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Is bounded rationality a capacity, enabling learning?

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Comments are welcome

Abstract

This papers contributes to the stream of research on rule based behavior, and rationality. A bounded rational agent can deal just with a reduced number of variables, neglecting part of the overall complexity. This is usually taken as just a limitation: agents cannot deal with all relevant information and use biased decisional shortcuts. The stream of research on Ecological rationality, yet, evidences the possible advantage of using a limited amount of information. The present paper takes a similar, but not identical, point of view. I propose an idea based on some contributions on the ecology of the mind by Gregory Bateson. Learning requires to recognize a series of situations as identical and then to observe the effect of given variables in specific fixed contexts. Two situations can be considered identical only limiting considering part of the overall information and taking as unchanged a series of factors. This process determines an individual representation which have just to be coherent with the world. Only in abstract world contexts are objective situations. In the real world, they are just hypothesis to be continuously tested. This vision of bounds and learning has many implications for the debate on rationality and rule following.

Keywords

Bounded rationality, ecological rationality, cognition, Gregory Bateson, contexts, learning, rules

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Is bounded rationality a capacity, enabling learning?

If the doors of perception were cleansed, every thing would appear to man as it is, infinite
(William Blake -*The Marriage of Heaven and Hell*)

Introduction

This papers contributes to the stream of research on rule based behaviour and rationality. It tries to understand if bounded rationality can be seen as an adaptive capacity instead than as a limitation. Bounded rationality implies a reduced capacity to evaluate and use information. A bounded rational agent can deal just with a reduced number of variables, neglecting part of the overall complexity. This is usually taken as just a limitation: agents cannot deal with all relevant information and use biased decisional shortcuts. The stream on ecological rationality (Gigerenzer & Todd, 1999), on the contrary, evidences how fast and frugal heuristics - rules which uses just few information - can be advantageous in the real world. Rationality is redefined, as it cannot be evaluated in reference to the abstract word of mathematics and logic, but has to be measured in an evolutionary perspective. Human beings developed their cognitive characteristics in an environment where the tendency to take fast decisions - using few clues and without the need to make hard computations - allowed an evolutionary advantage and were, therefore, selected, becoming part of the human nature.
The present paper takes a similar, but not identical, point of view. I propose an idea based on some contributions on the ecology of the mind by Gregory Bateson. His work is usually neglected in Economics, but I think it can be useful for understanding learning and bounded rationality. In my view, bounded rationality may be seen also as the attitude to make abstractions, and therefore limiting the perception of differences among situations. This capacity to generalize is necessary to deal with a complex world, as it reduces the amount of variables to manage, but it can be also, and even mainly, necessary to learn. Learning, in fact, requires to recognize a series of situations as identical and then to observe the effect of given variables in fixed contexts. Two situations can be considered identical only limiting information considered and taking as unchanged a series of factors. Only in abstract world such contexts can be objective. In the real world, contexts are just hypothesis which have to be changed with the evolution of knowledge and of the same environment. Even in scientific experiments, *ceteris paribus* conditions have to be considered hypothesis, as something relevant, but hidden, could affect and undermine expected results.
This vision of bounds and learning has many implications for the debate on rationality and rule following, that I try to preliminarily discuss.
The first section of this paper synthesizes the literature on bounded rationality, showing that such attitude can be described both as a liability and as an asset. The following section describes the link between bounded rationality and rule-following; it also describes how, in an evolutionary perspective, we need to explain at different levels the advantages of rule-following and the usefulness of specific rules. Rule-following have to be compared with other information processing approaches, but this comparison requires explaining the same bounded rationality. Section 3 links the previous discussion with the different level of learning in Bateson's view. Section 4 tries to show that some kind of bounded rationality is a pre-requisite for being able to learn and discuss some implications of this view for the discussion on rationality and knowledge. The last section concludes.

1. Bounded rationality as a liability or as an asset

Bounded rationality is usually presented as a kind of limitation of the human cognitive and decisional capacity, as it same label seems to evidence. Conslik (1996), as an example, observes that sometimes agents behave in a way which can be described with the following words by Puck, the Shakespeare's character in "A Midsummer Night's Dream": "Lord, what fools these mortals be!”. According to Conslik (1996), there is, in fact, now plenty of evidence confirming that human rationality is bounded. Some of the models based on this idea proved to be quite efficient. Unbounded rationality, besides, is logically inconsistent: if an agent evaluates all costs, also energy spent for this same elaboration should be considered. This would require a kind of pre-analysis to determine how many data should be used. Before this, it would - yet - also be necessary a calculus to determine how much energy should be devoted to the pre-analysis, and so on in an infinite regression. The logic of evolution and competition, besides, cannot account for a perfect and complete elimination of all non rational agents. A firm can go bankruptcy, but how can irrational consumers be selected off? In some cases, therefore, Economics should include in its model less than rational behaviour.

This aim has been mainly pursued by behavioural economists as, for example, Daniel Kahneman whose Nobel Lecture was titled just "Maps of Bounded Rationality" (Kahneman, 2003). His works with Tversky are famous for having shown a series of biases in human judging and decision making.

These positions are strongly criticized by Gigerenzer and his group (see, as an example, Gigerenzer & Todd, 1999). In their view, bounded rationality is meant as an attitude to use just part of overall information but it doesn't imply irrationality. On the contrary, in many cases, *less* can be proved to be better than *more*. In fact, in many real world settings, using a limited amount of information allows better results, as optimization techniques would require too much computational resources and time. Besides some real world problems are mathematically intractable and ill defined and cannot be solved with mathematical techniques. Cognitive limitations can, therefore, stimulate adaptive decisions. As perfect rationality is just possible in the abstract world of logic and mathematics, decisions should, in fact, be evaluated in term of their adaptiveness. Rationality has, therefore, to be defined in ecological terms. Irrationality is usually defined just in relation to an ideal and unrealistic world. When the starting point is the real uncertain environment, a different approach is needed. Knowledge and strategies have to be constructed and developed. There is no utility function to indicate the optimal solution; aspiration levels have to be fixed and changed, in a continuous adaptation to the environment (Selten, 1998).

Both of the approaches recalled can be founded in the work of Herbert Simon. He introduced the idea of bounded rationality (see as an example Simon, 1983) to criticize the neoclassical approach to decision. He just noticed that standard rationality implicitly requires the capacity to deal with all relevant information. Real persons don't have this capacity, and can just use a limited amount of variables. As information is not given neither perfect, the mechanism for searching and selecting variables are the key factor in decisional processes. Knowledge is not given. As there are plenty of information, agents should, learn to read the environment and to react to some of its stimuli. They have to develop intelligent strategies to deal with a complex world.

As noted by Rizzello (1999), with his theory on bounded and procedural rationality Simon proposes both a *pars destruens*, criticizing neoclassical view, and a pars *construens*, in which he tries to model behaviour in a more realistic world. The two streams recalled before, in some way, seem to focus on one of the two different approaches. Behavioural economics uses environment similar to the standard neoclassical one, and therefore points mainly to the limitations in human rationality, defined in relation to a standard perspective. Gigerenzer and his group start from a different perspective less grounded in economics contexts and discussions and try to find the effective heuristics used by real persons.

Hayek (1967) shows many similarities with Simon, as evidenced by Rizzello (1999). Given their computational limits, human beings need to reduce the complexity faced, focusing on a limited number of variables. In a free market environment, as an example, the institutional arrangement spontaneously evolved, allows actors to take decision considering just the price. Just the existence of institutions and the individual tendency to follow simple and abstract rules allow bounded rational individuals to survive and be efficient in such a complex world. Rules are therefore the alternative way to found the need for free market, in substitution to the neoclassical perfect rationality.

Also in Heiner (1983) the reduced human capacity to deal with complex environments - what he calls a Competence-Difficulty gap - stimulates and make at the same time appropriate a reduction in the capacity to consider variables. A perfectly rational agent, in any situations, should take into account all information available, given his capacity to evaluate and include it into the analysis. Given limited knowledge and computational capacities, it can be better focusing on the few variables, whose reliability was proved, than trying to consider all of them. This reduced perception determines a limited set of choices too. Again, limiting the use of information and focusing on few choices can be seen as a useful way of dealing with the real world.
Vanberg (1993) tries explicitly to integrate rule following and rationality, breaking what he consider a wrong dichotomy. Rule following is, in fact, the best way to survive. A rule-following agent, using reliable actions, can outperform those trying to consider all information. Given bounded rationality, rules selected trough a process of prove and errors allow better results than case by case choices (Hayek, 1967). Bounded rationality is taken as given and determines the need to simplify. Hertwig and Todd (2003) yet, revert the causality effect. Bounded rationality could be result of the usefulness of simple and fast heuristics. The capacity to use heuristics requires limitations and stimulates such tendency. A less limited agent could not be able to apply simple rules, trying to maximize. The desire to maximize could be an anti-adaptive attitude where competition requires fast choices.
In abstract term, rationality could have been less bounded. Evolution, in fact, proved to be able to shape "prodigious processing" (like motor coordination) and "exceptional individuals" with "extraordinary abilities" for computation or memory (Hertwig and Todd, 2003, p. 224). If this is not the norm, there should be a reason: bounded rationality is a kind of skill.
Similarly to reliable action by Heiner (1983), heuristics should be robust to different contexts. Robustness requires often abstractness, as we'll see better later. While heuristics have to be simple, their simplicity has to be smart. Smartness is again and necessarily determined by natural selection and is, therefore, a product of the specific environment faced. Beyond such environments, heuristics determines biased decisions.
The human tendency to abstractness and to reduce the amounts of information considered emerges also in many non economics approaches. Again we can find different evaluations of this characteristic. Henry Bergson (1946) criticizes what he sees as a common human attitude: the tendency to abstract and generalize. Generalization, in fact, is not a product of the capacity to find elements of unity in different domains. It usually arises because of the human incapacity to see differences and varieties. Brain and nervous system relate past and present, finding similarities, reducing complexity and forgetting differences.
Semir Zeki (2001) describes the visual brain using two hypotheses: "the law of constancy" and "the law of abstraction". In his view, the brain is designed to search for "constant and essential properties of objects and surfaces" (Zeki 2001, p. 51) and to subordinate the particular to the general. These two laws are linked: "abstraction is a critical step in the efficient acquisition of knowledge; without it, the brain would be enslaved to the particular. The capacity to abstract is also probably imposed on the brain by the limitations of its memory system, because it does away with the need to recall every detail" (Zeki 2001, p. 51).
As the capacity of visual short-term memory is limited, the ability to select the most relevant information from the environment - filtering off all useless details - seems to increases long term memory (Vogel et al, 2005). Brain's storage capacity would be fixed for all individuals. Differences in memory could therefore be related to the capacity to select off what is irrelevant (McNab & Klingberg, 2007). Selection of the information to be retained could be done by the common activities of prefrontal cortex and basal ganglia. Basal ganglia could have the specific task to give the mental strength necessary to reduce information processed[1]. Basal ganglia are quite old mental structures. Also reptiles have basal ganglia and could therefore be capable of generalization. Given Bergson's idea of abstraction, this could not be a surprise.

[1] Focusing on few variables can be useful for pursuing a specific aim, but what abut the efficiency of the specific goal pursued? I can set the goal to be a good rabbits hunter; focusing my attention on all the hints needed to catch this animal. But what about the rationality of choosing this kind of food?

All of these analysis point to a link between human limitations and some attitude to use a reduced set of information to simplify and manage real world complexity. Such simplicity could have selective advantage over completeness. Some mental structures could, therefore, just have evolved to filter off information. Even the tendency to follow cultural rules can be seen as an evolutionary adaptation useful for overcoming bounded rationality. Instead of increasing some capacities, selection could have developed mechanisms aimed at stimulating a reduced use of information.

2. Evolution and rationality

Vanberg (1993) and Hayek (1967 and 1964) take bounded rationality as given, and show how rule following can outperform case by case choices, if rules are selected by an evolutionary mechanism. Competition among routines selects reliable rules. As both Hayek and Vanberg states, yet, there are different levels of rules. A particular attention has to be given to the competition between the higher level rules defining how to deal with information. The competition among routines at the last levels cannot explain the same preliminary tendency to follow rules which is the result of a different mechanism of selection. From a logical point of view, specific rules are part of the general class containing "Rules". We can imagine a competition among the elements of this class, but the same class is not part of the category and should eventually compete in another class of behaviours. The tendency to follow rules has, therefore, to be differentiated by specific rules and it has to be selected against other kinds of information mechanism (as case by case one). So we need to pay a specific attention to this level of the selection processes. Competition among rules selects more advantageous ones, but cannot account for the usefulness of the same rule-following. So to justify rule-following we need to compare it with other mechanisms; in other words, we need to imagine a different preliminary selection contest among mechanisms to deal with information[2]. The problem, therefore, is: how can rule following be reinforced against case by case choice? If we take bounded rationality as given, this question could be useless and the answer obvious. Bounded rationality implies rule following. In fact, it determines a reduced capacity to recognize variables and contexts (as we'll see better later). A person, who has a limited capacity to take into account variables, has also a limited capacity to recognize differences and therefore a limited need of different actions. If I consider all persons identical, I need just one rule to deal with them. If I recognize each person as different (as I evaluate them using more clues, and do not just consider them as part of the human class), I need a wider set of actions for interacting with them. Bounded rationality is, therefore, at least in part coincident with rule following. More in general, if agents are not able to consider all information, they should have also a reduced capacity to recognize cases and therefore to make case by case choices. Under bounded rationality a comparison between rule following and case by case choice doesn't make, therefore, much sense.
On the contrary it could be interesting trying to understand the same existence of bounded rationality. Another consideration leads in the same direction. Rule following can be seen as a way to deal with bounded rationality, taken as given. We can imagine an evolutionary process in which rule-follower bounded rational agents outperform case by case bounded rational decision-makers. This explanation suggests a question: if evolutionary processes stimulated mechanisms for deal with bounded rationality (as rules, or as memory filters), why didn't it stimulates an increased capacity to deal with information? Hertwing and Todd (2003) think that an increased capacity is not unrealistic. So this question is not completely provocative. Bounded rationality can be taken as something given, or it could be seen as the result of a process in which less is better than more. If

[2] From a different perspective case by case choice can be seen as one among other rules and therefore we could imagine a competition between rules using more or less information, given the need to simplify (optimization can be seen as a well defined rule which requires yet, again a series of simplifications; while economics agents have a perfect rationality, economists have the need to simplify and, in fact, they focus on few variables, inserting in the utility function all other information). The present analysis can be useful also under this perspective, as I'll try to show how limiting perception can help in learning.

we take the first position, we do not explain bounded rationality, taken as given. Yet, we have to deal with a kind of paradox: why evolution shaped mechanisms to deal with bounded rationality instead of favoring more rational agents? The second position is stated by Hertwig and Todd (2003) and is developed here along similar but not identical lines. I focus less on action and more on perception and knowledge. My starting point is that agents have to learn to deal with the surrounding environment. Knowledge can either be pre-given or acquired by cultural or genetic learning. If we start from the second idea, bounded rationality, defined as the tendency to limit the amount of information considered, can be seen again as a necessary skill. If we want to explain how rule following can be useful, we need a different approach: instead of considering bounded rationality as given, we should try to explain it. As it seems to be such a pervasive phenomenon, it may be worth trying to understand its origin. This can be done developing some ideas already stated in Vanberg (1993). I adopt a *construens* approach while he is probably more concerned with a different and proper aim: that of criticizing the mainstream.

3. Bateson and the contexts of learning

Bateson (1973) proposes an evolutionary analysis of the mind, modeling different levels of learning. A person hears a bell and learns that is midday and she have to go home for lunch. If this reaction is stable, the person is simply reacting to information. Bateson individuates this as "zero learning". Most of economics models imply just this level. Agents already know and just have to acquire information and react to the new data gathered (like a change in a price). The following level implies a change in the way agents react to a signal. At time t, when information A is seen, there is no reaction. After our agent has undertaken a learning one process, on the contrary, information A determines a new reaction, differently from what happened before[3]. A well know example of what Bateson define learning one is the Pavlovian conditioning. After the experience in its laboratory, a dog reacts to a buzzer producing saliva. Before the training, the same dog didn't react to that same stimulus. So learning I implies a difference between a first and a second moment and determines an evolution in the behaviour, which creates a specific relation between the agent and its environment. All examples of learning one are based on some process of trial and error which determines fixed reaction to a given stimuli.

There is a point that is worth noting: learning one implies also the capacity to abstract. A given answer is repeated in a series of situations, in response to a signal which can be never completely identical. In general term, besides, to be able to learn, agent should recognize a stable context. Within and given the context of the laboratory, Pavlov's dog learn to react to the stimulus (a generic buzzer sound), while it doesn't react to the same buzzer, outside this environment. An agent can individuate a stable reaction between two variables, only within a given situation perceived as stable. If the world would change (or be perceived as different at) every second, there would be no room for learning as no trial and error or reinforcement can happen. Learning implies a change, between two moments, but in a stable environment. The capacity to identify a context is necessary to learn. If there is no such capacity, there could be no way to learn and the eventual behavioural change has to be seen as pre-programmed.

Context recognizing, therefore, implies abstraction. The stimulus should be perceived as identical in all repetitions. Abstraction determines, therefore, the perception of the existence of a variable. At the same time, also all the rest of the environment has to be perceived as stable. If the capacity to define these similarities is missing, no variable can be defined, no context is fixed, and no stimulus can be perceived.

Abstraction is even more relevant considering learning II, the further step in Bateson's hierarchy of adaptation. Learning II is defined as a change in the way learning I happens. Bateson names it also "learning to learn", to indicate that it affects how learning one takes place. We can better explain this idea with an example. In a given (experimental) environment, a buzz announces the

[3] There is learning even if before the training, there is a reaction to information A, and after the training, it has no effect.

possibility of a reward, which can be obtained pressing a red button. Pressing the red button in the absence of the signal is not rewarded. Pressing another buttons, before or after the buzz, doesn't have any effect. After a phase of trial and error, our agent can understand the link between the sound and the need to press a specific button. Now, imagine the same agent faced with a new similar environment, where a stimulus (not necessarily a sound) is sometimes given and different actions can be undertaken. Agent will probably try to find a specific reaction (one of the possible actions) to the stimulus, as in the first environment. Previous experience and learning II make agent looks for a specific segmentation of the new reality, where an action should follow to a stimulus. Bateson (1972, p. 294) exemplifies this situation in this ways:

> In the Pavlovian case: If stimulus and a certain lapse of time: then reinforcement. In the Instrumental Reward case: If stimulus and a particular item of behaviour: then reinforcement. In the Pavlovian case, the reinforcement is not contingent upon the animal's behaviour, whereas in the instrumental case, it is. Using this contrast as an example, we say that Learning II has occurred if it can be shown that experience of one or more contexts of the Pavlovian type results in the animal's acting in some later context as though this, too, had the Pavlovian contingency pattern. Similarly, if past experience of instrumental sequences leads an animal to act in some later context as though expecting this also to be an instrumental context, we shall again say that Learning II has occurred

In this way successful solutions are applied to a new set of alternatives, and therefore to new contexts. Similar solutions are generalized to different domains and habits tend to spread among class of problems. Learning II, therefore can help in reducing the number of trial and errors needed to find a solution, but only at given condition. While Learning I is always adaptive, Bateson (1972, p. 294) notes:

> Learning II is adaptive only if the animal happens to be right in its expectation of a given contingency pattern, and in such a case we shall expect to see a measurable learning to learn. It should require fewer trials in the new context to establish "correct" behaviour. If, on the other hand, the animal is wrong in his identification of the later contingency pattern, then we shall expect a delay of Learning I in the new context. The animal who has had prolonged experience of Pavlovian contexts might never get around to the particular sort of trial-and-error behaviour necessary to discover a correct instrumental response. (p 294)

Habits can spread only when founded on a proposition that is sufficiently general to be true in more occasions. So usually there is a link between the possible existence of habits and abstraction. From another perspective, only general habits can spread and therefore learning and adaptation tend to create generalized solution. Habits have to be founded on statements that are generally true and which can be applied to different domains. Statements can be seen as representation of the world, or as contexts. They have to be abstract.

Usually, yet, most efficient solutions require a specific adaptation to an environment. General solutions, therefore, could hardly be the best one. An example is given by a rule like: "avoid all reptiles". Some of these animals are really dangerous, but not all of them. If we cannot distinguish the dangerous ones from the others, it can be better avoiding all of them; that is creating a unique category which includes all reptiles. A rule like "avoid all reptiles" is not efficient, but has some advantages.

There could be rules which are often true even if or, just because they are generic. The more general a statement, the less it can be falsified. According to Bateson, in some cases specific segmentations cannot even be really tested and falsified. Consider our previous example of learning II. In the new environment, the agent could fail to find the correct action in reply to the stimulus, and he could just carry on with trial and learning, if there are lots of possible responses. The failure could just be due to the difficulty of finding the correct action, among all possible ones. Bateson says that segmentation is like seeing a picture in an inkblot: there is no wrong or correct way and therefore no clear feedback.

Learning and abstraction seems therefore to be related in many ways. So, if we accept as a starting point the idea that agents have to learn, the capacity to recognize contexts is necessary[4] as it is the related attitude to focus on part of the information and make abstractions at different levels. A complex world allows recognizing multiple contexts, which is it contains various ways of dealing, successfully, with the environment. As rules are abstract and un-specific there could be room for different representations of a same environment. For this reason, learning can take different forms.

4. Learning, bounds, and rationality

In a stable world, learning requires the capacity to make abstractions. Bergson (1946) distinguishes between two kinds of abstraction: one which has to be seen as a reduced capacity to see differences, and another which represent an ability to find elements of unity among different situations or items. This distinction is a fundamental starting point to evaluate the rationality or usefulness of bounds in information use. A rational agent neglect irrelevant information. Bounded rational individuals neglect also relevant information. But what information is relevant? Contexts should be defined leaving a part what is not relevant. A part from the abstract world of economics and logic, recognizing two contexts as identical is not easy, nor even obvious and maybe impossible in absolute and objective terms! According to Bateson, a same situation can be perceived, or segmented, in different way, in relation to what is perceived as a stimulus or as a response. A variable becomes relevant if an agent decide to react to it and according to the kind of reply chosen.

Gould & Lewontin (1979) represent evolution in a similar way. There is no objective environment, unique for every species and agents. Any environment is subjective and created by a reciprocal interaction between all of its involved elements. The key point has to be found in the information exchanged and in the kind of relation established with the surrounding world, individuals and species. This subjective environment just has to be compatible with the objective one, but there are multiple forms of compatibility. In other words, there are more ways to survive in a same environment, as shown by the variety of living species which populate the world and live pursuing different strategies. As underlined by Simon (1983), species are rarely competing for the same resources. They develop different niches and therefore different relations among themselves and their environment.

The relation between bounded rationality and learning relies on contexts recognizing. To recognize a context, agent need to neglect part of the information, focusing on just some variables and considering the others as given. Some information becomes fundamental and other irrelevant, as specific aims are now fixed.

Pavlovian dog should, as noted by Bateson, forget the time (which is irrelevant, if an environment is stable), and with it, obviously, all what changes among the different moments. While some of this changes are irrelevant for the relation between the stimuli and the arrival of the food, others are, yet, not so extraneous. Notably the most relevant variable is Pavlov's willingness to feed the dog (a variable that depends on other ones, by the way). The buzzer is just a sign of Pavlov's willing (at the beginning not even voluntary). The dog notices that within the laboratory, after the sound, it always gets food, notwithstanding eventual other differences which appears, therefore, to be not relevant. The past experience determines a justified conjecture about the future, based, yet on the incapacity and impossibility to understand the real relation of cause and effect and to observe all the relevant variables. The fundamental information is hidden and, in fact, the dog salivates even when the buzzer rings just to test its reaction.

The past is not always reproduced in the future, even when, we would expect it, according to our experience. Something change and we miss it. The Greek philosopher Heraclites stated that "into the same rivers we step and yet we do not step, we exist and at the same time we do not exist".

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[4] When we say that agents have to learn, we are stating something different from a bounded rationality hypothesis, as we are speaking of their missing knowledge and not of their cognitive capacities.

Bounded rational agents are not able to recognize all these changes, but in this way he can understand if a river is dangerous and have to be avoided, or if he is good at swimming or not.
A complex world can be seen in different ways, many of which compatible with the real unknown one. Should we take perfect rationality, as defined in a logical world, as a reference point? Or should we take ecological rationality as our judge? If so, are we allowed to consider human beings more rational than other creatures which have existed for longer time? Or should we evaluate human knowledge in reference to an ideal Truth? Probably the answer depends on the perspective we decide to take. Difference interests explain the differences among philosophers, mainstream economists and other social scientists.
In my view, in Economics, the rationality of bounds should be evaluated in its relation with learning. Recognizing contexts can be seen as a tool, or, in other words, as a form of procedural rationality[5] which can activate learning and therefore allow better and better decisions. Considering limited contexts can be the only way to learn and therefore this is not a limitation, if, contexts are changed, refined and evolves, according to the feedback and the experience gathered.
Besides, if we want to model learning, we should probably consider bounded rationality as a starting point. In fact, it determines in which way learning takes place. Contexts need to be defined and explored, but have to be eventually refined or changed. In a new and unknown environment, fixing a context is necessary for learning, but it could eventually stop a further understanding of the environment, if it is not seen as a tool. What allows us to learn, at the same time, constrains further learning. Representations can differ in they efficiency, in their possibility to be applied in different domains, and in their capacity to evolve and change. So some representations can lock evolution of knowledge. When and how this happens is a problem to be studied, as it affects the capacity to take good decisions[6].
The vision of bounded rationality proposed here is connected with Popper's view of decisions and science as trial and error mechanisms. As we need to fix contexts for learning, we also need to continuously test and eventually change them. As Vanberg (1993) states:

> in order for trial and error learning to work, the behaving organism must somehow, explicitly or tacitly, classify problem situations into categories of situations which are, in some relevant sense, 'similar'. Such classification embodies, in essence a conjecture about what makes situations, in a behaviourally relevant sense, similar or different.

Trial and error is necessary to learn and it requires categorization and therefore the need to neglect part of the differences. Defining a context allows to test a hypothesis (in the context C, A determines B or in context C, in order to get a reward, I have to chose the action X), as in the scientific experiment.
Even errors arising from an imperfect capacity to keep up with a given choice, can be useful, for the same reason. Grobstein (1994) notes that variability in behaviour, even when a task seems to be well known, can have beneficial effects in adaptive terms, as the right context for a specific action is not a given date. A certain level of exploration, arising from errors, can usefully go with the adaptive capacity to repeat successful choices. There is, again, a trade off. Opposite tendencies can be both beneficial and the right mix could depends on the environment.
Rationality needs therefore to be studied in a dynamic context and in relation to agent's environment. An example can be useful. An agent creates a context C1, when both the variables x and y are equal to one, neglecting the variable z. So all of these situations

1) x= and y=1 and z=1
2) x= and y=1 and z=2
3) x= and y=1 and z=3

[5] This perspective allows a different and new unifications of the two sides of Simon's approach.
[6] Heiner (1983) gives some insights on the innovation in behaviour, but his model is mainly static and need to be further studied and developed.

are seen as identical. Given C1, the agent chose the action A1 which can give a different payoff, P, according to the value of z:

if z=1, P= 3
if z=2, P=2,
if z=3, P=-10

If z=3 is a rare event, our agent could have no incentive (and even possibility) to look at z and therefore his representation of the world would neglect it. As rules are understood as a product of a specific past and experience they could not be able to deal with unusual situations or *black swans* (Taleb, 2007).
This simple example just tries to show how learning could depend on the environment and on its stability. Rationality should, therefore, be defined also as a relation between the different agents interacting and their environment, as in Bateson's systemic approach.

5. Conclusion

I tried to understand if bounded rationality can be beneficial. This same idea is proposed by others, like Gigerenzer & Todd (1999), whose definition of bounds have to intended as a attitude to take decision based just on few information. In their view, the limited amount of variables taken into account doesn't imply irrationality or even a reduced capacity to take good decisions and solve problems. On the contrary, simplifying complexity can be useful, if and when there is the capacity to concentrate the attention on the appropriate information. A similar idea of bounded rationality is proposed by Vanberg (1993) whose aim is that of showing the rationality of rule following, given bounded rationality. The idea I tried to develop is similar, but introduces elements I haven't explicitly found in the recalled papers.
I focused on the need to recognize contexts as a necessary step for learning and even for self recognition (an obvious precondition for learning). To recognize a context, a large part of available variables should be ignored. Understanding if part of the neglected information is really irrelevant is a matter of experience which requires a trial and error process. So rationality has to be evaluated in a dynamic perspective because it is a product of the past and of the specific situations experienced. Innovation has to be seen as a change in this structuration of the reality (Bruner, 1991). Rules following is, therefore, a necessity, and have to be seen as an attitude to extract specific information and use them to build a given segmentation of stimuli and reactions. This process could be defined as rule based perceptions. Rules are, in fact, seen here more as constrains on attention than on choices, as they determines the way in which reality is defined. For this reason rules can be also seen as the building blocks of human knowledge (Vromen, 2004).
The eventual need to recognize contexts determine a specific form and a series of possible constrains on learning. The creation of a contexts has to be seen as a tool, allowing - at least at some conditions - a better way to deal with the environment and therefore a possible evolution in behavior. Once fixed a context, in fact, an agent can also learn to respond to more variables within it. Contexts can be refined into sub contexts, creating sequential decision (Simon, 1983) or a hierarchical structure, where a variable at a time is considered and define the further path of analysis (Heiner, 1983). As contexts imply a reduced complexity, they can be easily explored and understood. Within contexts agent can even tries to deduce and make some computations.
If we define a context using too much information, it could be hardly repeatable and then trial and error would be impossible[7]. Without come kind of bounded rationality, even categorization and abstraction would be impossible, as categorization requires the capacity to simplify. Even at a pure logical level, abstraction requires the capacity to forget something, and to reason considering

[7] In order to repeat a successful action in a new situation, an agent should find some similarity with what experienced in the past. Abstraction can help also to reduce decisional time. Evaluating all differences and similarities with the past can requires time, and be an infinite process. Only a limited amount of information could probably be considered at a time.

ceteris paribus. Without abstraction there could be no theories (as there would be no two identical situations) and therefore not even deduction.
Agents should be able to change their representation of the world but, probably, should also have the capacity to maintain a given idea which proved to be useful in the past. Contexts building allows creating knowledge but can constraining and limiting its further evolution, at least at some conditioning that need to be studied, to understand individual performance. Rationality should therefore be evaluated in relation to its capacity to find relevant contexts and appropriate generalizations and to switch to new hypothesis or contexts definitions.
Usually Economics uses well defined contexts, when studying learning and decision. There is no problem in recognizing them. Given the idea presented here, on the contrary there is the need to study how and when contexts are defined and changed. The processes of abstraction and context recognition and their Economics effects need to be studied and better understood. Economists usually define a priori the variables relevant for the individuals and these are almost often related to material incentives, independently from the history and experience of the agents and from the complexity of the environment. Usually economic agents have the opportunity to learn in stable and well defined fixed contexts and interacting with representative agents all identical. So, in most cases, reinforcement mechanisms lead to automatic optimal decisions. This can be seen as a paradox, but in a fixed environment, when the best choice has been found, there is no way to change and no need to think. Just a world with multiple contexts enables and requires reflection and the use of cognition.
Ambiguities and problems in contexts recognition allow also persons to understand the real nature of their knowledge. When someone is not sure about the nature of the environment faced, this creates a decisional problem, and determines discomfort in the individual. This situation undermines the same base of knowledge. Yet this kind of discomfort can be the key to understand its nature and evolve it. Errors and difficulties can be useful and frustrating at the same time.

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