HOW IS OUR RATIONALITY SITUATED?*

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It is an honour to contribute in a volume dedicated to Professor Raghunath Ghosh, whose prominence as a philosopher within the Indian community is so pronounced. One is inspired by his contribution to the discipline of philosophy in general and Indian philosophy in particular. His exposure to the world of philosophy is both at the national and international level. Personally, one has to appreciate his contributions to our community and this opportunity given to me is very humbling. I sincerely believe that he continues to inspire young minds to contribute to our discipline with sincerity and perseverance.

A recent theory of ecological rationality holds that the accuracy of decision making strategy largely depends on the "structure of the environment" in which the strategy is used. Ecological theory strongly focuses on the structural properties of the environments and takes a structure-specific, situated approach to the study of cognitive processes (Brighton and Todd, 2009). Adaptive choices are employed by the decision maker, which are in tune with the specific environmental characteristics. So, in a way, ecological rationality addresses the concern of how and in what ways the environment influences the contents and the processes of the mind. Ecological rationality is said to depend on "agents deploying their various decision strategies in particular situations, sensitive to the structure of the environment in which they are embedded" (2009).

In this paper, we explore the dimensions of ecological rationality with respect to the use of an 'adaptive toolbox' (Gigerenzer), where people can be effective decision makers by using simple heuristics which are appropriate to the structure of the environment. These theorists hold that intelligence in not only in the mind but also in the world, captured in the structures of the information around us (Todd and Gigerenzer, 2012).

Introduction:

Research on various dimensions of problem solving and decision making of human beings have been going on for quite a long time and has offered many ways of understanding the cognitive processes involved in human decision-making and

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problem solving. Decision-making and problem solving are too prevailing in our lives in the sense that almost every one of us cannot do without it. These two functions - problem solving and decision-making are considered as higher-order cognitive functions – for these are assumed to be constitutive of complex cognitive processes (both in terms of complexity in information handling and processing).[1] Decisions may appear simple - but the processes involved need not be likewise. So there is a lot of debate on what goes on in such cognitive acts; what leads to either proper decision making or to decision biases and errors.

Given the vast extent of researches, that has been devoted during the last many decades, on human reasoning, problem solving and decision-making we can discern at least three varieties of approach to understand the phenomena:

a. Theories of rationality, forwarded by philosophers, which have almost a unidirectional tone in their explanation of how human reason is expected to perform - often overstepping to accept an ideal rationality.
b. Theories forwarded by cognitive psychologists and cognitive scientists expanded the outlook to include within their explanation the fallibility of human reasoning and problem solving - not just as exceptions. They were interested in inquiring about the cognitive structure and the processes involved in reasoning and problem solving as higher-order cognitive functions. This has led to either a normative theory of reasoning and problem solving or a descriptive one with fundamental differences at the core of how decision making and problem solving function cognitively.
c. Theories of rationality and problem solving have been influenced by researches on embodied cognition and situated cognition. This research approach, known as ecological rationality aims to explicate the mind-world interactions underlying (good) decision-making. There is a shift in this approach, with respect to the earlier two, in terms of how the environment and body plays a constitutive (causal) role in our cognitive processing. Ecological rationality addresses the concern of how and in what ways the environment influences the contents and the processes of the mind.

[1] These would further involve many other structural and functional complexities of the human cognitive system.

> Ecological rationality is said to depend on "agents deploying their various decision strategies in particular situations, sensitive to the structure of the environment in which they are embedded" (Todd and Brighton, 2009).

We will discuss the claims of ecological rationality - claims as to why decision making and problem solving accounts must be inclusive of the constraints of human body and its interaction with the environment.

I

The Shift in Approach from Traditional Cognitive Science to Embodied Cognition:

Embodied cognition[2] is considered to be a departure from traditional cognitive science[3] with respect to how cognition is understood and also the relation between an organism's cognitive processes and its body. In the traditional cognitive science framework, cognition and cognitive processes are comparable to the functioning of a computer or a computational machine. The sense organs of an organism are instruments of data/input reception, thereby serving as input devices, translating stimulation from the environment into syntactic codes that the nervous system can manipulate based on various rules that are either innate or learned.[4] Within this framework, *cognition* is understood as nothing more than the above kind of *symbol manipulation.* The output of these cognitions is *additional symbols,* some of which might be translated into a form that causes *bodily motions or other sorts of behaviour*. Thus, traditional cognitive scientists have predictively claimed cognition to be computational. So the computational minds are software programs that run on the hardware, called the brain. Larry Shapiro observes:

> … this description of traditional cognitive science is the insular nature of thought. Cognition is cut off from the world in the sense that cognitive processes operate only on symbolic deliverances from the sense organs. … Because cognition begins and ends with inputs to and outputs from the nervous system, it has no need for interaction with the real world outside it.[5]

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[2] Embodied cognition is seen as an emergence from phenomenology, robotics, ecological psychology, artificial life and ethology.

[3]According to Shapiro, traditional cognitive science embraces the idea that thinking is a process of symbol manipulation, where symbols lead both a syntactic and semantic life. The syntax of a symbol comprises those properties in virtue of which the symbol undergoes rule-dictated transformations. The semantics of a symbol constitute the symbol's meaning or representational content. - Larry Shapiro, "The Embodied Cognition Research Programme", *Philosophy Compass*, 2/2, 2007, pp. 338-346.

[4] Ibid., 339

[5] Ibid., 339

According to Shapiro, the challenge most acute for the cognitive scientists is about the origin of mental content. How do the symbols in the head acquire their meaning? Embodied cognition approach puts less emphasis on the importance of representation, for understandable reasons. For them, it is not clear why organisms must produce a representation of the world around them in order to navigate if the world is right in front of them? For Shapiro, embodied cognition has three distinct and yet related goals:

1. From a traditional perspective, the steps in a cognitive process are attributed to symbol manipulation; whereas from the perspective of embodied cognition, they emerge from the physical attributes of the body.
2. The content of cognition[6] may be accounted for by appealing to the nature of the body containing the brain, rather than the brain alone in isolation from its host body and situated environment.
3. Cognitive processes or states might extend into the environment in which the organisms live and not just be confined to the neural level functioning of the human brain.

According to Anderson[7], the doctrine of embodied cognition treats cognition as a set of tools that are evolved in organisms for coping with their environments and adapting to them. He points out some of the basic features of embodied cognition are:

a. Cognition is like any other adaptation having an evolutionary history;
b. Cognition evolved because it was *adaptive* (with effective coping with the environment);
c. Cognition evolved in specific environments and the solutions to survival challenges can be expected to *take* advantage of the concrete structure or enduring features of those environments.

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[6] For understanding the contribution of human body to the contents of cognition, one has to look into Lakoff and Johnson's work on concepts and metaphors. According to them, human beings *make essential use* of metaphors in their conception of the world. For example, understanding love in terms of a journey which highlights the nature of the former with respect to the characteristics of the latter. Love is like a journey implies that love has a beginning but perhaps no end.

[7] Michael L. Anderson, "How to Study the Mind: An Introduction to Embodied Cognition". (http://cogprints.org/3945/1/bes_ec.pdf) downloaded on 20th February 2014.

d. Cognition evolved in organisms with specific physical attributes, bodies of certain type with given structural features, and can therefore be expected to be shaped by and to take advantage of these features for cognitive ends.
e. Cognition evolved in organisms with pre-existing sets of behavioural possibilities, instincts, habits, needs, etc.

Thus, interestingly cognition can be seen as a set of tools constitutive of specific, complementary and cooperative functions. I think that the analogy through which we can understand the main thesis of embodied cognition is that of shaping and designing our tools in accordance with the functions that they are expected or likely to carry out. These functions in turn are related to ways how we handle the different objects of the world. Thus tools are moulded in ways they are supposed to function in the world. Cognition, likewise, evolved like a tool which got shaped according to the challenges that has been presented by the environment. Thus cognitive adaptation involves the process in which human cognitive systems have learnt to deal with the given environment.

Now the question is - whether this new insight about cognition as primarily being embodied and with adaptive interactions with the external world, has cast any influence on ways we have understood the cognitive processes involved in reasoning, decision-making and problem solving. Before we go into the discussions of ecological rationality, it may be appropriate to glance through three models of relationship between mind and environment that is proposed by Shepard, Brunswik and Simon respectively.

II

Models of Relationship between Mind and Environment:

We do not live our lives devoid of surroundings. We are situated in midst of them. Thus, if we are to describe our ways of life, we cannot do that without including our interactions with the given surroundings and people. Therefore, it becomes primary to investigate how our decisions are shaped by the environment. In other words, it is crucial to consider the environment in which the mind (the agent) performs its different tasks and acts accordingly to the given situation. This lends a further understanding of how the mind has evolved. This ecological and situated

perspective was promoted by Richard Shepard.[8] Shepard holds that much of our perception and cognition are achieved, as if, with mirrors, and he proposes that the key aspects of the environment are internalised in the brain by natural selection in order to provide a veridical representation of the objects and events in the external world. This is known as the Mirror Model.

The Lens Model was proposed by Egon Brunswik.[9] The lens model approach proposes that the mind reconstructs a representation. In other words, the mind models and projects the world more than just reflecting it like a mirror. Herbert Simon recommended the Scissors Model which metaphorically depicts the coupling between mind and environment. According to him, Human rational behaviour is shaped by a scissor whose blades are the structure of task environments and the computational capabilities of the actor.[10]

He observes that bounded rationality is similar to a scissor whose two blades stand for (i) the task environment (structure of the environment); and (ii) the computational capacities[11] of the decision maker respectively. Mind has limited capacities like, time, knowledge, and other resources; and it can exploit structures of the environment to its advantage. When these cognitive limitations get coupled with certain characteristics of the environment, then they can complement one another. Todd and Brighton observes that:

> Rather than the mind reflecting or projecting properties of the environment, Simon's scissors metaphor highlights a very different kind of relationship in which the properties of mind are viewed as fitting properties of environment in an exploitative and complementary relationship.[12]

In one way or the other, all these proposed models of relationship between mind and environment posit a strong bearing of the environment on the agent who acts within the given, that is, the given choices and constraints of the given.

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[8] R. N. Shepard, "Perceptual-cognitive universals as reflections of the world", *Behavioural and Brain Sciences*, 24:4, 2001, 581-601.
[9] Egon Brunswik, "Representative design and probabilistic theory in a functional psychology", *Psychological Review*, 62, 1955, pp. 193-217.
[10] Herbert Simon, "Invariants of human behaviour", *Annual Review of Psychology*, 41, 1990, pp. 1-19.
[11] Computational capacities refer to sensory, neural and other mental characteristics that may impose cognitive limitations (on memory and processing).
[12] Henry Brighton and Peter M. Todd, "Situating Rationality: Ecologically Rational Decision Making With Simple Heuristics", in *Cambridge Handbook of Situated Cognition*, Cambridge University Press, USA, 2009, p. 234

Before concluding our discussion on what forms of coupling are proposed between mind and environment, I will touch upon in brief on how embodied cognition has been understood by Varela et.al and Thelen in their respective expositions. The purpose is to highlight some important aspects of their theories which I believe helps us in considering why ecological rationality has grown to embrace the embodied thesis.

Varela, Thompson and Rosch conceives of cognition as "embodied action" -

> By using the term *embodied* we mean to highlight two points: first, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context. By using the term *action* we mean to emphasise once again that sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition.[13]

According to them, perception and action are fundamentally inseparable in our lived cognition. The contents of perception are to some extent determined by the actions an organism undertakes and these actions in turn are guided by the perception of the world.[14] Esther Thelen et al. observe that:

> To say that cognition is embodied means that it arises from bodily interactions with the world. From this point of view, cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capabilities that are inseparably linked and that together form the matrix within which reasoning, memory, emotion, language, and all other aspects of mental life are meshed.[15]

III

Theory of Ecological Rationality: Adaptive Toolbox

Traditional theories of rationality mostly engage in providing rational principles of human decision-making that reveal valuable insights into our cognitive system. The positives of such an approach are that given these rational principles are

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[13] *Embodied Mind: Cognitive Science and Human Experience*, MIT Press, Mass, Cambridge, 1991, p. 173

[14] Varela et al. posits that different body types give rise to different environmental perceptions for the organisms. For instance, consider two organisms with different body types. Org_A is twice the size of Org_B, the former walks vertically, whereas the latter walks on all four limbs. Org_A's sensory organ faces forward, whereas, Org_B's sensory organs provide a 270° view of the world. As a result of these differences in body and perceptual systems, the sensorimotor capacities of the two organisms will differ. Given the difference in what the organisms perceive, there will be differences in the actions that the organisms choose to undertake.

[15] Thelen, E. et al., "The Dynamics of Embodiment: A Field of Infant Perseverative Reaching, *Brain and Behavioural Science*, 24, 2001, 1-86, p.1

proven to be correct; they can offer universal normative principles governing the cognitive system. Thus, a universal structure can be posited to human rationality. However, situated theories of cognition would consider such a move to be faulty in terms of its incompleteness. For them, the traditional approach sidelines (if not ignores) the interaction of the mind (the decision maker) and environment - thereby ruling out the possibility of any measures of adaptability of the agent in consideration to the limits or possibilities that the immediate situation may offer.

Theory of ecological rationality (Gigerenzer et al. and ABC16 Research Group at the Max Planck Institute, Germany) holds that the effectiveness of decision making strategy largely depends on the "structure of the environment" in which the strategy is used. Ecological theory strongly focuses on the structural properties of the environments and takes a structure-specific, situated approach to the study of cognitive processes.[17] The adaptive choices that are employed by the decision maker are in harmony with the specific environmental characteristics. So, in a way, ecological rationality addresses the concern of how and in what ways the environment influences the contents and the processes of the mind.

Ecological rationality sees human rationality as a result of an adaptive fit between human mind and environment. It highlights how decision mechanisms can produce useful inferences by exploiting the structure of information in their environment. Gigerenzer, Todd et al, speaks of the "Adaptive Toolbox"[18] which is referred to as a collection of specialised cognitive mechanisms (including fast and frugal heuristics) shaped by evolution, learning and culture for specific domains of inference and reasoning. However, it is not claimed that all cases of human reasoning is ecologically rational, because if a person has ample time and training, then he may apply more general methods of reasoning (like tools of logic or probability theory) to make decisions with little concern for adapting their reasoning to the specific structure of the current task environment. Gigerenzer et al. propose that much of our

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[16] Center for Adaptive Behaviour and Cognition at the Max Planck Institute for Human Development in Berlin

[17] Henry Brighton and Peter M. Todd, "Situating Rationality: Ecologically Rational Decision Making with Simple Heuristics", in *The Cambridge Handbook of Situated Cognition*, eds. Philip Robbins and Murat Aydede, Cambridge University Press, USA, 2009, pp. 322- 346.

[18] This metaphoric toolbox (adapted from the environment) contains several classes of simple heuristics for making different types of decisions in a variety of domains.

decision making is ecologically rational, guided by typically simple decision heuristics that exploit the available structure of the environment to make good decisions. An outcome of this theory is that:

> "a single all-purpose decision-making system is no longer the appropriate unit of study, as different tasks call for different simple mechanisms. The idea of the adaptive toolbox leads us to consider a collection of simple mechanisms drawn on by the cognitive system. We view these mechanisms as structure specific rather than domain specific. In contrast to the concept of domain specificity, structure specificity is the ability of a process to deal effectively with informational structures found in environments that may or may not be encountered in the multiple domains. … These mechanisms are built from basic, cognitively primitive building blocks for information search, stopping the search, and making a decision based on the search's result."[19]

According to Todd, there are two kinds of constraints that generally arise from the nature of the environment: (i) the external world is uncertain and thereby unpredictable; and as a result we never face exactly the same situation twice. Therefore, our mental mechanisms must be robust enough to generalise well from old instances to new ones; (ii) since the world in a sense is competitive, our decision mechanisms must generally be fast. In other words, to maintain a reliable speed of decision mechanism, we must minimise the information or alternatives we search for in making our decisions. That is, the external world also constrains us to be frugal in what we search for. Thus simplicity, frugality, speed, and robustness go together with exploiting the structure of information in the environment. These characteristics are the foundations of the conception of ecological rationality.

Fast and frugal heuristics are simple heuristics, using both little time and little information. Simple heuristics are the building blocks that control the search for information in the environment (or in memory), stop that search, and use the information found to reach a decision. Since these heuristics are precisely defined, their ecological rationality can also be precisely defined - we can say just what information structures in the environment will enable a given heuristic to make good decisions. Gigerenzer observes:

> The adaptive toolbox is a Darwinian-inspired theory that conceives of the mind as a modular system that is composed of heuristics, their building blocks, and evolved capacities. The study of the adaptive toolbox is descriptive and analyzes the selection and structure of heuristics in social and physical environments. [The study of ecological rationality is prescriptive and

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[19] Brighton and Todd, 2009, p. 326

> identifies the structure of environments in which specific heuristics either succeed or fail. Results have been used for designing heuristics and environments to improve professional decision making in the real world.][20]

Ecological rationality implies a two-way relationship between simple heuristics and their environments. The success of simple heuristics is defined with respect to pragmatic goals in a particular environmental context, and the success of simple heuristics is enabled by their fit to environmental structure. Exploiting the information structure of environments, and thereby letting the environment do some of the work of decision making, is what allows effective heuristics to be simple. Different environment structures can be exploited by -and hence call for - different heuristics, just as different tasks call for different heuristics. Let us consider two such heuristics:

a. Paired Comparison Using *Recognition* heuristics:

This heuristic decides between two available options. It searches for cues in order of their validity, stopping when the first cue is found that distinguishes the options, and selecting the option indicated by the higher cue value. Given the task of deciding which of two objects in the world scores higher on some criterion of interest, the recognition heuristics provides a quick and robust decision procedure by exploiting lack of knowledge or minimum knowledge. If one of the objects being considered is recognised and the other is not, then the recognition heuristic tells us to judge the recognised object as scoring higher on the criterion. For example, given the names of two tennis players, the recognition heuristic simplifies the task of deciding which of the two tennis players is most likely to win the next Grand Slam tournament: if we only recognise only one of the players and not the other, then the recognition heuristics tells us to pick the players we have heard of.

b. Paired Comparison Using *Take the Best* heuristics:

When both the objects are recognised and knowledge of several cues about each object is available to aid the decision, then many possible decision processes exist. Take the Best heuristic is a simple heuristic built from three building blocks where (i) cues are searched in order of their ecological validity; (ii) search stops at the

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[20] Gerd Gigerenzer, "How Heuristics Work", *Perspectives on Psychological Science*, Vol. 3, No. 1, From Philosophical Thinking to Psychological Empiricism, Part I (Jan., 2008), pp. 20-29

first discriminating cue; and (iii) the object selected is the one indicated by the discriminating cue. Ecological validity is a property of a cue, which indicates how frequently in the past the discriminating cue picked out the object with the higher criterion value.

Going back to the same example with the two tennis players (who will win an upcoming tournament?), the first valid cue can be from – has this player won a Grand Slam competition in the past? If this cue discriminates (if true for one player and not the other) then Take the Best heuristics will stop information search and select the previous winning player over the other player. If the first cue does not discriminate, then other discriminating cues will be searched for.

Now the question of how does heuristics work becomes important. How does the mind select a heuristic from the adaptive toolbox or construct a new one? Gigerenzer says that it is reinforcement learning, with the unit of learning being heuristics rather than behaviour. In general heuristics selection can be guided by (a) individual reinforcement learning; (b) social learning (as in medical training in which physicians are instructed on what cues to look up in what order; and (c) evolutionary learning (as with rules of thumbs).

IV

Ecological Rationality as a Form of Situated Cognition:

B. C. Smith observes "The situated movement -- situated language, situated cognition and learning, situated behaviour -- views intelligent human behaviour as engaged, socially and materially embodied activity, arising within the specific concrete details of particular (natural) settings, rather than as an abstract, detached, general-purpose process of logical or formal ratiocination."[21] Todd and Brighton consider the following six characterisation of situated cognition by Smith:

1. Located: The significance of being located arises when we adopt the view that context-dependence is a central and enabling feature of human endeavour. Understanding the characteristics of the environment is important in order to apply any heuristics.
2. Concrete: Concreteness mainly refers to constraints. Ecological rationality considers two degrees of concreteness: (i) Computational Level: what can be

[21] Brian Cantwell Smith, "Situatedness/Embeddedness", in *MIT Encyclopedia of Cognitive Science*, 1999.

achieved by the computationally tractable processes[22]; (ii) Cognitive Limitations (e.g. memory)

3. Engaged: This property considers how "ongoing interaction with the surrounding environment is recognised as primary". Heuristics are adjusted to specific environmental contexts. The adjustment of the decision mechanism is contingent upon the structure of the task environment which demands that a decision maker consider the inference task as an ongoing activity rather than a static activity. The heuristics are always engaged with the environment in search for information, like running to catch a ball. The player has to constantly re-calculate his body alignment and running speed based on his perceptual information of the trajectory of the moving ball.
4. Specific: Specificity refers to the fact that "what people do is seen as varying, dramatically, depending on contingent facts about their circumstances". For ecologically rational inference, the given circumstances are crucial to the decision maker. Subtleties and minute differences in the specific nature of the task can lead to quite different cognitive tools being used. Circumstances where subjects are required to act under time pressure show how the choice of decision strategy changes as a result, displaying a strong tendency by the decision maker to prefer simple sequential cue-based decision mechanisms.
5. Embodied: The importance of embodiment refers to the fact that "material aspects of agents' bodies are taken to be both pragmatically and theoretically significant". The Gaze heuristic for ball catching is a process that relies on a particular morphology: an eye and a bipedal locomotion system. An agent with a different morphology (with wings and echolocation) will apply a different process for the same task.
6. Social: Being social means "being located in humanly constructed settings among human communities". Ecological rationality must acknowledge that a significant part of environment structure will often be made up of other individuals and the results of their actions, whether choosing a mate;

[22] It refers to those processes that cannot be achieved in polynomial time.

selecting a parking space, deciding how to communicate important information.

V

The central claims of the doctrine of embodied cognition may make one wonder why environmental context/situation did not highlight in previous theories of human rationality. To be fair to the traditional theories, one point of defence can be that the paradigm in which cognition was understood was computational. Failures in decision making and reasoning tasks were seen as performance errors of certain kinds. Thus, inherently, our cognitive system was expected to be computational. So we were expected to have the competence, but in certain typical conditions we committed performance errors. These conditions varied from our cognitive limitations, like memory limitation, limited processing speed; to even context variation. Initial experimental studies to investigate the nature of human reasoning (where logicality of reasoning was challenged) showed that performance varied depending on the context of the task. Wason Selection Task was one such experiment performed by Peter Wason, which went on to become one of the most tried experiments to test the logical performance in a reasoning task. Some posited the performance variations in the Wason Selection Task was due to the fact that "real-life content" in the same format of the task led to better understanding of the problem. The question is, what was in the real-life content that made the decision-maker see through the problem better and come up with a solution. The correct, logical response to the problem was attributed to the presence of real-life context in the problem. It seems strange that logical performance depends on the 'content' of the logical problem being presented.

May be we did not probe deep enough. We were constrained by the computational paradigm, which made us emphasise more on some aspects while ignoring others. We ignored why the real-life content made the problem easier to understand. Familiarity of context within a given problem does simplify our 'seeing through the problem'. Thus, we may exploit "stable environmental features" or "context features" to simplify cognitive tasks. Furthermore, the information flow between our minds and the world is so dense and continuous that any meaningful analysis of the cognitive processes behind any cognitive act must take note of the impact of such transactions.

We must be careful to note that ecological rationality also talks about rules; there are computational aspects in cognitive processing. But to consider these rules only as innate is a mistaken position. Rules may be innate in the sense that they have been learned (evolved within us through our exposure to nature and in overcoming various kinds of challenges in our evolutionary history). In the current paradigm of situated cognition, if cognition's being situated means that cognition is adapted to serve needs of survival and would take advantage of stable environmental structures to simplify and speed cognitive processing, then why can we not assume that cognitive rules of reasoning may have similarly adapted? Decisions are rational if they are able to solve the problem at hand – which also must be in sync with the external reality. Embodied approach to cognition does open a relevant approach to comprehend human rationality as a mechanism evolved and adapted in an environment which constitutes an integral component in the matrix of our life.