# Rethinking basically Economic Assumption on Individual Behavior from Empirical Viewpoints of Evolution and Behavior

Zhao, Liang

School of Economics and Management, Nanjing University of Science and Technology, China

15 October 2008

**Rethinking Basically Economic Assumption on Individual Behavior from**

**Empirical Viewpoints of Evolution and Behavior**

School of Economics and Management, Nanjing University of Science and

Technology, China


Liang Zhao


Author's correspondence:

520 room, School of Economics and Management, Nanjing University of Science

and Technology(NJUST); No.200, Xiao-ling-wei Street, Nanjing City, Jiangsu

Province, China; Postal code: 210094; E-mail: zhaoliang1967@gmail.com


(address and author's name in simplified chinese as following):

中文地址：中国 江苏省 南京市 孝陵卫街 200 号 南京理工大学 经济管理学院

520 房间；

中文姓名： 赵 亮

Words count: 3,830 or so

**Abstract**

Building on the predecessors' thoughts and modern researches from empirical disciplines, and with thinking over the behavior assumption usually held and used by mainstream economics, the paper generalizes three basic assumptions and one explanatory framework on human individual behavior and its process, and stresses hierarchical characteristics in preferences, heterogeneity between learning capacity and learning and, human dealing with and reducing uncertainty from environments in the process of natural evolution, and rethinks the questions of individual rationality, acquirement of behavior mode, intellectual history on "knowledge" in the level of experientialism. The purpose is that along the path of "falsifying a theory" and with the help of empirical results, the paper trys to propose behavioral presuppositions and thinking framework, so that enhancing the effectiveness of economic theory on explaining individual behavior in real situations, and in the end advancing transdisciplinary researches between the empirical and social sciences.

**Keywords**: assumption, explanatory framework, individual behavior, hierarchical preference, learning capacity, knowledge, evolutionary process, empirical substrate, transdiscipline

# 1. Introduction

Economicists have been continuously qustioning basically economic assumption on individual behavior held by main stream economics - the rational assumption (for instance, Allais, 1953; Smith, 2003; North, 2005; etc.). Debates among economic methodologies based on respective behavioral assumptions, which even lasted longer(Boland, 2005).

In fact, one implicit problem in debates is: what so ever does economics need basic assumptions in order to properly explain or anylize human individual behavior? For those assumptions and their uses, need or not, can or not, in the basis of empirically testable results but not in some prior or axiomatic postulate, be it given, even if there is not perfectly mathmatic formalization at first?

If there is certain ambiguity in exploring human individual mainly from viewpoints of philosophy or psychology(Vanderwolf, 2007), then nowadays, many empirical disciplines, for instances, brain science, neuroscience, modern anthropology and animal behavior study so forth, which are developing rapidly, have been accumulating a large number of fruits on human behavior and, have thought it from the transdisciplinary viewpoints(e.g., Wilson, 1998; Fellows, 2004; Bloom, 2006; Gintis, 2007).

Following the thought on " falsifying a theory "(Popper, 1963), the paper insists that to economics, it is necessary and feasible that basing on testable materials from empirical disciplines, we put forward individual behavior assumptions and explain behavioral process. And by this way, we also can avoid theoretical randomicity or arbitrariness possibly from superficial induction or logically abstact deduction.

This method is possibly denounced as "reductionism" in social sciences. But it will be worth if doing this way can make us achieving more facts and comprehension on them (Crick,1994).

Through generalizing predecessors' thoughts and marshalling empirical findings, in the paper, we summarize three assumptions on human individual behavior, and propose a basicly reduced framework on thinking individual behavior process. The aim is that starting from testable materials we try to understand and explain human individual behavior in real situation.

The paper will be arranged as follow: based on empirical materials, three basic assumptions on individual behavior are offered separately from the second to the fourth part; based on the assumptions, one reduced framework on individual behavior process is given in the fifth part; finally in the sixth, related questions are discussed and the paper is concluded.

## 2. Basic Assumption 1 : Hierarchical Preferences

In the process of natural selection dealing with uncertain environments, biological organisms, including human individual, form stable behavioral tropisms or propensities internalized in their genes (Lorenz, 1981; Morris, 1970; Wilson, 2000; etc.). In a study on behavioral science, Vanderwolf (2007) thought generally those innate tendencies come from activity of micro-particles within organismic cells.

To human behavioral tendencies to "trending" or "avoiding", mainstream economics ususally generalize all of them into a conception "preference", to which, however, its scope is not narrow within innate ones but more wide, for instance, including individual interests or aims(e.g.,Becker, 1976).

From viewpoints of modern neurobiology (Nicholls, et al., 2001; Jirsa and McIntosh, 2007; ect), innately behavioral propensity of an individual can be considered as a stable contact from one neuron to another, which is characterized by the neuronal synapse. By contrast, in human economic-social activities, these behavioral tendencies (or interests), varied with persons or space-time, are not so. They are acquired by trying or imitating in individual experiences in uncertain environments. Therefore, when describing individual tendenties (or preferences) in economics, it is necessary to deal with them hierarchically: at last two hierarchies - the innerly stable preferences (or propensities) and the outerly mutable ones. Therefore, we may have:

## assumption 1 - hierarchical preferences.

That means: while some of individual preferences vary with outside conditions, there exist unalterable ones. Comparatively, preferences can hierarchically be divided into the innerly stable and the outerly mutable ones.

Formed in the process of natural evolution, the innerly unalterable preferences mainly involve those of energy ingestion, sex, exploring or novelty-seeking, ect1. The first two have been deeply studied by sociobiology and other behavior sciences. The paper mainly discusses innate and unalterable features of the last.

Morris(1970, p.114) concluded that all mammal owns "neophilia", the propensity of liking novelty; it is most prominent in human, and with increasing of years it is enhanced in adulthood, and ultimately it becomes the foundation of human innovating. From the basic biology, there exist some links between genes and the risking behavioral propensity in the sense of innovation(or novelty seeking). Hamer and Copeland (1998) attributed the propensity to dopamine, and thinks its quantity perhaps mainly depends on the D4DR gene positioned in No.11 chromosome2.

---

[1] Ohter types which can be viewed as inner preferences, such as obedience (Milgram, 1963), ritualized behavior (Boyer, et al., 2006, a, b), and so forth, have been researched in empirical disciplines, too.
[2] Benjamin et al.(1996) and Ebstein et al.(1996) thought D4DR is only a part and not all. Herbst et al.(2000) thought the assoviation is not significant between some kinds of novelty seeking and polymorphic D4DR.

In comparison between populations, by estimating samples from different nations in different areas, Ono et al.(1997) concluded that to the relation between polymorphic D4DR and novelty seeking propensity, the relevancy is independent of national differentiae. In their sampling statistics of genetic-epidemiology, Eisen et al.(2001) showed that the essential reason about pathological gambling (PG), the preference of morbidly seeking stimuli from gambling, exist in genetic factors, and the patients have a genetic defect singly corresponding to the sickness; in the aspect of nervous mechanism, the morbid behavior is rooted in neurotransmitters determined by genes, such as dopamine.

Therefore, to human species, we may believe that the inner preferences are stable and same between everyone (if neglecting the difference on food-taking among Inuit lived in the Arctic regions and other humans).

Compared to the above, largely exsiting behavioral preferences, which alteded with individuals or space-time (e.g., Salganik, 2006), are the outerly mutable ones, influenced by individual behavior learning.

Innerly stable preferences are the ultimate substrate forming outerly mutable ones; the reason why inner preferences are same and stable is that they are derived from the essential requirements in biological existence of human species and coping with uncertainty of circumstances; based on them, the reason why the outer preferences

have great differences is that individuals encounter different environmental signals in respective experiences, or endow signals with different weighting (value).

In addition, the paper believes preferences can be measured. The inner ones are determined by measurable intensities of synaptic connections, and the outer ones can ultimately be showed on the level of behavioral performances.

## 3. Basic Assumption 2: Learning Capacity

Built on the innerly stable preferences, the reason why an individual can perform a learning behavior in facing with repeated or new signals outside is that from behavioral performance, connections caused by some conditions are rewarded and the others are published. But the foundation of the learning behavior - capacity of forming connections - is offered by biological substrate from an individual and not by acquired learning. When discussing on human aggression, Wilson(2000, p.255) had indicated, "We are now sophisticated enough to know that the capacity to learn certain behaviors is itself a genetically controlled and therefore evolved tait."

Various behavior abilities showed by individuals are results from learning or training in different situations postnatally, but the capacity which makes individual's learning possible is unlearned one, not of the traits of Lamarckism in inheritance: it is identical in nature to humans. Empirical disciplines have discovered some types of the capacity.

Therefore, different from learning3, learning capacity means biologically unlearned substrate which make individual learning possible in the beginning, and limit consequent connections acquired from learning process. In this way, there is:

**assumption 2 - learning capacity**

Which means that learning capacity is a kind of unlearned one on which an individual must depend to perform learning behavior. It is irrelative to acquired learning and to cultures in different areas.

It involves key points as following.

## 3.1 Acquiring of Behavior and Unlearned Learning Capacity

**acquiring of behavior (learning)**

Learning is a process an individual forming and storing connections between signals, as which can be called acquired connections. The process also can be accomplished by

---

3  There are abundant empirical materials on learning in the fields of behavior study and other disciplines. Summing up them, we consider that *learning* is an individual to establish connections between events(signals) and form the storage about them, and then some of them will be able to be retrieved and primed. Therefore, learning means a process in which connections can be formed and established; the storage of connections that have been learned in this process can be called *memory*.

means of mechanisms of reinforcement.

By experiments, early behaviorism opened out the mechanism of rewards or punishments about individual learning on the level of behavioral performance(e.g.,Thorndike, 1931). Bandura et al.(1963) and Bandura(1986) expatiated on a learning behavior, modeling. Linked with the research from Bingenheimer et al.(2005), it is showed that through learning (enactive or observational), an individual can establish and store the relational connections between signals (events) and, prime them under corresponding situations. Frank et al.(2004) explained neurobiological basis for human learning from experiences.

**unlearned learning capacity**

As indicated above, learning capacity is a biological substrate on learning behavior. It not only can make learning behaviors possible, but also limit the degree and domain human individuals undertaking them.

## 3.2 Basic Types of Learning Capacity and Their Functions

Combining empirical results together, we perhaps can divide learning capacity into following three types on signals (or signal modes) outside the world within certain degree and domain: capacity of recognizing, anticipatory operating, and dynamic

switching between signal connections.

### 3.2.1 Capacity of Recognizing

In chemical signals recognizing, for instance, Hao et al.(2005) found that the neurons of the anterior piriform cortex in the brain of mammal (including humans), possess a basic capacity for recognizing a deficiency of indispensable amino acids (IAAs) for protein synthesis, and then guiding and adjusting food selection for their survival.

In socio-signals recognizing, Rudebeck et al.(2006) showed that the primate's brain can appropriately recognize and respond to some important social information, such as observing other attracting individuals or others upper in social class.

### 3.2.2 Capacity of Anticipatory Operating

Schultz et al.(1997) indicated that a neural substrate of the capacity is dopaminergic neurons in the primate whose fluctuating output apparently signals changes or errors in the predictions of future salient and rewarding events, and suggested that it is the fluctuating output that forms the primate's the capacity to predict future events, and permits the creature to detect, model, and manipulate the causal structure of its interactions with its environment.

Brown and Braver(2005) showed that some areas in human brain predict error likelihood in a given context, even for trials in which there is no error or response conflict.

Rougier et al.(2005) suggested in normally human brain, the specialized neural substrate and its fundamental capacity for producing abstract rule-like representations, and guiding stimulus processing according to abstract dimensions that apply across both familiar and task-novel stimuli.

### 3.2.3 Capacity of Dynamic Switching Between Signal Connections

It is obvious that normal individuals' behavior can be adjusted to adapt to environmental changes. Its substrate is that neural networks and neurons adapt to environmental demands by switching between distinct dynamical behaviors.

Machens et al.(2005) showed the dynamical properties of the frontal-lobe neurons switching between stimuli happened in succession. Ridderinkhof and Wildenberg (2005) also showed that regions, even single neurons, in the frontal brain can implement cognitive control through dynamic adaptation of their firing patterns.

### 3.2.4 Basic Functions of Learning Capacity

Common function of learning capacity is to cope with and reduce uncertainties from

the world outside, and to improve survival probability of an individual in environments. Although far from perfect and sufficient, the capacity is great important to human beings.

For instance, the capacity of recognising signals, especially extracting modes, is a foundation abstracting rules about certain behavior category, which will allow an individual to greatly reduce environmental complication, to enhance the brain's memory to signals (events) and rapidly accumulate individual knowledge; the capacity of anticipatory estimation makes individuals in advance preparing for the relevant signals, which is a basis forming mechanisms of anticipatory evaluation-feedback (details in Assumption 3 following); together with the former two, the capacity of dynamic switching between signal connections makes possible the continuous adjustment in individual behavior and cognition, and enhances individual flexibility and adaptability.

## 3.3 Individual Homogeneity in Learning Capacity

As far as its essentially unlearned property and function is concerned, learning capacity is identical to each person.

Evolutionary psychology (e.g.,Cosmides and Tooby,1992) indicated that in the long evolutionary history, human beings have reliably and universally evolved a series of

cognitive circuits to provide humans with neural-physiological substrates of social behaviors.

Hauser and Spelke (2004) called the basic capacity as the "core knowledge" systems, a set of psychological and neural mechanisms, which evolved before humanity and thus are shared with other animals, and emerge early in human development and thus are common to everyone. They form the foundations for human acquired skills.

By a visional study, Hasson et al. (2004) indicated a tendency of individual brains to respond to the same scenes identically and collectively during natural vision. The characteristics of activations in the brain showed the homogeneity that all human brains work under the same natural signal conditions, and can use signals from one person's brain to predict those in another's when that person is in the same natural conditions (Pessoa, 2004).

## 3.4 On Other types of Capacity

The operating capacity pointed in Piaget(1972), and the logical reasoning and judgement usually talked over in social sciences, and so forth, all may be in certain degree treated as the more subtle types of capacity subsequently produced after the capacity of recognizing and anticipatory operating about signals(or signal modes). Lumsden and Wildson(1983) had pointed out that advanced reasoning is in the last

period of human evolution. Cosmides and Tooby(1994) explained that rational decision-making is very limited in human beings, by which human ancestors never can resolve the reproducing and surviving problems repeatedly encountered themselves.

The plasticity of brain, i.e., the expanding capacity of human brain in some degree (Stern and Hines, 2005; Sur and Rubenstein, 2005; Feldman and Brecht, 2005; ect.), is also distinct from the learning capacity in the paper, although it may give behavioral learning a hand. Through Gray and Thompson(2004), Draganski et al.(2006) and Tashiro et al.(2006) so forth, it is shown that the effects from the plasticity of human brain is too limit.

## 4. Basic Assumption 3: Anticipatory Evaluation-feedback Mechanism

From the assumption 1 and 2 above, when coping with the environments, an individual can anticipatably estimate environmental signals, and compare them with stable preferences distributed in respective hierarchies: if signals identical with the orientation of preferences, "rewarded" evaluation will be formed and the same directional connections between the signals and the stable preferences can be stored in the individual. On the contrary, the individual forms the reverse connections - "published" evaluation, and stores a resulting state at the same time so as to prime consequent behaviors. So there is assumption 3:

**assumption 3 - anticipatory evaluation-feedback mechanism**

It means a process and its resulting state in which, basing on hierarchical preferences and learning capacity, an individual anticipatably responds to and evaluates signals from the outside.

Empirical findings demonstrate that there exist multi-types of the mechanism in individuals. According to hierarchical thinking in the paper, it possibly can be divided into 3 types as following, those of which, based on the innerly stable preferences, usually can not be consciously perceived by individuals; but the other, mainly based on outerly alterable preferences, can be done ( for instance,  economic anticipation and evaluation in daily life).

## 4.1 The Most Stable Mechanism in The Most Inner Hierarchy

Reflex, well known in early behavior study (e.g., Pavlov,1927), can be regarded as the type based on unlearned capacity and the innermostly stable preferences and, responding to specific signals in almost fixed manner.

## 4.2 The Stable Mechanism in Inner Hierarchy

Stabler types of the mechanism in inner hierarchy are built on learning capacity and

innerly stabler preferences.

There are abundant researches for the aspect recently, in which, for instances, on neural networks in the brain involving immediately available rewards and the delay ones (McClure, et al., 2004); anticipatory evaluation in the brain to some cognitive information and relevant behavior regulating(Camille, et al., 2004); the brain distinguishing, evaluating different decision-making information and guiding behaviors in an iterated, two-person economic exchange(Tomlin, et al., 2006); social evaluation mechanism in the brain towards other individual's actions and intentions derived from the period of preverbal infants (Hamlin, et al., 2007).

Additionally, emotion systems in the brain play an important role when coping with risky and ambiguous choices(e.g., Hsu, et al., 2005; etc.). Cosmides and Tooby (2006) also believed that some of human morality or emotions are evolved from the process of natural selection, which work so naturally that their operation disappears unnoticed into the background, or is taken for granted.

## 4.3 The Mutable Mechanism in Outer Hierarchy

Based on alterably acquired preferences, there exist large numbers of types of the mechanism in outer hierarchy which mainly process signals from individual experiences, and they vary with stability of those preferences.

Changes in individual's behavior, behavior modes and customs so on, discussed by most economists and other scholars (e.g., North, 1981; Schotter, 1981; Masahiko Aoki, 2001; Ostrom, 2004; Camerer and Fehr, 2006.), which is behavior adjustments mainly processed by the mechanism.

## 5. One Reduced Framwork on Individual Behavior

Synthesizing the three assumptions above, the paper trys to offer a reduced framework on individual behavior, showed by Figure.1.
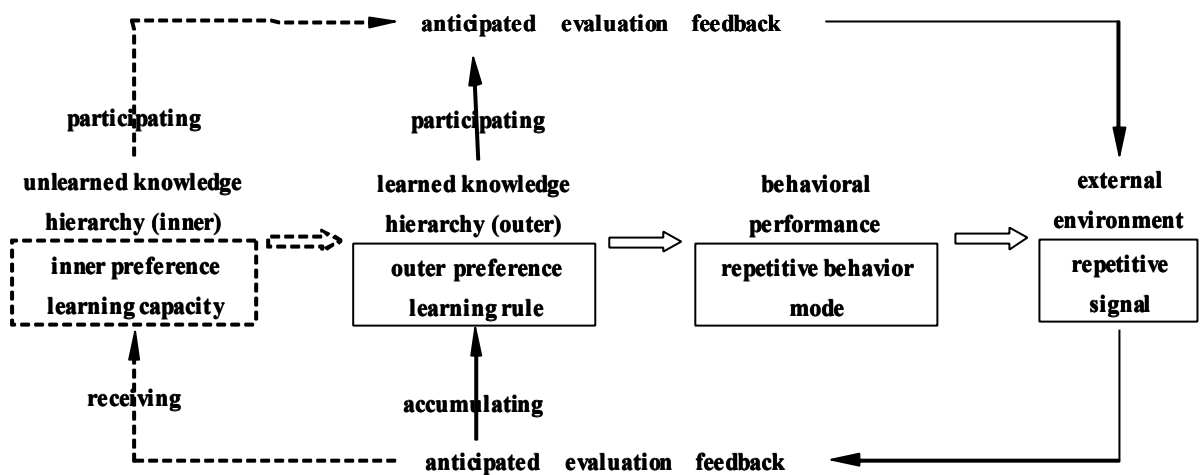


**Figure. 1    reduced framework based on assumptions**

In the framework, inner preference and learning capacity constitute the stablest hierarchy of individual behavior; basing on it, an individual anticipates and evaluates

repeatedly environmental signals(events), and increasingly outside the hierarchy forms multi-hierarchically, perceivably and alterably outer preferences with different stability; thereby, facing with the signals(events), the individual shows repetitively and observably behavioral mode acting on environments(such as, behavioral habits, customs, etc.); after that, he or she anticipates or receives relatedly feeding-back signals, and through evaluating in inner and outer preferences, maintains or adjusts originally behavioral mode(such as change of habits, customs). In this way, an individual forms a dynamic behavior process on signals(events) outside: from stable learning capacity and inner preferences to mutably outer preferences and, to repetitively behavioral mode in facing of signals.

The innerly stablest preferences will throughout engage in the process of evaluating and feeding back signals, which unnecessarily can be perceived. So, in Figure.1, it is denoted by an arrow with the broken line.

Additionally, evaluating results from the outer preferences can not be accumulated in the inner preferences and learning capacity, but just done in the outer. The reason is that the stable inners and capacity are derived from the evolutionary process. Although human behavior modes have vastly been changed from the agricultural revolution to now, from the viewpoints of natural evolution, the time is too short to select for new complex cognitive programs (Cosmides and Tooby, 2006). Therefore, the paper treats inner preferences and learning capacity as unalterable ones.

## 6. Discussion and Conclusion

The paper puts forward three assumptions and one framework on individual's behavior and its process. Its aim is that basing on researches from empirical disciplines, we rethink basically behavioral presupposition in economics and try to enhance the effectiveness in behavioral explanation from economic theory. According to empirical findings, we believe the qustions as following deserve to be thought and discussed in economics and other sciences.

## 6.1 Understanding Individual Rationality Anew

Rationality is just weaker one of imperfect capacities owned by human individual. Building on the assumption 1, we believe, three axiomatic characteristics, "completeness, transitivity, desirability" (e.g., Pindyck and Rubinfeld, 1997, p.59), which are used to describe the preference of consumer behavior from the rational assumption usually held by mainstream economics, are only adaptive to the domain involving inner preferences, not to others. Because empirical evidences show that compared to outerly mutable preferences, just the inner ones have these more tangible characteristics. But on another hand, those evidences also provide empirical foundation for appropriately using mainstream economics.

## 6.2 Acquirement of Stably Behavior Mode (Learning Rule) of Individual

There is no difference in individual learning capacity. But through acquirement in individual experiences, some stabler behavior tendency can be accumulated in outer preferences, which forms relevant learning rule (seeing Figure.1) distinctively influencing behavior mode, and brings about different people possessing different performances or abilities. So, learning rule means behavioral learning rule about how establishing connections between signals (events) acquired from individual experiences. It is of hierarchies with different stability. Therefore, individual experiences have an important role between human biological substrate and realistic thought and psychology ( Stern and Hines, 2005).

The differences between these stabler learning rules in more inner hierarchies (such as, some cognitive schemes or behavioral habits from a persistent process of individual socialization), decide most differences between other learning rules (e.g.,Gordon, 2004); Also, learning rules different one another determine that under the similar condition of experiences, some people adjust their behaviors better, but others may do not(e.g., Bloom and Weisberg, 2007).

## 6.3 Thinking Intellectual History on "Knowledge" in The Experientialism

In early time, philosophers, such as the School of Sophists, Plato, Aristotle in ancient

Greece, and Descartes, Hume, Kant so forth, continued to discuss the origin and property of human knowledge. Hayek(1952) used more contemporarily empirical materials to expatiate on the problem of individual mind, in which some viewpoints have been confirmed by modern empirical disciplines (Steele, 2002).

Now, for the similar conjectures and questions in intellectual history above, we can rely on new empirical results and from the individual behavior point of view, give them new thinking.

Generally, relatively stable behavioral mode, viewed from behavior performance, is the regular one, in which when facing with (certainly or uncertainly) environmental signals, an individual knows how responding to them or knows how not doing(i.e., know how or know how not); viewed from the level of the brain's anatomy, it exhibits stable responding states, in which the related brain areas are activated by some stimuli; viewed from the level of neurology and molecular biology, it expresses that the stable connections between neurons are shaped, and the stable channels are established in which neurotransmitters are released and transmitted. Integrated the three levels together, we believe, individual knowledge is the stable connections formed between signals(or events); accumulation of individual knowledge is the storage about the stable connections; shared knowledge between individuals is the stably shared anticipation between individuals on behavioral responses from others facing with signals. (The stably shared hierarchies in preferences is crucial to forming shared

knowledge between individuals, which make possible communication between different people.). And, basing on the three assumptions above, we can realize that there still exists hierarchical characteristic in individual knowledge and shared knowledge, which respectively corresponds to the domains of innerly stable or outerly mutable preferences; similarly, to the inner knowledge of individual or innerly shared knowledge between individuals, it usually can not yet be perceived consciously (seeing the Figure. 1).

Economists had regreted to so little cooperation between economics and biology (Tullock, 1987). Almost up till now, the questions on human individual behavior and cognition are still "discussed completely independently in the faculties of neurobiology and psychology, and on a different level in economics and linguistics" (Stern, et al., 2004, p.431). Correspondingly, an inexplicable phenomenon maybe is: many researchers from empirical disciplines may pay attention to propositions usually in philosophy or other social sciences; economists and other scholars in social science, however, are short of "coordinate" interests to think over empirical results carefully in long time. In such a condition, facing with the rapid increase of results from empirical and trans-disciplines, how to treat and utilize those findings properly to correct, support or test their theories, which is one of important problems necessary to be reflected on by economics, even all social scientists.

## Acknowledgment

## References

Allais, M. (1953). Le comportement de 1' homme mtionnel devant le risque:Critique des postulats et axiomes de l'ecole Americaine. *Econometrica*, 21, 503－546.

Bandura, A., Ross, D., Ross, F.A. (1963). Imitation of Film-mediated Aggressive Models. *Journal of Abnormal and Social Psychology*, 66: 3-11.

Becker, G.S. (1976). *The Economic Approach to Human Behavior*. Chicago: The University of Chicago.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. New Jersey: Prentice-Hall.

Benjamin, J., Lin Li, Patterson, C. et al. (1996). Population and familial association between the D4 dopamine receptor gene and measures of Novelty Seeking. *Nature Genetics*, 12: 81–84.

Brown, J. W., Braver, T. S., (2005). Learned Predictions of Error Likelihood in the Anterior Cingulate Cortex. *Science*, 307(5712): 1118-1121.

Bingenheimer, J. B., Brennan, R. T., Earls, F. J. (2005). Firearm Violence Exposure and Serious Violent Behavior. *Science*, 308(5726): 1323-1326.

Boland, L. A. (2005). *Critical economic methodology*. New York: Routledge.

Bloom, F. (2006). Prying Open the Black Box. *Science*, 314(5796):17.

Boyer, P.(2006). (a), Why ritualized behavior? Precaution Systems and action parsing in developmental, pathological and cultural rituals. *Behavioral and Brain Sciences*, 29, 1–56.; (b), Whence Collective Rituals? A Cultural Selection Model of Ritualized Behavior. *American Anthropologist*, 108(4): 814–827.

Bloom, P., Weisberg, D. S. (2007). Childhood Origins of Adult Resistance to Science. *Science*, 316(5827): 996-997.

Cosmides, L., Tooby,J., with Barkow, J.(1992).(Eds.) *The Adapted Mind:Evolutionary Psychology and The Generation of Culture*. New York: Oxford University Press.; (1994). Better than Rational: Evolutionary Psychology and the Invisible Hand. *the American Economic Review*, 84(2): 327-332.; (2006). Evolutionary Psychology, Moral Heuristics, and the Law. In Gigerenzer, G., Engel, C.(Eds.) *Heuristics and the Law* ( pp.181-212). Cambridge: MIT Press.

Crick, F. (1994). *The Astonishing Hypothesis: The Scientific Search for the Soul*. New York: Charles Scribner's Sons.

Camille, N., Coricelli, G., Sallet, J. et al. (2004). The Involvement of the Orbitofrontal Cortex in the Experience of Regret. *Science*, 304(5674): 1167-1170.

Camerer,C. F., Fehr, E.(2006).When Does "Economic Man" Dominate Social Behavior? *Science*, 311(5757): 47-52.

Draganski, B., Gaser, C., Kempermann, G. et al. (2006). Temporal and Spatial Dynamics of Brain Structure Changes during Extensive Learning. *The Journal of Neuroscience*, 26(23): 6314-6317.

Ebstein, R.P., Novick, O., Umansky, R. et al. (1996). Dopamine D4 receptor(D4DR) exon III polymorphism associated with the human personality trait of novelty seeking. *Nature Genetics*, 12: 78-80.

Eisen, S.A., Slutske, W.S., Lyons, M.J. et al. (2001). The genetics of pathological gambling, Semin Clin. *Neuropsychiatry*, 6(3): 195-204.

Fellows,L. K. (2004). The Cognitive Neuroscience of Human Decision Making: A Review and Conceptual Framework. *Behavioral and Cognitive Neuroscience Reviews*, 3(3):159-172.

Frank, M. J., Seeberger, L. C., O'Reilly, R. C. (2004). By Carrot or by Stick: Cognitive Reinforcement Learning in Parkinsonism. *Science*, 306(5703): 1940-1943.

Feldman, D. E., Brecht, M. (2005). Map Plasticity in Somatosensory Cortex. *Science*, 310(5749): 810-815.

Gray, J. R., Thompson, P. M. (2004). Neurobiology of intelligence-science and ethics. *Nature Reviews, Neuroscience*, 5: 471- 482.

Gordon, P. (19 August 2004). Numerical Cognition Without Words: Evidence from Amazonia. *Science Online*, Science DOI: 10.1126/science.1094492.

Gintis, H. (2007). A Framework for the Unification of the Behavioral Sciences. *Behavioral and Brain Sciences*, 30 (1): 1-16.

Hayek, F. A. (1952). *The Sensory Order: An Inquiry into the Foundations of*

*Theoretical Psychology.*   Chicago: The University of Chicago Press.

Hamer, D., and Copeland, P. (1998). *Living With Our Genes.* New York: Random House Inc.

Herbst, J., Zonderman, A. B., McCrae, R. R. et al. (2000). Do the dimensions of the temperament and character inventory map a single genetic architecture? Evidence from molecular genetics and factor analysis. *American Journal of Psychiatry*, 157 (8): 1285-1290.

Hauser, M. D., Spelke, E. (2004). Evolutionary and developmental foundations of human knowledge: A case study of mathematics. In Gazzaniga, M. (Ed.) *The Cognitive Neurosciences* III (pp.853-864). Cambridge: MIT Press.

Hasson, U., Nir, Y., Levy, I. et al. (2004). Intersubject Synchronization of Cortical Activity During Natural Vision. *Science*, 303(5664): 1634-1640.

Hsu, M., Bhatt, M., Adolphs, R. et al. (2005). Neural Systems Responding to Degrees of Uncertainty in Human decision-Making. *Science*, 310(5754): 1624-1625.

Hao, S., Sharp, J. W., Ross-Inta, C. M. et al. (2005). Uncharged tRNA and Sensing of Amino Acid Deficiency in Mammalian Piriform Cortex. *Science*, 307(5716): 1776–1778.

Hamlin, J. K., Wynn, K., Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, 450(7169): 557-559.

Jirsa, V. K. and McIntosh, A.R. (2007). (Eds.), *Handbook of Brain Connectivity.* Berlin: Springer.

Lorenz, K. Z. (1981). *The Foundations of Ethology.* New York: Springer-Verlag, Inc.

Lumsden, C. J., Wildson, E. O. (1983). *Promethean Fire: Reflections on The Origin of Mind*. Cambridge: Harvard University Press.

Morris, D. (1970). *The Naked Ape*. Ontario: Bantam Books of Canada Ltd.

Milgram, S. (1963). Behavioral study of obedience. *Journal of Abnormal and Social Psychology*, 67, pp.371–378.

Masahiko Aoki.(2001). *Towards a Comparative Institutional Analysis*. Chinese Version. Shanghai: Shanghai Far East Publishes.

McClure, S. M., Laibson, D. I., Loewenstein, G. et al.(2004). Separate Neural Systems Value Immediate and Delayed Monetary Rewards. *Science*, 306(5695): 503-507.

Machens, C. K., Romo, R., Brody, C. D. (2005). Flexible Control of Mutual Inhibition: A Neural Model of Two-Interval Discrimination. *Science*, 307(5712): 1121-1124.

North, D. C. (1981). *Structure and Change in Economic History*. New York: W.W. Norton & Company, Inc.; (2005). *Understanding the Process of Economic Change*. Princeton: Princeton University Press.

Nicholls, J. G., Martin, A. R., Wallace, B.G. et al. (2001). *From Neuron to Brain* (4th Ed.). Washington: Sinauer Associates, Inc.

Ono, Y., Manki, H., Kimio Yoshimura. et al. (1997). Association between dopamine D4 receptor (D4DR) exon 3 polymorphism and novelty seeking in Japanese subjects. *American Journal of Medical Genetics*, 74(5): 501-503;

Ostrom, E. (2004). The working parts of rules and how they may evolve over time. working paper(#0404), Max Planck Institute for Research into Economic Systems Evolutionary Economics Group.

Pavlov, I. P. (1927). *Conditioned Reflexes.* London: Oxford University Press.

Popper, K. R. (1963). *Conjectures and Refutations.* New York: Basic Books.

Piaget, J. (1972). *The Principles of Genetic Epistemology.* New York: Basic Books.

Pindyck,R.S. and Rubinfeld, D.L.(1997). *Microeconomics*(3rd ed.). Beijing: Tsinghua University Press/Prentice-Hall.

Pessoa, L. (2004). Seeing the World in the Same Way. *Science*, 303(5664): 1617-1618.

Ridderinkhof, K. R., Wildenberg, W. P. (2005). Adaptive Coding. *Science*, 307(5712): 1059-1060.

Rougier, N. P., Noelle, D. C., Braver, T. S. (2005). Prefrontal cortex and flexible cognitive control: Rules without symbols. *Proceedings of the National Academy of Sciences of the United States of America*, 102(20): 7338-7343.

Rudebeck, P. H., Buckley, M. J., Walton, M. E. et al. (2006). A Role for the Macaque Anterior Cingulate Gyrus in Social Valuation. *Science*, 313(5791): 1310-1312.

Schotter,A.(1981).*The Economic Theory of Social Institutions.* Cambridge: Cambridge University Press.

Schultz, W., Dayan, P., Montague, P. R. (1997). A Neural Substrate of Prediction and Reward. *Science*, 275(5306): 1593-1599.

Steele, G.R. (2002). Hayek's Sensory Order. *Theory & Psychology*, 12(3): 387- 409.

Smith, V. L.(2003). Constructivist and Ecological Rationality in Economics. *The American Economic Review*, 93(3): 465-508.

Stern, P., Chin, G., Travis, J. (2004). Neuroscience: Higher Brain Functions. *Science*, 306(5695): 431.

Stern, P., Hines, P. J. (2005). Neuroscience: Systems-Level Brain Development. *Science*, 310(5749): 801.

Sur, M., Rubenstein, J. L. R. (2005). Patterning and Plasticity of the Cerebral Cortex. *Science*, 310(5749): 805-810.

Salganik, M. J., Dodds, P. S., Watts, D. J. (2006). Experimental Study of Inequality and Unpredictability in an Artificial Cultural Market. *Science*, 311(5762): 854–856.

Thorndike, E. L. (1931). *Human Learning*. New York: The Century Co.

Tullock, G. (1987). Biological Applications of Economics. In J., Eatwell, Milgate, M. and Newman, P. (Eds.) *The New Palgrave: A dictionary of Economics* (volume 1, pp.246-248). London: The Macmillan Press Limited.

Tashiro, A., Sandler, V. M., Toni, N. et al. (2006). NMDA-receptor-mediated, cell-specific integration of new neurons in adult dentate gyrus. *Nature*, 442(7105): 929-933.

Tomlin, D., Kayali, M. A., King-Casas, B. et al. (2006). Agent-Specific Responses in the Cingulate Cortex During Economic Exchanges. *Science*, 312(5776): 1047-1050.

Vanderwolf, C. H. (2007). *The Evolving Brain: The Mind and the Neural Control of Behavior*. New York: Springer.

Wilson, E.O. (1998). *Consilience: The Unity of Knowledge*. New York: Vintage Book.; (2000). *Sociobiology: The New Synthesis* (25th Anniversary ed.). Cambridge: Harvard University Press.