## Title
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# Identity of Comparative Psychology: Its Status and Advances in Evolutionary Theory and Genetics

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Recent developments in theories in evolution, development and comparative psychology indicate that a redefinition of comparative psychology may be useful. A brief review of the marginalization of the scientific and academic identity of comparative psychology indicates the need to integrate contemporary thinking in evolutionary biology, genomics and developmental theory. Schneirla's concept of integrative levels, punctuated equilibrium and exaptation theory elaborated by Eldredge, Gould, and Vrba, and advances in genomics (e.g., retrotransposon function) would be helpful in countering the marginalization of comparative psychology. A provisional redefinition is offered for discussion by those who identify themselves as members of the discipline; comparative psychology is the science of the elucidation of similarities and differences in the evolution and development of the activity of all species to illume the processes by which their activity contributes to the beneficence of their relationship to the abiotic and biotic aspects of the environment. Comparative psychology as a "science" emphasizes methods of investigation relating to all levels of the integration of processes that are relevant to the evolution and development of the activity of all species.

In this paper, I suggest that there are three reasons for the need to consider a redefinition of comparative psychology: first, the identity of comparative psychology is marginalized; second, advances in evolutionary theory and genetics may affect the theory and practices of comparative psychology; third, the activities of the human species are of significance to all sciences today, and especially to comparative psychologists who work with the relationship between humans, nonhuman organisms and the environment. Comparative psychology could make a special contribution to the development of policies designed to ensure the welfare of the planet and its inhabitants. Comparative psychology can make history by addressing these issues, as they are inherent to its identity. This third reason requires considerable discussion and is offered here as a possible stimulus for further work.

The following provisional definition is proposed for consideration of that possible redefinition of its identity: comparative psychology is the science of the elucidation of similarities and differences in the evolution and development of the activity of all species to illumine the processes by which their activity contributes to the beneficence of their relationship to the abiotic and biotic aspects of the environment.

Usually the term "study" rather than "science" is used in the definition of comparative psychology. It is proposed that science is the more useful term, emphasizing different methods of investigation relating to the integration of all the processes that are relevant to the evolution and development of all activity in all species.

It is suggested that "activity" theory can contribute to the theoretical base of comparative psychology as it emphasizes the agency of the organism as it changes internally and externally in its relationship to the abiotic and biotic envi-

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ronment in which it acts and which it changes by its activity (Waddington, 1959). The history of the concept of "behavior" is limiting, for example, as it became behaviorism. Activity theory (Leontiev, 1978; Luria, 1979; Vygotsky, 1997) could be important to the theory of the science of comparative psychology (see Gottlieb, 2002; Gottlieb & Lickliter, 2004; Kuo, 1967); although these authors did not cite activity theory, their emphasis on the activity of the organism as in important process in development and evolution is noteworthy.

Consideration of these rationales for the provisional definition of comparative psychology as a prelude to a redefinition of comparative psychology is organized as follows: I. The marginalization of the identity of comparative psychology: comparative psychology as an academic discipline; II. contemporary thinking in evolutionary biology; III. advances in genomic theory; IV. developmental theory; V. some alternatives towards redefining comparative psychology.

## Marginalization of the Identity of Comparative Psychology

The identity of a science is dependent on its ideological recognition by the scientific community, by the academy and by society. When the status of comparative psychology is compared with related disciplines, the possible need for a redefinition of comparative psychology is clear (Greenberg, Partridge, Weiss & Pisula, 2004; Lickliter, 2004).

### *Status of Comparative Psychology in the Academy*

One method for signifying the academic attraction of relevant disciplines for students who wish to understand the relationship of humans and other animals is the use of a popular search engine (e.g., Google) to find where a person might enroll to obtain a higher degree in the subject. Searching for comparative psychology, ethology, sociobiology or evolutionary psychology degree-granting institutions, it was evident that although it is older than ethology, sociobiology and evolutionary psychology, comparative psychology does not enjoy their visibility. For comparative psychology, there are 6,980 entries; for ethology, there are 75,400 entries; for sociobiology, there are 78,100 entries; for evolutionary psychology, there are 59,700 entries. The listings are not very accurate and the searcher has to cull appropriate information. Lists of places to earn an advanced degree in evolutionary psychology were compiled by the Human Behavior and Evolution Society and Steven Kaplan of the University of Michigan; no such listing was given for the other disciplines.

### *Marginalization of the Identity of Comparative Psychology in the Psychological Community*

The lack of visibility is somewhat similar in the psychological community as seen in the *Annual Review of Psychology*. This series of review volumes in psychology, started in 1950, is prestigious although not an official publication of the American Psychological Association (APA). The chapters on comparative psychology were variously combined with physiological psychology, ethology, animal

behavior and ecology; sometimes they featured behavioral patterns such as learning, cognition, and foraging. The last chapter on comparative psychology as such appeared in 1964; in 2001 there was a chapter on evolutionary psychology.

To what societal, scientific or academic processes are these patterns related? The interests of the writers of the chapters certainly played a role in the subject matter of the chapters and their titles. The editors of the *Annual Review of Psychology* carefully select authors who are experts in the field of the evolution of behavior. Perhaps the authors may have reflected the thinking of the psychological community, as well as the public. As far as the public is concerned comparative psychology is frequently identified as animal behavior or ethology ("a scientific study of animal behavior," *Webster's New Third International Dictionary*, 1965, p. 781) and sociobiology and evolutionary psychology help to understand human behavior. Popular literature, nature and health television programs, daily media and cinema regularly and frequently feature the ideology of ethology, sociobiology and evolutionary psychology, by discipline name and by citations of researchers who are known to be proponents of those disciplines. Comparative psychology may not have an iconized writer or scientist in the public arena who is regularly and frequently quoted as to human and nonhuman behavior.

As the informative article by Jaynes (1969) clearly related, the disciplinary origins of comparative psychology are rather old. It was established as the science of the study of the mind (see Flourens in Jaynes); Darwin was eager to establish the study with George Romanes, who is frequently seen as the father of comparative psychology. Because of the association with Darwin, the relationship of evolutionary theory to comparative psychology was clear, and the comparative method of studying behavior (emotion, intelligence, learning) was within the mode of comparative anatomy. The weakening of the relationship between evolutionary theory and comparative psychology is well known.

Some more recent history may be informative. In 1967, Scott, a psychologist, wrote a chapter on "Comparative psychology and ethology" in the *Annual Review of Psychology*. Scott wrote that there was great interest in "animal behavior" and "ethology." Ethology, studying behavioral evolution as the unfolding of innate, instinctive patterns, became well known in the United States after 1950 when Lorenz returned from prisoner-of-war camp in the USSR and headed the Institute of Comparative Ethology at Altenberg (1949 to 1951; see also Lerner, 1992). In 1950 he established a comparative ethology department in the Max Planck Institute of Westphalia. Scott wrote: "This new wave has not yet reached its full height nor is it likely that it will ebb as suddenly as did that of the old comparative psychology." (p. 65). In that chapter, Scott included a section called "Ethology (Evolutionary Psychology)", in which he reviewed the ethological study of behavioral evolution to determine the social organization of species. Scott was also active in the Ecological Society of America and led the establishment of a Division of Animal Behavior in that Society. In one of his talks to that division, he called for the study of the biological basis of social behavior and used the term "sociobiology" to describe that study.

In the *Annual Review of Psychology* chapter, Scott noted that the Division of Physiological and Comparative Psychology merged with the Division on Experimental Psychology in 1947. In 1963, I urged Hans Leukas Teuber and Sidney

Weinstein to convince the APA to reinstitute the Division of Physiological and Comparative Psychology in the Association, which occurred. Today that Division is called Behavioral Neuroscience and Comparative Psychology.

### *Marginalization of Comparative Psychology in Scientific, Refereed Journals*

Today, there are several disciplines under which the evolution of behavior may be studied, with a view towards a doctorate, publications, and a job. This is reflected in two reports relating the publications of the research in these fields and in many disciplines. In 1989, Crawford wrote an article about the value of the theory of evolution to psychology in which the phrase "comparative psychology" does not appear in the bibliography. The only nonethological, nonsociobiological, nonevolutionary psychological reference are Gould's *The Panda's Thumb* (1981), Kitcher's *Vaulting Ambition* (1987) and some biological writings that were produced before the influence of ethology became widespread. The ethological, sociobiological and evolutionary psychological approaches to the relationship between evolutionary theory and psychology rest on the Darwinian assumptions of natural selection, adaptation, ultimate and proximate basis of behavior (without giving Tinbergen, 1963 any credit for this distinction), and above all, the centrality of reproductive activity to secure the species and the genes. Evolution is the unfolding of the innate, instinctive patterns that are useful in this way of seeing behavior.

A more recent paper by Ord et al. (2005, p. 1401) analyzed publications on the study of animal behavior.

> *We provide the first quantitative overview of animal behaviour research covering 42,836 documents published in the last three decades, across 25 journals. … Profound historical distinctions between early ethology and comparative psychology have been recently bridged by shared interest in communication and social behaviour, and research from physiology and applied areas.… Although we reiterate the rise of sexual selection and mating behaviour as prominent areas of research, we also show that interest in …development has proven …resilient…*

### *Comparative Psychology: Is it Really Different?*

Two ideologies have been present throughout the known human history of thinking about the nature of being human and animal: (1) the concept that there is a superordinate force that directs and organizes all life (intelligent design; creationism; instinct; preformed; all changes in the organism are managed by genes, needs, drives); and (2) that this force can only be modified to some extent by the experience of the organism, by the material basis of its existence. This dichotimization persists today in the ideologies of ethology, sociobiology, and evolutionary psychology.

Comparative psychology has not exposed these fallacies efficiently. In many ways, psychologists have attempted to make comparative psychology more "scientific," more positivistic, more operational and more mechanistic by incorpo-

rating biological technologies in its theory and practice. It may be said that the discipline of comparative psychology has not gained an identity that distinguishes it from other disciplines. Comparative psychology reflects the history of science and society in general and in particular (Allen, 1992; Allen & MacLeod, 2001).

## Contemporary Thinking in Evolutionary Biology and the Scientific Theory and Practice of Comparative Psychology: May These Affect the Identity of Comparative Psychology?

Increased knowledge about genetic and protein processes has emphasized the need to understand the interconnectedness of open complex systems of inanimate and animate entities. This new knowledge has also emphasized the relationship of the organism as it develops to the inanimate and animate entities and processes of the setting in which it develops. Some evolutionary biologists are now turning to the effects of the environment on the ways in which the genes and proteins function (Jablonka, Lachmann & Lamb, 1992; Jablonka & Lamb, 1995; 2005). Others are aware that the developmental processes of gene and protein function are important for evolutionary change (Ho, 1987; Prum & Brush, 2002; Sawyer et al., 2005). Most troubling and least reconciled are the discussions about the process of speciation: how do different species arise? Two of the most stimulating concepts about how speciation may have occurred are punctuated equilibrium (Eldredge, 1971; Eldredge & Gould, 1972) and exaptation (Gould & Vrba, 1982). For comparative psychology these concepts are critical for understanding how the changing activity of the individual organism in changing environments plays a critical role in evolution. These processes also involve the developmental changes brought about by the agency of the organism (Gottlieb, 2002a, 2002b; Lickliter, 2000).

The writers (Eldredge, Gould, Vrba) on these two concepts put genetic processes into the context of the organisms' relationships to the environments in which they lived and how such factors may have played a role in the activity of the organism which then affected the process of speciation. A brief statement of the two ideas suggests how this issue may be elaborated by comparative psychology: the science of the relationship between the individual's activity within the community of species, and the speciation that results from some changes in all integrative levels (earlier and later levels of organization and function, that is, as related to the development of the organism) within the individual.

### *Punctuated Equilibrium*

Punctuated equilibrium deals with the original problem that critiques of Darwin emphasized: if evolution meant descent and relationships among species with the [unexplained] occurrence of new species, how does one explain the lack of intermediate species? Eldredge and Gould (Eldredge, 1971; Eldredge & Gould, 1972) proposed the following when they proposed an alternative to phyletic gradualism (accumulation of small changes leading to a new species): "The history of life is more adequately represented by a picture of 'punctuated equilibria', dis-

turbed only 'rarely' (i.e., rather often in the fullness of time) by rapid and episodic events of speciation" (Eldredge & Gould, 1972, p. 84).

They postulated that the rapid and episodic events of speciation were related to the fact that

> *Importance of peripheral isolates lies in their small size and the alien environment beyond the species border that they inhabit—for only here are selective pressures strong enough and inertia of large numbers sufficiently reduced to produce the "genetic resolution"* (Mayr, 1963, p. 533) *that overcomes homeostasis* (p. 114).

Mayr was using the concept of homeostasis within the individual as self-regulation and responsible for the stability of species within a particular area where speciation does not take place. The concept of punctuated equilibrium stimulated critical discussions (Somit & Peterson, 1989). For those who are interested in the sociology of science, the following may be informative. This is what Somit & Peterson (1989, p. 48) write "…we sought to weigh the scientific implications of punctuated equilibrium..."As has been the case with many other theories, ideological issues have become intertwined with scientific ones in the debate over punctuationism. There have been allegations that the proponents of punctuated equilibrium were influenced, if not motivated, by Marxian ideological considerations, an allegation not discouraged by Gould's active involvement in the Sociobiology Study Group of Science for the People and that group's ideological criticism of Edward O. Wilson's Sociobiology. On the other side of the scientific fence.some have noted that punctuational theory may provide at least metaphoric support for advocacy of revolutionary change (Peterson & Somit, 1983). Combine this with Gould's candid comment about learning Marxism at his father's knee and one can understand the ideological suspicion the theory has elicited. "The formulation of punctuated equilibrium also coincided with the rise of sociobiology…" (Somit & Peterson, 1989, p. 2).

Eldredge, an invertebrate paleontologist, did his dissertation in 1969, which became the basis for his paper in 1971, in which he proposed that instead of a "gradualist" approach to speciation, saltation was more likely the relevant process by which new species arose. In 1972, Eldredge and Gould published their first paper on punctuated equilibrium. E. O. Wilson published "Sociobiology" in 1975.

The concept of punctuated equilibrium is noteworthy for comparative psychology because it raises questions about the ways in which the activity of the individuals and the group bring about the small isolate populations: What is the agency that leads to these allopatric speciations? Is it a response to environmental changes? Is it changes in the food eaten? Is it changes in predator-prey relations? As Venable (1966, p. 3) said, "The behaviour of…individuals or groups…within their physical and historical environments, change…these environments and themselves."

Knowledge of the developmental and activity processes in evolution is necessary and comparative psychology can play a role in the gathering of this knowledge. Evolutionary biologists have focused traditionally on the gene as the central factor in development and activity; today researchers find that other struc-

tures in the living organism's cells, such as proteins, chromatin and cytoplasm, play significant roles. This requires a change in approaches to evolution that are solely genecentric (Burian, 2000; Colot & Rossignol, 1999; Cullis, 1986; El-Hani & Emmenche, 2000; Gottlieb, 2002; Jablonka et al., 1992; Lutsenko & Bhagwat, 1999; Orton, 1955; Pennisi, 2001; van Speybroeck, 2000; Waterland & Jirtle, 2003; Wolffe, 1994; Xu & Deng, 2002;). This new knowledge has also emphasized the relationship of the organism as it develops to the setting in which it develops: the inanimate and animate entities and processes.

Nonetheless, many evolutionary biologists are still guided by the idea that all the changes that take place in evolution are determined by the need for the individuals to reproduce organisms that are very similar to them, and that they are thus behaviorally bound by genetic processes. Geneticists, working at molecular and other early levels of structure and function (that is, levels that are early in development, such as genetic, protein and hormonal, cascades in sexual determination; (Gilbert, 1997), frequently turn to later levels of organismic structure and function, such as activity/behavior (that is, levels that appear later in development in which the total organism is involved). However, they are still guided by the necessity of genetic survival. When comparative psychologists, working at later levels of organismic structure and function (later development of the activity of the entire organism) turn to earlier organismic levels, such as genes, proteins, hormones, neurotransmitters, they frequently focus on genetic processes thought to have emerged in evolution to reproduce similar organisms (Dawkins, 1989).

### *Exapation*

The second concept, exaptation, developed by Gould and Vrba (1982) offers an alternative process by which change in individuals and species takes place. Together with the paleontological findings that dinosaurs were not only reptilian in their descendants but ornithological as well, the concept of exapation has come to integrate molecular and activity processes within developmental processes.

Citing the many definitions and usages of the word "adaptation," Gould and Vrba (1982) proposed that a new word was needed to clarify relevant processes: exaptation. They described a process (cooptation) in which a character (structural; but could also be behavioral, or an activity) that was previously shaped by natural selection for a particular function is coopted for another, current use as elaborated by the environment. The origin of this character cannot be ascribed to the direct action of natural selection (a nonadaptation). The example they give is of the evolution of feathers. Originally, the structures were protuberances of the skin which were related to thermal regulation. As the environmental pressures brought about a modification of jumping to flying, these protuberances maintained their thermal regulatory pattern and developed into feathers, which made flying possible.

***Biological Evolutionary Aspects.*** As indicated above, the paleontological findings of the ancestry of birds stimulated a good deal of research and discussion about the evolutionary origin of feathers (Maderson & Homberger, 2000; see also Prum & Brush, 2005). Although these discussions are all related to exaptation theory, which featured feathers prominently in the article by Gould & Vrba (1982),

the work of Gould and Vrba is not cited. The discussion clearly emphasizes developmental processes on all levels—molecular and total organismic activity—but there are no papers relating to research on bird flight and how factors related to bird flight may have played a role in the development and evolution of feathers as flight organs.

***Comparative Psychological Aspects.*** In the discussions of the evolution and development of feathers, the psychological agency of the organisms as a factor in evolution and development is not discussed. What brought about the change in activity from jumping to flying: responses to environmental changes, or perhaps responses to changes in predator-prey relationships? These two possibilities would require an integration of the levels of biochemical, muscular, and neural structure and functions that were involved (Gottlieb, 2002).

Although exaptation stimulated a great deal of critical and supportive discussion (Gould, 1991a) as was the case of punctuated equilibrium, its relation to psychology, or activity (behavior) is relatively slow to develop. A check of publications that discussed or used the concept showed interest among a variety of scientists: geneticists; biologists concerned with evolution, speciation, proteins, bipedalism and hormonal function; professionals working with mental disorder and cognition. In addition, there were papers by animal behaviorists (Delius & Siemann, 1998; Jones, Bllum & Pawhk, 2005; Withgott, 1996). Not all researchers found the concept useful, but all considered it worthy of examination. The animal behavior papers are particularly of interest to comparative psychologists.

Gould (1991) wrote on exaptation and psychology and suggested that exaptation would be of use to psychology, but dealt with evolutionary psychology particularly. The reactions of sociobiologists and evolutionary psychologists were published in the *American Psychologist* (1998, 1999). Despite their criticisms, the concept is of great potential significance for comparative psychology.

Most of the papers that appeared in the *American Psychologist* were criticisms of Gould's paper and how he viewed evolutionary psychology. One paper addressed the theory itself (Beauchaine, 1999). Beauchaine titled his contribution "Definitions and levels of analysis." He pointed out that the criticism made by evolutionary psychologists did not recognize the fact that language, religion, principles of commerce warfare, reading, writing and the fine arts are all complex psychological phenomena. Beauchaine formulated his criticism in terms of biological phenomena (brain size, structure and function); he did not refer to the appropriate levels of analysis of these phenomena, that is, the psychological/societal level. Gould also ignored the level of these *psychological* phenomena and placed them into a "biological" level, which does not lead to an understanding of exaptation. The concept of levels of integration is relevant to the process of exaptation.

***Concept of Integrative Levels.*** Although neither Gould and Vrba (1982) nor any of the other authors viewed their work in terms of levels of structure and function (or even hierarchy), the concept of exaptation can be seen to be an example of integrative levels of structure and function. According to the concept of integrative levels, each level can be categorized as to what is its proper method of study or enquiry (Tobach, 1995). The psychological level is a complex level, involving many categories within the level. An investigation of language is exemplary of the concept of integrative levels. To study language, the category level

within which language develops needs to be specified. Not only does the category need to be specified (for example, one category might be: comparative anatomy of speech morphological structures; another might be a comparative study of respiratory structures and their functions; another might be syntax and other language aspects of speech). In addition, the historical and developmental stage of the level (whether the category is morphological or physiological) are important. It is necessary to indicate at which stage of evolutionary history and individual development, the category is to be studied. For example, if the category is morphological, the evolutionary history of the morphology involved in sound production would have to be known. If the category is physiological, the developmental of the organism would have to be known. Is it embryonic? Is it neonatal?

The listing of language, religion, principles of commerce warfare, reading, writing and the fine arts as the result of exaptation without specification of the category to which these belong, and at which historical stage both for species (evolutionary history) and for individual organisms (developmental stage) makes it difficult to understand how exaptation is working in the regard to such societal, social processes that yield language, religion, warfare, reading, writing and the fine arts. They are not similar in terms of their categorization as psychological activities. Religion, commerce, warfare, and the fine arts may be related societal products, depending on the question being asked, but their histories are complex and different from each other. Language, reading and writing, all human activities, may also be related to each other, but the questions to be asked about them require specification as to category, history and developmental stage. However, each of them integrates levels that could be shown to have been processed as exaptations of structures and relevant functions. As the evolutionary biologists working on the origin of feathers have shown, there are exaptative processes in molecular, hormonal, structural and physiological functions.

For comparative psychologists a question arises: if the new species differs from earlier entities not only in its molar characteristics (body shape, color, activity) but in its genome, in its molecular levels of structure and function (genes, proteins, biochemicals—hormones, transmitters, receptors, etc.), how did these changes take place? Were all changes dependent first on some change in a nucleotide or a group of nucleotides? Or did the agency of the individuals play a significant role in the ways in which these changes could take place? The activities of the organisms in the setting in which they functioned not only changed the setting, but the relationship of the individual to the setting as well. Did the organism internalize those changes to bring about a change in the structure and function of all levels, or of specifically significant levels, such as the genomic level? (See Gottlieb, 2002a, 2002b; Honeycutt, 2006; Lickliter & Schneider, 2006.) It is interesting to note that one of the developers of the exaptation concept worked together with the developer of a particular process focused on the genome: Brosius, worked with retrotransposons (Brosius & Gould, 1992).

## Advances in Genomic Theory

### *Retrotransposons*

The third concept of significance to comparative psychology (Brosius, 1991, 1999, 2005; Brosius & Gould, 1992; Makalowski, 2003, 2000) is that of the retrotransposons (also called a retroposon) as a significant factor in evolution. The classic definition of a retrotransposon is, "Transposable element that utilizes reverse transcriptase to transpose via an RNA intermediate" (Griffiths et al., 1996, p. 875). The significance of RNA in genetic function is well described and the transcription process (the synthesis of RNA using a DNA template) involves transcriptase, a polymerase (naturally occurring compound consisting of large molecules made up of a linked series of repeated simple monomers, that is, a molecule that can combine with others to form a polymer). This polymerase catalyzes the formation of RNA from a DNA template in the process of transcription. The retrotransposon reverses the process so that a nucleotide can be inserted in a new place via RNA.

A persistent genomic question concerns the high number of repeated nucleotides that seem to be functionless; these are called "junk DNA." Brosius (2005) has made a significant contribution by suggesting that a transposition of DNA sequences that does not occur in DNA itself, but happens rather when mRNA is transcribed back into the genomic DNA (retrotransposon process). This does not necessarily result in degenerate functions but can create new nucleotide configurations that lead to new functions (Brosius, 1999). Makalowski (2000, 2003) is an active researcher in such reversals that have taken place and has published the results of his findings, many of them in humans.

***Integration of Concepts of Exaptation and Retrotransposons.*** The evident relationship between exaptation and retrotransposons is discussed in the paper by Brosius and Gould (1992; see also Brandt et al., 2005). They propose new terms in regard to the use of the term "gene." The main point they are making is of significance to comparative psychology: "…since their current names reflect the prevalent view that they constitute dispensable genomic noise (trash), rather than a vast repertoire of sequences with the capacity to shape an organism during evolution." (abstract, p. 10706). It is possible that the retrotransposon can integrate the activity of the organism and the changes that result on all levels—the molecular and its integration into the succeeding levels leading to psychological processes.

These advances in evolutionary biological theory deal mostly with the genetic process but they are suggestive as to the relationship among the integrated levels of structure and function within the organism and in all categories of interest to comparative psychologists: social activity, problem solving, individual adjustment and species adaptation to changes in the environment, etc. Although some of the writers on evolutionary biology recognize that development is an important aspect of the integration of levels bringing about the changes in the organism and the species, there is not enough collaboration between the evolutionary biologist who looks at punctuated equilibrium, exaptation and retrotransposons and the scientist who studies developmental processes that demonstrate the changes in the individual and the species…the integration of development and evolution. A con-

sideration of the discussions in developmental psychological theory and practice suggests possible ways in which this integration may take place.

## Developmental Theory

As indicated above, evolutionary biology and genomics/proteomics have seriously attempted to take developmental processes into account. Yet, genetics rather than developmental processes is still a dominant focus in evolutionary explanations. Despite serious criticism of the genetic emphasis in ethology, sociobiology and evolutionary psychology (Lickliter & Honeycutt, 2003a, 2003b; Levins & Lewontin, 1985; Tobach & Rosoff, 1978-1994), the acceptance of genetic determinist views of total organismic activity (behavior) continues (see also Kalikow, 1983). The persistence of genetic determinist (cf. creationism; intelligent design; instinctivism) explanations for human activity, mental and otherwise, is a matter for further analysis and discussion of societal processes possibly responsible for their popularity. (Allen, 1992; Allen & MacLeod, 2001).

Two approaches in developmental theory address these issues. Lickliter and Honeycutt (2003a, 2003b) proposed developmental dynamics as the biological challenge to the theory of evolutionary psychology; evolutionary psychology is unable to meet and overcome that challenge. Probabilistic epigenesis based on developmental processes is another important alternate approach to the genetic determinism of ethology, sociobiology and evolutionary psychology.

In addition, for comparative psychologists interested in evolution and development, Schneirla's thinking is appropriate: To understand developmental processes, the evolutionary processes need to be understood; to understand evolution, the developmental processes need to be understood (Schneirla, 1957).

### *Developmental Dynamics (Human Development as a Dynamic System)*

Developmental dynamics, as elaborated primarily by Thelen and Smith (Smith & Thelen, 2003; Thelen, 1989; Thelen & Smith, 1994), present a concept that is pertinent to all levels (for example, molecular to psychological) for both individuals and species. "Dynamic" is defined variously (e.g., in Webster's Dictionary, 1965) and the following definitions seem most appropriate: characterized by continuous change, activity…an interactive system or process, especially one involving competing or conflicting forces; marked by continuous, usually productive activity or change. In dictionary definitions, two concepts appear that are particularly relevant to our discussion: continuous change and conflicting forces.

For Thelen and Smith, the concept of change in their elaboration of dynamic systems rests primarily on multicausality. The equivalence of multiple factors requires some consideration. Smith and Thelen (2003, pp. 343-344) discussed "the two major tenets of dynamic systems theory as it applies to the self-organization of human development": multicausality and nested time scales (pp. 343-344). The two major tenets are elaborated as assumptions. Multicausality is an assumption of the dynamic approach (Smith & Thelen, 2003, p. 343):

> *Developing organisms are complex systems composed of very many individual elements embedded within, and open to, a complex environment…[which] can exhibit coherent behaviour:…the parts are coordinated ….[and] produce the organized pattern…the coherence is generated solely by the relationships between the organic components and the constraints and opportunities of the environment. This self-organization means that no single element has causal priority….Development can be envisioned, then, as a sense of evolving and dissolving patterns of varying dynamic stability…*

By assuming that "no single element has causal priority" it may be inferred that the genetic level of change is presumed to be equal to other levels of change. System theory requires precision of the definition and function of parts of the system to understand their priorities in the system. The way in which those priorities are defined is a fundamental theoretical issue.

Nested time scales are developed from the idea that behavioral change occurs over different time scales. The coherence of time and levels of the complex system mean that the dynamics of one time scale (e.g., neural activity) must be continuous with and nested within the dynamics of all other time scales (e.g., growth, learning and development).

Time and space are characteristics of matter in motion (dialectical materialism; see Engels, 1954; Plekhanov, 1961) and all matter is always in motion, and always changing. The different time scales may be studied according to the categories that define the phenomena that are being investigated. As all matter is interconnected, time scales and spatial relationships are interdependent on the multicausality that Smith and Thelen (2003) saw as an important aspect of the characteristics of change in all living systems.

The issue that needs further research and discussion are the processes that bring about the changes. In the dictionary definition of dynamic, the role of conflicting or competing forces is given as part of the meaning of dynamic. The changes are the resolution of the conflict, or competing, or contradiction (Bitsakis, 2002, pp. 275-277) that exists in all levels of structure and function. One such contradiction is that which is between the structures and functions within the cell, the tissue, the organ, the individual organism, among its conspecifics (social processes) and heterospecifics, within its inanimate setting (climate other planetary changes). It is the contradiction between structure and function in all levels which develops as the organism lives and maintains its integrity.

Structures and functions are continuously changing. Each is changing in a process that involves their inner contradictions (the structures are metabolically active and are either maintaining their integrity, if they are getting the proper inputs of energy needed for that; or they are losing their integrity (or, are dying; compare apoptosis and its significant role in development). The external contradictions brought about by the functions they are performing (becoming stronger and more integrated with other systems; or becoming deformed because their functions are in contradiction, or competing, or conflict, with the inner contradictions brought about by metabolic processes—in other words, their structures are being negatively affected by the functions being performed). Thus the contradictions of

structure and function are sharpened by the ways in which the structure and functions are changing, or are being resolved by the changes that are brought about by internal or external contradictions (Marquit, 1981).

The time scales that are significant in the dynamic system of development are also related to the levels of structure and function. Each level has its time scale based on its structure and function, as well as its relationship to other levels (Tobach, 1987). For example, the time characteristics of change within a cell are dependent on the time characteristics of receptor change at the cellular membrane as well as the receptors within the cell. The substances that are within spatial relationships to the receptors in turn are dependent on the time scale of the change in the motion of the matter that produced them.

Thelen and her colleagues have applied this approach to behavioral development at many levels (for example, organismic, social); they have demonstrated how the dynamic developmental approach can answer questions about behavioral development. They discuss the evolutionary significance of the approach, but this is not as thoroughly discussed as the developmental aspect.

### *Probabilistic Epigenesis of Development (Gottlieb, 2003)*

In an integration of the theoretical approaches of Kuo, Schneirla and Lehrman, Gottlieb (1993) offered an important definition of development that goes far in the elucidation of the false dichotomies of nature and nurture or genes and environment: "…individual development is characterized by an increase of complexity of organization—i.e., the emergence of new structural and functional properties and competencies at all levels of analysis (*molecular*, *subcellular*, *cellular*, *organismic*) as a consequence of horizontal and vertical coactions among its parts, including organism, environment coactions " (Gottlieb, 1993, p. 36). Three significant words appear in that definition that stimulate further discussion in that elucidation: epigenesis, level, coaction.

***Epigenesis***. There is no emphasis on the genetic process in Gottlieb's (1993) use of the term "epigenesist" in his new definition. However, the term, like "adaptation," is used in many disciplines with a multitude of historically based meanings, and it may be that it is difficult at this time to produce consensus (Goodwin & Saunders, 1989).

The beginnings of epigenetic conceptualization can be seen as antivitalistic, materialist—Needham (1934) and Glass (1959) called the conceptualization of epigenesis mechanist—and developmental. It stressed that explanations for speciation and evolution can be obtained from observation and experimentation. However, contemporary definitions of epigenesis express a dependence on genetic function that may be seen as vitalistic:

> *Epigenetics: the study of mitotically and/or meiotically heritable changes in gene function that cannot be explained by changes in DNA sequence* (Rusos, Martinssen & Riggs, 1996, p. 1).

> *Epigenetic inheritance: Processes by which heritable modifications in gene function occur but that are not due to changes in the base sequence of the DNA of the organism* (Griffiths et al., 1996, p. 864).

The emphasis on the DNA sequence is clear; epigenesis is about how genes function (Jaenisch & Bird, 2003).

Epigenesis, an old word, reflects a persistent argument (Needham, 1934) that is important in comparative psychology: preformationism versus development, or as it became formulated later, gene versus environment. Aristotle is said to have been the first to note the antithesis between preformationism and "fresh development" which Needham equates with epigenesis (Needham, 1934, pp. 22, 37, 129) The argument about preformationism and epigenesis continued throughout recorded scientific history (Waddington, 1966). However, the concept of epigenesis was elaborated in new, rather developmental, ways. Needham quoted from Harvey (1653, pp. 223-224): "The perfect animals, which have blood, are made by epigenesis, or superaddition of parts and do grow…An animal produced by epigenesis attracts, prepares, concocts, and applies, the matter at the same time, and is at the same time formed" (Needham, 1934, pp. 118-119).

Preformationism was deemed an inherent component of evolutionary thinking, and the argument against preformationism was couched in antievolutionary frames. An important proponent of antipreformationism, but within an evolutionary approach, was deMaupertuis (1698-1759) whom Glass (1959) described as a forerunner of Darwinian theory. Glass wrote that deMaupertuis projected concepts such as mutation, natural selection and geographic isolation; despite his brilliance, deMaupertuis is not well known. Glass (1958, pp. 61-62) wrote that despite the fact that the "theory of preformation prevailed almost universally," deMaupertuis formulated the concept of epigenesis as "the view that the parts of the embryo are formed in succession out of unorganized material…"

Hertig (1892, p. 24) credited Caspar Friedrich Wolff as the "founder of the doctrine of epigenesist." Although Woff opposed preformationism, in his doctoral dissertation in 1759, he "opposed the dogma of the evolution theory," and casting aside preformationism, said, "…the germ is nothing else than an unorganized material eliminated from…the parent…which gradually becomes organized, but only during the process of development…" (Hertig, 1892, p. 24). The concept of epigenesis was firmly based on the developmental process.

However, today epigenesis is about how genes function; the emphasis on the DNA sequence is clear. The definitions of the term epigenetic inheritance, or epigenesis, demonstrate the core of the term: the DNA structure. In all that is being said about epigenetics, the understanding is that the nucleotide configuration of adenine, cytosine, guanine, thymine and uracil will not change. The lack of possible explanation by genetic function is interpreted as an attribution to the role of environmental, or nongenetic factors. Geneticists and evolutionary biologists are discussing the inheritance of nongenomic effects on the phenotype which do not change the genotype. This formulation supports dichotomous thinking.

Some evolutionary biologists and geneticists are discussing how the genes might be changing, given the interdependence of all the factors in the history of the species and the organism (Brosius, & Gould, 1992; Ho, 1984, 1986, 1987;

Jablonka & Lamb, 1995; Makalowski, 2000; see also Graur, 1993; Waddington, 1942a, 1942b). Those who are concerned with the stability of species recognize that the function of the gene changes, and that these functional changes might be inherited. Others recognize that change in function is the primary criterion of the process of development and evolution.

***Formulation of Levels.*** The concept of integrative levels is core to the integration of developmental and evolutionary processes. The term "hierarchical" is used interchangeably with "level" (Brannas et al., 2005; Gottlieb, 2003; Reuter et al., 2005). The difference between the two terms sharpens the issue of genetic determinism. In genetic deterministic ideologies, the gene is seen as the most important factor, the dominant factor. This is supported by the concept of hierarchy, a term that is based on the concept of ranking or placing some entity as higher, better or more powerful than another. The concept of integrative levels rests on the definition of "level" as an even plane with no elevations or depressions. Thelen and Smith (1994) did not find this designation of the gene acceptable and they spoke of the equality of all factors in multicausality.

The notion that all levels are equivalent needs to be supported by research investigation. Some contradictory levels may be "eu" (good; as in euphoria) and contradictories of "dys" (bad, as in dysfunctional). For example, a dysfunctional protein that is effective in all cells would be an "opposite", or a contradictory to a properly functional protein. The ubiquity of the dysfunctional protein would thus be very significant, and place the biochemical level as the most important level. The dysfunctional protein leads to disintegration of the individual (for example, a break down in a metabolic process because of a toxin that becomes a part of every cell in the body).

To designate a level as the positive opposite or contradictory to another level as the negative, it is necessary to define the contradictions internal to that level and to investigate how the resolution of the contradictions would lead to an earlier level (e.g., turning a cell into its chemical components, an earlier level of matter, because of a metabolic contradiction that is not resolved, as in the case of the protein above). After resolution (in the Hegelian sense, Marquit, 1981) of the earlier contradictions the next, later, level of organization and function would be definable. Such a resolution would be one in which the dysfunctional protein becomes subordinate to the functional form of the protein, and the functional protein reproduces itself with a receptor that destroys the dysfunctional form of the protein; this process could take place in a successful fight against a disease, and take place at a later level, describing a change in the protein. Levels would not be seen as lower or higher, but rather earlier (contradiction between the two proteins) and later (resolution of the contradiction between the two) in a developmental sense.

The key to a levels approach is the recognition of the need to define the contradictions, their opposition and their resolution to produce another level…either to an earlier level or a later level that represents a unity of the two opposites in total organismic activity; it is difficult to define the contradictories. The two contradictories are not equivalent, and their character changes.

***Coaction.*** These resolutions of contradiction and the resultant unity of opposites that are part of the level being acted on are not coactions only. The changes may appear in time and space to be coactions but they are the result of the resolu-

tion of contradictions and the unification of the opposites. It is in knowing the nature of the contradictions and their resolution that makes possible the understanding of the changes, past, present and future by appropriate investigation (each level needs its own instruments, etc.; Tobach, 1995)

## Some Alternatives Toward Redefining the Identity of Comparative Psychology

### *Levels, Evolution and Development*

The primary argument today is between some form of vitalism and materialism; between some form of static stability and dialectical change. The history of the concept of epigenesis is a good example of the persistence of the useless dichotomy of an idealist force (preformation; instinct) and materialist development. In 1960, Schneirla (p. 305) referred to the "hardest-headed epigeneticists" who may be impressed by the "genic-behavior" correspondences described by the behavior geneticists, but he added the following: "…although such evidence may not do much more than emphasize the problems of ontogeny without solving them…that question of instinctive behavior must be investigated along other lines."

The process of development (ontogeny) was Schneirla's brilliant resolution of the conflict. On one side of the conflict were the vitalists, instinctivists, ethologists and others of the persuasion that evolution and individual behavior are based on inborn, innate, predetermined (preformed) structures and functions. On the other side were mechanists, logical positivists, scientific materialists, and operationalists who believed they were the contrary of the instinctivist persuasion; they said that all was learned, trained or the result of the environment.

The process of development as formulated by Schneirla (1960) was founded on several concepts: a materialist base to all organismic activity, function and structure; integrative levels of matter (Tobach & Greenberg, 1984); approach/withdrawal processes; adjustment of the individual to the setting in which activity takes place in the process of internal and external changes (individual experiential development and environmental processes); and integrity (fusion) of internal and external processes. Two aspects of his writing on the concept of development (e.g., Schneirla, 1957) are worthy of notice. First, he clearly stated that to understand comparative psychology it is necessary to remember the concept of integrative levels: "The concept of levels has great potential significance for comparative psychology, as a comprehensive basis for the analysis and synthesis of evidence concerning similarities and differences among the varied adaptive patterns of major phyletic types" (Schneirla, 1960, p. 308). In his article in 1951 (in Aronson, Tobach, Rosenblatt, & Lehrman, 1972) on the "levels" concept in the study of social organization in animals, he discussed the ways in which the integration of levels in the individual are related to the activity of the individual in groups, in social situations.

Second, he stressed the need to study the development of behavior in order to understand the evolution of the organisms that evidence the behavior: "…the concept of psychological levels is advanced to express the phyletic range of behav-

ioral organization and psychological capacities, and the concept of functional orders is advanced to express the ontogenetic range on any one level….The term development with respect to individual behavior stresses progressive changes in organized adaptive function through ontogeny. Behavioral development on any phyletic level is not so much a retracing through the stages and levels of successive ancestral forms as a new composite leading to a new pattern distinctive of the level" (Schneirla, 1957, in Aronson et al., 1972, p. 287).

In the history of epigenesis, and in the discussion by Schneirla (1960) about comparative psychology, the relationship between the two processes of change, evolution and development, is very clear: they are interdependent, interrelated and interconnected; as all matter changes all the time, this relationship is very complex. What scientific method and theory can deal with this complexity?

### *Dialectical and Historical Materialism*

Although Schneirla rejected identification with dialectical materialism (personal communication), like all accurate scientists who study natural phenomena, he was a dialectical materialist in his research and in his theory. It may be that the dialectical materialist approach to life processes (Sommerville, 2005), on all levels, within the individual, in the individual's social, (in the human, societal) activities, and within the planetary, climatic contradictions that are threatening our survival daily, could be helpful. Perhaps developmental comparative psychology based on historical materialist concepts (the history of the species, the history of the individual) would be a good way to go. Comparative psychology is needed to bring about a resolution of the persistent conflict between vitalism and materialism and the dialectical materialist approach may help.

## Epilogue

The theoretical advances by Gottlieb, Thelen, Smith, Lickliter and Honeycutt are important. The expert scientist reflects the reality of the natural processes that are studied. Their conceptualizations involve materialist analyses of the matter of the organism, of its structure, of its function, of the setting in which it lives. They reflect an acknowledgement of the law that matter is continually changing; they see this as a challenge to the scientist who seeks to understand the activity of organisms. They indicate that the activity of the organism is essential to the changes within and the changes in its relationship to the external setting. They have chosen development as the process that is key to understanding those changes, and have indicated that there are levels of organization and function within the organism that need to be considered. A review of each, taking into account their similarities and their differences suggests that dialectical materialism and historical materialism is a fundamental philosophical consideration that may be useful to the further elaboration of their theoretical approaches.

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