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# Exploring the concept of homeostasis and considering its implications for economics☆

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ABSTRACT

In its standard format, the concept of homeostasis refers to the ability, present in all living organisms, of continuously maintaining certain functional variables within a range of values compatible with survival. The mechanisms of homeostasis were originally conceived as strictly automatic and as pertaining only to the state of an organism's internal environment. In keeping with this concept, homeostasis was, and still is, often explained by analogy to a thermostat: upon reaching a previously set temperature, the device commands itself to either suspend the ongoing operation (cooling or heating), or to initiate it, as appropriate. This traditional explanation fails to capture the richness of the concept and the range of circumstances in which it can be applied to living systems. Our goal here is to consider a more comprehensive view of homeostasis. This includes its application to systems in which the presence of conscious and deliberative minds, individually and in social groups, permits the creation of supplementary regulatory mechanisms aimed at achieving balanced and thus survivable life states but more prone to failure than the fully automated mechanisms. We suggest that an economy is an example of one such regulatory mechanism, and that facts regarding human homeostasis may be of value in the study of economic problems. Importantly, the reality of human homeostasis expands the views on preferences and rational choice that are part of traditionally conceived *Homo economicus* and casts doubts on economic models that depend only on an "invisible hand" mechanism.



## 1. What is homeostasis?

The idea behind homeostasis originated with the French physiologist Claude Bernard, in the late nineteenth century. Bernard noted that living systems needed to maintain numerous variables of their internal milieu within fairly narrow ranges so that life would continue and did so quite naturally (Bernard, 1878). The essence of the internal milieu (*milieu intérieur* in the original) is a large number of coordinated chemistries. The standard bearers of such chemistries can be found in the blood stream, where they help accomplish metabolism, and in certain circuits of the nervous system where parts of life regulation are coordinated. The chemical messaging makes the processing of energy sources possible by ensuring that water, nutrients and oxygen are present in living tissues in appropriate quantities. This is necessary so that the respective cells maintain their individual lives, and that the organism can survive as an integrated whole. Deviations from the requisite

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level of certain variables above or below specific critical values, result in disease, and, if not corrected, death. The genomes of all living organisms ensure the machinery of homeostasis.

The term homeostasis, in turn, was coined by Walter Cannon, an American physiologist (Cannon, 1929) half a century later and he too was referring to living systems. To name the process he chose the Greek root *homeo*- [for similar] and not *homo*- [for same], because, rather than thinking about fixed set points, which are often present in systems engineered by humans, such as thermostats, he was thinking of systems engineered by nature, whose variables often exhibit workable ranges—hydration, blood glucose, blood sodium, temperature, and so forth. The synonymous terms "allostasis" and "heterostasis" were introduced later with a good purpose: calling attention to the fact that life regulation operates relative to ranges of values rather than set points (Richter, 1943; McEwen, 1998). But the idea behind those more recent terms is not essentially different from the one conveyed by the original term and the terms have not entered common use (Day, 2005).

The main problem with the classical concept of homeostasis, however, has little to do with terminology. The problem is that the traditional concept of homeostasis does not usually conjure up the fact that there are two distinct kinds of control of internal milieu parameters, and the extraordinary significance of that duality is thus ignored. Specifically, the traditional concept of homeostasis calls attention to a non-conscious form of physiological control which operates automatically without awareness or deliberation on the part of the organism. Indeed seeking food or drink when energy sources are depleted can be achieved by most organisms without any willful intervention on their part. Should food or drink not be available in the environment, hormones automatically break down sugars stored in certain cells and deliver them to the blood as needed to offset the deficit. Likewise, when water balance is low, the kidneys automatically slow down their operation in order to reduce diuresis and restore the level of hydration (Kotas and Medzhitov, 2015).

In numerous living creatures, however, and in humans for certain, the traditional concept of homeostasis provides an incomplete version of reality. Humans also benefit from automatic controls, of course. But in human beings and in good probability in most vertebrates, there is a supplementary mechanism of control that involves feelings of the simplest variety, also known as homeostatic feelings. We need to know what homeostatic feelings are and how they operate (Berridge and Kringelbach, 2015; Damasio, 2000, 2010; Damasio and Carvalho, 2013).

## 2. Augmenting the range of basic homeostasis by means of feeling and consciousness

Homeostatic feelings operate within the compass of basic homeostasis. They intervene in the solution of essential problems of life regulation. Examples of homeostatic feelings include thirst, hunger, desire, pleasure, well-being, malaise, and certain kinds of pain. Feelings are regulatory interfaces and curiously they are double-sided, a trait that tends to be unacknowledged. One side of the feeling phenomenon corresponds to standard physiological operations and includes the chemical and cellular mechanisms that typically allow for the automatic regulation of internal body variables, for example, the uptake of excessive circulatory glucose by fat cells under the influence of insulin, and the simultaneous suppression of release of glucose from cells in which sugars are stored. The other side of the feeling phenomenon is *mental*, and it provides organisms with something evolutionarily new: a direct and explicit *experience*. It allows the owner of that experience to sense the state that its organism is in. Consider for example a restriction of the airway into the lungs, in an enclosed space or under water. The situation generates a forceful, rapid and automatic motor reaction aimed at gaining access to air. This is observable in any living creature, non-human and human alike, that depends on respiration to deliver oxygen to its internal milieu. This is entirely automatic. The fact that in humans this reaction is *also felt as air hunger and experienced as fear* is a bonus that guarantees our attention to the danger the organism faces but is not essential for the basic, automated, motor reaction to kick in.

What does mental experience bring to the table then? Each feeling experience has a certain content, a certain intensity, and a certain valence. The content refers to what the feeling describes (for example, the acceleration of the heart and the difficulty breathing that often appears in anxiety states). The parameter of intensity is self explanatory: feelings can be weak or strong. The critical parameter, however, is valence, positive or negative. It gives feelings their pleasant aspect (joyful, energetic, enthusiastic, relaxed) or unpleasant aspect (disagreeable, painful, sick). The ensemble of these parameters of feeling is informative. It indicates to the mind of the organism's owner, in rapid, global, summary style, whether the current state of the organism is generally conducive to continued health or even flourishing (well-being is an example), or if that state requires a correction (hunger or thirst, certain kinds of pain or malaise are examples of the latter). In other words, *feelings are informative regulatory interfaces*. Their mental aspect, emerging as it does in consciousness, turns the owner of the respective organism into a potential agent of its own regulation.

We need to make clear that the potential for individual, conscious, intervention in its life regulation, depends on two elements. First, the evolutionarily novel presence of a *mental aspect*, which opens a channel of information into the mind processes of the organism's owner. Second, the fact that the mental aspect of feelings is *valenced* and is either affectively positive or negative. This valence commands the attention of the organism's owner. It literally *compels* that owner to act on the information provided by feeling. Valence dictates action, namely, "correct as needed", "correct urgently", or "do little or nothing", or "do more of what you have been doing". Feelings are by definition *affect-full* mental representations and do not permit indifferent experiences. They *seize* the owner and experiencer. References to feeling that omit the full range of components described above, do not capture the reality and significance of the phenomenon.

## 3. Comparing the two varieties of homeostatic control

The simple automated kind of homeostatic control is generally reliable and efficacious. It is optimal for relatively simple organisms and it requires an appropriate niche. The conscious, feeling variety of regulation adds a number of advantages. The organism becomes far more adaptable to a larger range of circumstances. The fact that feelings are experienced in mind compels the organism's owner to action and promotes learning. The efficiency of memory increases when the facts of a situation are present via mental states imbued with positive or negative valences, i.e. present with the incentives or disincentives, which correspond, in classical learning and memory studies, to *appetitive* or *aversive* conditions. On the other hand, the conscious/feeling variety of homeostatic regulation is far more prone to malfunction than the plain, automatic version. This is because it offers too much freedom of operation. It allows the organism's owner to make non-preprogrammed choices and those choices may, immediately or over time, be in conflict with or even counter the main homeostatic goals.

How can we account of this greater vulnerability? One answer is that homeostatic feelings, as is the case with all feelings, engage components of the complex machinery of affect, namely, *drives*, *motivations*, and *emotions*. That machinery has been built for each species, over evolutionary time, by a slow process of variation, selection, and genomic fitness tuning. Just as importantly, that machinery has been adjusted in every individual by experiences related to sociocultural circumstances. In other words, responses to homeostatic feeling states are not influenced *only* by the basic homeostatic variable that prompted the feeling in the first place; *the responses are also affected by a host of phenomena associated with the processes of affect and their individual or cultural group tuning* (Bisin and Verdier, 2001). These phenomena play a major role in the construction of the possible menu of more or less deliberated responses to feelings. This is especially the case in humans, as should be expected and the result is the shaping of such affect-related phenomena as: a. social cooperation; b. behaviors related to the in-group versus out-group status of each organism; c. the cultural identity built for each individual and for groups as a result of factors such as past social experiences and related historical and geographic factors; and d. the deployment of a host of social emotions, such as compassion, altruism, gratitude, and indignation which are often engaged in a variety of social contexts (Damasio et al., 2000; Immordino-Yang et al., 2009; Singer, 2015; Fox et al., 2015). In turn, overtime, the repeated engagement of such responses contributes to the construction of human preferences, and ultimately, to the construction of what is known as rationality, in individual and in cultural groups.

## 4. The downside of conscious, feeling driven regulation: the introduction of reflexivity and the increase in fallibility

The consequence of the role played by this complex set of affect-related factors is that some of the advantages that come by way of conscious/feeling responses are easily reduced or lost. A system that regulates homeostasis by automated non-conscious means has too narrow a control and is not sufficiently flexible to take advantage of new opportunities or avoid the misapplication of an automated response. But when homeostatic regulation is enriched by feeling/conscious interfaces, adaptability increases at the risk of basic efficiency. The system becomes too open to new possibilities. When organisms include a conscious/feeling regulatory interface, they introduce a higher degree of uncertainty in the regulation which results in less predictable and potentially less advantageous responses. The fallibility of the decision-making apparatus increases. The novelty of some responses deviates from the standard path; in turn, the unexpected response generates yet another non-standard response because the system is still searching for stability and oscillates. (Later in the text we connect this instability to the notion of reflexivity as introduced by Popper (1959), and applied to the domain of economics by Soros (2013).)

We can illustrate the disregulation that results from feeling interfaces with examples from health, a critical human problem. The feeling of hunger, as opposed to a mere unfelt drop in the level of circulating glucose, enhances and guides one's search for food, and thus secures energy sources. But food ingredients produce different degrees of pleasure and satiation. They taste differently; once they are consumed they have different effects in the gastro-intestinal tract; they are craved differently; they can be greatly anticipated or merely tolerated; they can cause immediate pleasure but late discomfort. As a consequence, it is not that difficult to eat in excess, especially ingredients whose effects are immediately positive, in terms of feeling and energy production. Most fats and sugars are desirable prior to their consumption and pleasurable as they are consumed. To add insult to injury, they are comforting as they are digested. There is now ample evidence that the brain is profoundly influenced by the operations of the gastrointestinal tract. There is massive signaling from the gut to the brain via the enteric nervous system, one of the largest sectors of our entire nervous system, and the result of this influence does manifest itself in the form of feelings (Mayer, 2011). Unfortunately, the ultimate effects of excessive consumption over time are negative. They result, for example, in obesity and insulin resistance. Likewise, craving and over consuming salt in food is pleasurable but can contribute to unhealthy increases in blood pressure. In brief, the advantages of using feeling to mediate our choices, if not properly controlled by yet another layer of willful regulation, can become the primary cause of diseases such as diabetes, obesity, and hypertension (Morton et al., 2014; Wu et al., 2012).

But the saga of homeostasis and its adjustments does not end here. Because nature is immensely resourceful such disease processes tend to be countered by novel layers of *automatic* regulation. In other words, nature will attempt to control damage caused by poor conscious choice, *without any deliberate control*. This will happen at the same time that we, as conscious beings, may be trying to develop willful control of one's excesses, individually or even socioculturally—an example of the former is the personal attempt to curb excessive consumption; an example of the latter is the sort of health directives now frequently proposed by think-tanks and implemented by government agencies. The outcome of this mixed approach to a life-regulation problem is mixed as well. For example, inflammatory processes are automatically aimed at correcting potentially threatening deviations from homeostasis. Obesity can engage inflammation. Here is how: accumulation of toxic molecules in fat cells as well as in cells of the liver and muscles renders these tissues dysfunctional. The dysfunction triggers an inflammatory response whose natural, mindless intent is alleviating the problem. Ultimately, however, inflammation will aggravate the situation because in order to do its job inflammation temporarily overrides homeostatic controls (DeFronzo, 2010; Oh et al., 2012). As a result, the new layer of automatic regulation, which amounts to a rescue-mission, can end up perpetuating the problem rather than ameliorating it. This is another example of the perils of reflexivity.

The corrections result in oscillatory behavior and increase fallibility. Intriguingly, the weak link in this chain of *dis*-regulation comes from an evolutionary advance: the novel element introduced by feeling, consciousness and the possibility of deliberate choices.

## 5. Homeostasis, cultural invention, and economics

Feelings have been a welcome and beneficial evolutionary advance. We have good reasons to believe that feelings served as an impetus for inventing responses to problems of life regulation that could not have been solved automatically by the basic homeostatic devices that evolution had developed to maintain life. The compass of problems tackled by human invention is very wide and the resulting solutions are numerous. They include the extremely practical—the fashioning of tools, the harnessing of fire, the development of agriculture, the invention of the wheel and of writing. These technological advances have made life better in the sense that they boosted survival and led to greater well-being for many individuals.

The list of advances also includes somewhat less immediately practical inventions: arts such as music, a notable provider of social cohesion, poetry and theater; moral and belief systems; justice and governance systems; and, obviously, economics. In both sets of advances, the technical and the humanistic, the mechanism responsible for the new invention required the *identification of a need*, which was primarily accomplished on the basis of feelings, and the *intellectual capacity* to invent a new solution. We note that while the origin of these cultural instruments may be traced to life regulation needs, the subsequent development of these advances has given them considerable autonomy relative to the original needs and allowed them to reach sublime levels of intellectual complexity. We wish to make clear that we are not trying to reduce the arts or systems of belief and morality to mere responses to basic homeostatic needs. We are simply attempting to point out likely motives behind their *origins*, so that the operation of the system can be better understood.

We believe it is reasonable to list all these cultural advances under the general designation of *sociocultural homeostasis*, or better still, "attempted" sociocultural homeostasis. We say attempted because these sociocultural instruments may appear to be quite ancient but are, in point of fact, relatively recent in the overall history of evolution. Most human sociocultural artifacts appeared in the late Pleistocene and have existed for a mere instant, in good likelihood a mere *hundreds of thousands of years*. Living species, on the other hand, have been evolving and perfecting basic homeostasis for at least *700 million years*. Basic homeostasis has stabilized, to some extent; sociocultural homeostasis, on the other hand, is a work in progress, still in "attempt" stage.

From the perspective of life regulation all the devices of sociocultural homeostasis appear to have their origin in an identified need. They all aim at a goal compatible with both survival *and* a state of well-being. In other words, states of physical equilibrium or of neutral balance do not appear sufficient. An up-regulation toward well-being is easily identifiable as a general human goal.

Economic systems have been created by humans to manage the production, allocation, and distribution of resources necessary for the maintenance of life. They seem to have emerged naturally as sociocultural extensions of basic life management. They clearly contribute to making life possible in a complex environment and open paths to achieving well-being. And, in keeping with the position we assign them as components of less than perfect sociocultural homeostatic devices, they are quite open to malfunction.

We believe it is worth exploring the implications of this biologic perspective in a systematic fashion using homeostasis as a model. This would go beyond a general application of biology to decision-making as exemplified, for example, in our own somatic marker hypothesis (Damasio, 1994, 1996; Bechara et al., 1994) and in the work of other colleagues (Kahneman et al., 1997; Robson, 2001). It is beyond the scope of this brief essay to discuss the application in detail but we can point to issues whose study in the homeostatic perspective would appear promising. For example, the notion of humans as exclusively self-interested in terms of means and goals, is closer to fiction than reality. In this regard, the assumptions most at odds with current biological views include the notion of preferences that would be stable and impervious to the varied social factors that seem to have a major bearing on all sorts of economic decisions. Social phenomena have had a large influence on the evolution of the processes of affect, and the latter exert a huge influence on the matter of preferences and the calculation of utility. Feelings, in all their variety, intensity, and valence, exert powerful influences on economic preferences (intriguingly, the concepts behind terms such as "preferences" and "utility" in the vocabulary of economics, can be related to terms used in the biology of homeostasis such as "need" and "reward"). Varied degrees of cooperation of kin and non-kin, regulation of in-group and out-group behavior, social emotions, along with climate and geography, have generated varied historical paths and thus varied cultures. Such cultures, as George Ackerlof has suggested, impose separate socio-cultural identities (Akerlof and Kranton, 2010). Economic models which ignore the role of socio-cultural identities and their attendant affective profiles are not likely to reflect reality.

Because there is a dual nature to human homeostatic control, and because conscious deliberation is a patent human reality, it is not likely that economic systems operating well *only* on the basis of Adam Smith's "invisible hand" (Smith, 1776). The invisible hand idea fits well the homeostatic world of bacterial cells, an un-minded world in which quorum sensing accomplishes a lot of good governance and is indeed invisible. But the invisible hand does not capture fully to the human case. The wide variety of cultural instruments that human conscious feelingness and intellect have created, are subject to their own cultural evolution. The responses they generate may or may not coincide with those that the evolutionarily older invisible hand devices would produce. It also appears to be the case that Adam Smith's invisible hand idea has been somewhat deformed in typical accounts of *Homo economicus*, as pointed out by Wilson (2015).

Another application of the perspective of homeostasis in economics pertains to the work of Soros (2013). Soros has noted how the human factor in the operation of a decision system introduces an unpredicted effect of reflexivity which, in turn, entails an increase in the fallibility of the system's operation. Curiously, beginning at a far simpler biological level, the processes of homeostasis engage a comparable phenomenon. Reflexivity promotes unstable, oscillatory behavior. Realistic economic conceptions should factor in such phenomena.

In practical terms, understanding the successes and problems of life regulation may have something to contribute to the optimization of economic regulatory systems. In general human terms, we believe that the scientific and philosophical aspects of these two sets of processes, natural life regulation and culturally invented economics, should be explored together.

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