas of the brain and in the direction of the motor output (basal ganglia and motor cortex), the arrows represent the two streams originating in the visual cortex and the respective cross-talk between them. The intuition system is largely supported by this network: representation and identification of the particularities of the environment, acknowledging that during interpretation associations with previous experiences and the organism’s state of knowledge are made; and generation of possible actions and their refinement according to the organism’s actual state of knowledge and experience. At this point, behavioral (motor) responses can be executed, integrating the organism’s physiological state, by the hypothalamus, basal ganglia, and the motor cortex. This is sufficient for the implementation of simple and fast S–R models of organisms interacting with their settings in an ongoing routine.

The slow modulation of deliberation comes from the more anterior areas of the brain, the prefrontal cortex and the anterior cingulate gyrus, and influences the intuition process, although with different time frames. It mainly originates in valuation systems (in the orbitofrontal cortex) and future planning (in the ventromedial prefrontal cortex), and its flow is in the direction anterior to posterior. This system functions not only during the period prior to the decision (in such cases it is non-optimal because the intuitive system is usually faster in reaching the decision threshold), but also after the decision is “made”, either during the learning stage (when the outcomes are confronted with the previous expectations), or because of regret (when recently initiated behavioral responses are stopped and corrected according to new, better decisions). Nevertheless, its main role is when intuition fails because it does not have a ready solution, and the situation requires hard computations and optimization.

Strikingly, social mirroring neural bases (the dorsal premotor cortex and the posterior parietal cortex, i.e. the mirror neurons system) are located respectively in the anterior and posterior parts of brain, with the motor cortex in between. These two brain regions are connected by the superior longitudinal fasciculus, specifically the SLF I, which allows the swift exchange of information between both structures. Social mirroring delivers fast responses for

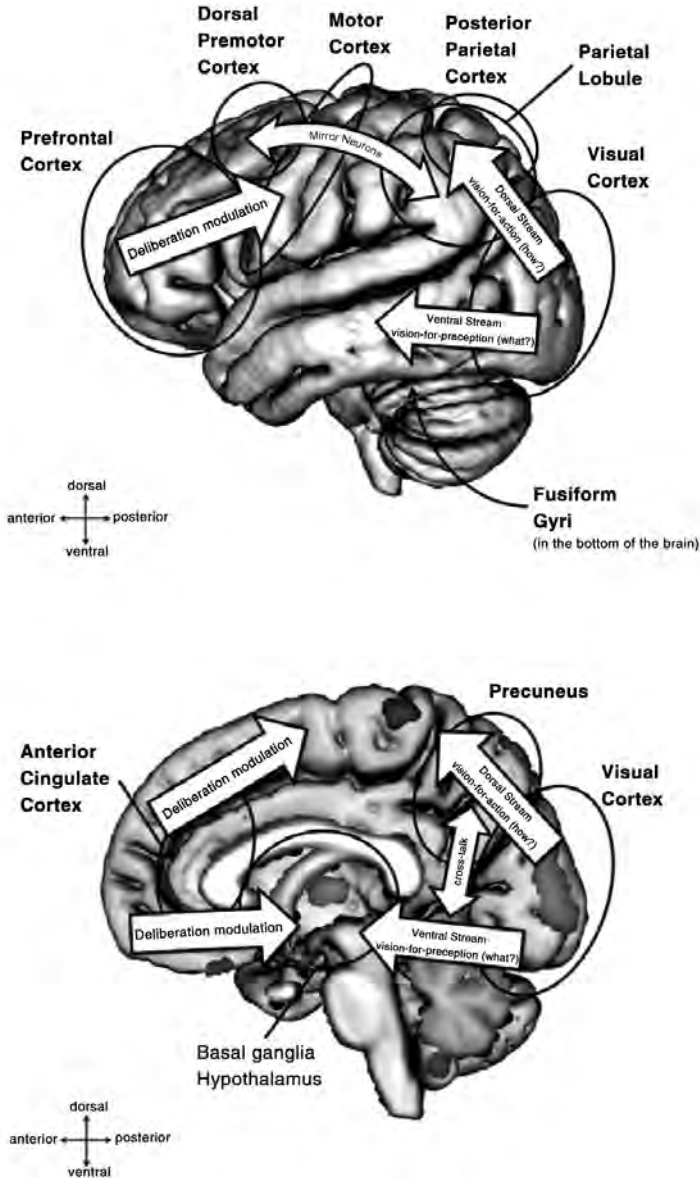


Figure 20.4 Generalized model of decision-“making”. Refer to the text for an explanation of the decision systems and their flow in the brain. Top: the left hemisphere. Bottom: the left hemisphere was removed in order to make the medial brain visible

the sort of situations characterized by intrinsic multiplicity, which require specific responses for that particular set of circumstances, and for which previous learned intuitive plans cannot help. Social mirroring uses others as a pool of knowledge, reflecting their actions. Although social mirroring is flexible, like deliberation, it does not require long computations or optimizations. It is just about processing responses, constrained by the setting situation and inspired by actions observed in others.

These three decision systems have different neural supports but concurrently and complementarily contribute to the generation of behavioral responses for one organism immersed in and interacting with his/her/its setting. The decision system in the brain is not a contest between S–R and S–O–R, but involves the coexistence of several complementary systems acting, when appropriate, as a hybrid S–R × S–O–R, which equips the organism with systems that make him/her/it better adapted to respond in a broader range of settings and situations.

Shortcutting decision-making for ecological adaptation: the case of favorite brands

There is accumulating evidence that the decision schema proposed with the *Homo economicus* is not sufficient to account for and explain the decisions that humans perform when immersed in naturalistic settings. Although the model so far proposed is data grounded (behaviorally and neurally), how does it account for and explain other observations? We have been studying brands with neuroscientific techniques.

Before we analyze the brain bases of brand-elicited behaviors, we must consider faces. Faces convey information about the entity that lies behind them. The nature of the information may be social or emotional. Research has shown that brands’ logos also convey social and emotional information (Santos et al., 2012; Santos et al., 2012). It has been proposed that faces have a special part of the fusiform gyrus, the fusiform face area (FFA), dedicated to their processing (Kanwisher et al., 1997; Sergent et al., 1992). Intriguingly, FFA is in the ventral stream and, although there are criticisms concerning the specificity or exact boundaries of this area, it is not unlikely that the human brain has structures or parts of structures dedicated to face processing (Weiner & Grill-Spector, 2012), given the importance that faces have in social navigation.

“With only a glance, humans instantly form impressions of another’s face” (Freeman et al., 2014, p. 10573). Indeed, everyone has experience of this and knows that it is a compelling fact of everyday life. How does one make a decision about a face? By putting his/her sequential multistage computer-like processing pipeline to work on it? Freeman et al. (2014) bring evidence that humans can make a judgment about a face’s trustworthiness even when that face is subliminally presented for 33 milliseconds, a glimpse too short for conscious perception. Even so, most humans perceive whether that face is trustworthy (or not) even in such a tight timeframe, a process that involves the amygdala according to these authors. Hence, outside of situations that are highly risky and are not time constrained, for instance buying a house, the most common decisions that one makes during the day exempt the computing pipeline. This is the case where decisions are needed for accurate social navigation, such as assessment of the information conveyed by human faces. Social decisions require fast processes like intuition or imitation. Otherwise, the process becomes slow and the situation awkward, which is typical of individuals with certain impairments, such as Asperger Syndrome, who supposedly have intrinsic synchronization problems between the frontal and posterior areas of the brain (Kana et al., 2009).

Social situations require fast processes, and social environmental restrictions (e.g. postmodern fragmentation) enforce the use of decision shortcuts. Studies that do not account for such environmental pressure bias the experiment, forcing deliberation instead of intuition or imitation. In our opinion, the bias is evidenced by the word used to name the process: decision-making. To make a decision implies planned participation and involvement, i.e. it requires deliberation. However, most social decisions do not follow such a scheme, missing out planning, for example. Mostly, they are reactive to environmental stimuli, depending on the situation, i.e. they are ongoing processes which call for fast behavioral responses. Because most human decisions are

not really made during deliberation, we propose in the title of the present chapter that they are in fact decisions—“made”.

Now, consider brands. Magnetoencephalography (MEG) is a neuroscientific technique that non-invasively measures, at the scalp level, the magnetic field generated by neuronal activity. Temporal resolution is one of its advantages (although with non-optimal spatial resolution), contrasting with fMRI, which has high spatial resolution and non-optimal temporal resolution. Braeutigam et al. (2004) used MEG with a choice task where subjects had to choose one among three products exhibited at the same time, on a virtual shelf. First, more salient products (whose choice was predicted) had faster response times than less salient products (whose choice was unpredicted), a result similar to the fMRI study that opened this chapter, where brands were exhibited one at a time (Santos et al., 2011). Second, where the neural activity flows from the posterior brain to the anterior:

1. at 100 ms there is evoked activity in the occipital cortex (vision);
2. at 150 ms there is bilateral activity in the inferior occipital-temporal cortices (visual stream);
3. at 250 ms the main activity is in the dorsal temporal lobe bilaterally;
4. in the range 350–700 ms there is increasing anterior prefrontal activity, with some flow back to parietal areas at 500 ms (with increasing activity until 1000 ms);
5. from this point, activity weakens and becomes dispersed throughout the brain.

Third, in the range 485–505 ms there is activity in the left inferior gyrus more intense for less salient products than for those mostly chosen; a similar pattern exists in the ranges 645–690 ms and 1255–1300 ms in the right prefrontal orbital cortex; in the range 860–950 ms there is activity in the right posterior parietal cortex more intense for salient products. Acknowledging that subjects made essentially explicit decisions, this pattern of brain activity is consistent and gives support to the model of decision-making herein advanced. It is important to note that the process flows backwards after reaching the anterior part of the prefrontal cortex, that less salient products recruit more time in the prefrontal cortex, and that more salient products generate increased activity in the posterior parietal cortex around 900 ms (mean reaction time is around 2100 ms).

Returning to Figure 20.1, it is possible now to suggest an explanation for the depicted data. Preferred brands had significantly faster decision times when compared with indifferent brands and fictitious logos. Probably subjects used intuition in reacting to the preferred brands' category of stimuli, i.e. subjects had previously coded their preferences in the early stages of the decision process, which prompted them to swiftly “make” their decisions. On the contrary, subjects used the deliberative system with indifferent brands and fictitious logos, either because it was the first time they had seen the logos (and therefore they had no previous experience to rely on), or because subjects were not certain how to make the assessment and therefore had to ponder, recalling information about the brand, and finally make an explicit decision. Importantly, the fine temporal data analysis reveals that the ventromedial prefrontal cortex participates more during the decision period for indifferent and fictitious logos than for preferred brands. After the decision moment, this pattern reverses: the ventromedial prefrontal cortex activates more for preferred brands than for the remaining (Santos et al., 2011). These observations cannot be explained with the sequential multistage computer-like processing pipeline, but the model proposed here accounts for them: the prefrontal cortex does not participate in deciding between familiar choices, but it is called on to participate when the decision requires deliberation.

One relevant aspect of the paradigm used in Santos et al. (2011) is that brands were assessed one at a time, whereas most studies on neuroeconomics and neuromarketing require that

subjects prefer one among a set of two or three alternatives simultaneously exhibited (e.g. TAFC paradigm – two-alternative forced choice). Although the former study was carried out in a laboratory, its paradigm replicates more closely naturalistic decision settings (e.g. when buying groceries in a supermarket, the customer has in mind an idea, or even a list, of needs, supported by a personal consideration set – also known as an evoked set – helping in the search for the product/brand that s/he needs, i.e. corresponding more closely to Simon’s notion of satisficing).

Some other studies and theories have involved the ventromedial prefrontal cortex in emotion-based judgments (Koenigs et al., 2007), with this brain structure being considered “a critical substrate in the neural system necessary for triggering somatic states from secondary inducers, although it can be involved in the emotions triggered by some primary inducers as well” (Bechara & Damásio, 2005, p. 340). A secondary emotional inducer is a stimulus that calls for past experiences and memories of something that was learned. Our model apparently contradicts this view. However, the ventromedial prefrontal cortex still may participate when the decision integrates information from several sources and this participation may happen before the decision (as in the case of indifferent and fictitious logos, i.e. deliberation), or may happen after the decision (e.g. for learning, or tracking long-term goals).

Studies with different data analysis approaches give extra support to the model. Hanson et al. (2004) used artificial neural networks to accurately classify faces, houses, cats, bottles, scissors, shoes, and chairs. The most interesting part is that they used data only from the fusiform gyri (the same structure that holds the fusiform face area), which belong to the visual ventral stream. Recently, Marques dos Santos et al. (2014) used artificial neural networks to extract information from two brain networks to classify, above randomness, faces, objects, and preferred and indifferent brands. The two brain networks contain voxels from the occipital and temporal occipital fusiform gyrus, the lateral occipital cortex, and the inferior temporal gyrus (temporooccipital part) all bilaterally, i.e. all brain structures that belong to the visual ventral stream. These results corroborate the suggestion that preference is already coded in early stages, in the visual ventral stream, probably in the fusiform gyri, which may explain the observed shortcuts in the decision process. In the brain, brand preferences, like human faces, exclude deliberation.

Cyclifying BPM and the regulation by reason

The Behavioral Perspective Model (BPM) is already implicitly cyclic, because of the interaction with the setting, which feeds back information that influences new behavioral responses. In this respect, the BPM and the model herein unfolded (see Figure 20.4) overlap, both acknowledging that contact with the setting is a crucial component of behavior. The individual does not exist in isolation from everything else. On the contrary, s/he/it is integrated in a setting, which encompasses the biological, sociological, and geological, institutions, and things, and the organism interacts with all of this world, and all of this world interacts with the organism, influencing and being influenced by his/her/its behavior in a continuously evolving cycle.

In the BPM, behavior is a consequence of the setting and individuals’ learning history, and antecedents of reinforcements and aversion, either utilitarian or informational (cf. Foxall, 2001, 2010). Behavior outcomes contribute:

- changes to the setting, with consequences for the biology, sociology, geology, institutions and occupants (both animate and inanimate) of the space, with such interference leading to reactions;
- by enriching the individual’s learning history, updating knowledge of the consequences of behaviors so they are available for integrating into future behavioral decisions.

Hence, the BPM is intrinsically cyclic, although its usual representation conceals this aspect. The individual acts, and the actions have consequences. Such consequences change the setting and also the individual encodes the relationship among actions and outcomes. The new framework will influence the next situation, and so on.

This behavioral schema has the same intuition and social mirroring (imitation) components of the decision-“making” model with their respective neural supports and constrictions. Intuition relies on the individual’s learning history. It consists of the sets of fast responses encoded in the brain that the individual calls on in specific situations. Social mirroring is also a swift reaction to a setting’s social content.

Deliberation, the sequential multistage computer-like processing pipeline, does not have a place in the BPM. This is because the BPM is a naturalistic model and a slow-acting deliberative model like the computational pipeline is ill-adapted to settings’ evolutionary pressure where there is a need for immediate and continuous interaction with the setting. Simply, the setting does not wait.

Nevertheless, deliberation is useful during the updating stage. Deliberation monitors behavioral errors, when expectations have not been met. Deliberation may not be useful for ongoing interactions because of its intrinsic slowness, but afterwards, when the individual has time to reflect on the situation, probably in reaction to the frustration of having encountered the unexpected, the learning history may be re-encoded with the new outcomes to update the brain’s repertoire of possible future behavioral decisions. In such cases, deliberation may be usefully integrated in the model, as situations where time is not critical and there is sufficient information available to make optimization possible are rare.

With all these considerations the parsimonious model of Figure 20.3 can be redrawn as in Figure 20.5, now incorporating the BPM’s terminology and the tripartite decision-“making” model.

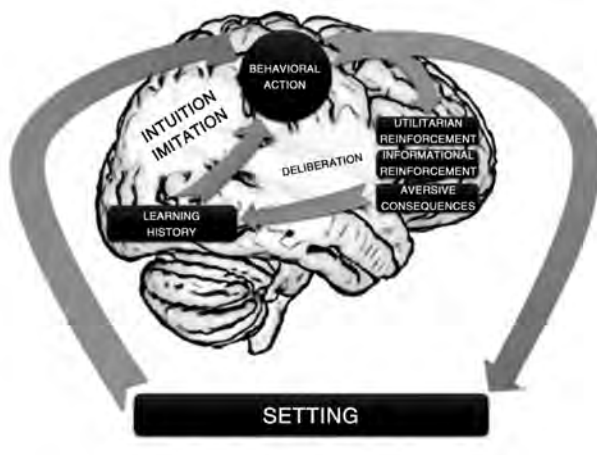


Figure 20.5 Integration of the BPM with the tripartite decision-“making” model in the brain. The diagram shows the situation of the brain interacting with its setting. Both information from the setting and the individual’s history contribute to action behavioral plans, which can be made primarily by two means: intuition and imitation. The role of deliberation is residual so far, but it may be important during reflective periods after action is completed, when integrating the outcomes within the individual’s history. The positioning of the constructs in the brain has to be considered parsimoniously

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