EVOLUTIONARY EPISTEMOLOGY

OF

DONALD T CAMPBELL

MASTER OF PHILOSOPHY

IN

NEURAL AND COGNITIVE SCIENCES

By

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December 2011

Evolutionary Epistemology of Donald T Campbell

A Dissertation Submitted to the University of Hyderabad in partial fulfillment of the requirements for the award of the degree of

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Declaration

I hereby declare that the work reported in this dissertation entitled **"Evolutionary Epistemology of Donald T Campbell"** was carried out by me under the supervision of Prof. Prajit K Basu, Center for Neural and Cognitive Sciences, University of Hyderabad, Hyderabad. It has not been submitted for any other diploma or degree either in part or in full to this or to any other university.

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CERTIFICATE

This is to certify that **Mr. Nagireddy. Neelakanteswar Reddy** has completed this dissertation entitled **"Evolutionary Epistemology of Donald T Campbell"** under my supervision and guidance for the period (August 2010 to December 2011) prescribed under **M. Phil** ordinances of the university and it has not been submitted for the award of degree or diploma of any other institution or university.

Place: Hyderabad

Date: 29/12/2011

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Acknowledgements

First of all, I am extremely thankful to my supervisor, Prof. Prajit K Basu, for his sharp remarks that were the 'selecting factors' in my 'blind' academic trials. I am also thankful for his patience, kindness, personal care and the freedom he provided me with.

I am also greatly indebted to Dr. Cicilia Heyes, Dr. Franz Wuketits, Dr. Nathalie Gontier and Dr. Adolf Heschl for sending me their works, which were relevant for my dissertation.

I thank the staff of Indira Gandhi Memorial Library, University of Hyderabad, for providing the best ambiance for peaceful studying.

I thank the faculty members and the research students of the Centre for Neural and Cognitive Sciences for providing me with an academically inspiring environment. I thank the centre for providing me with the computing and word processing facility.

I thank the administrative staff of the centre and of the various sections of the administration of the University of Hyderabad for their kind cooperation.

- N. Neelakanteswar Reddy

Contents

Introduction

Evolutionary epistemologists' characterization of knowledge is based on two related concepts. One group takes (phylogenetic) adaptation as knowledge while the other takes (ontogenetic) knowledge as adaptation.

Adaptation as knowledge: Evolutionary epistemologists - especially Donald T. Campbell, Karl R. Popper and Konrad Lorenz- suggested an identity between the processes of (biological) evolutionary progress without the attendant teleological connotation and those of knowledge gain. According to them, in the course of evolution, 'species' become more adaptive to the environment because of the natural selection; likewise, organisms' learning and human beings' engagement in science leading to progressive gain in knowledge are results of trial and error. These evolutionary epistemologists have no problem in identifying 'adaptation'- a concept in evolutionary biology- with 'knowledge'- a concept in epistemology. In this spirit, Campbell defines a 'knowledge process' as "any process providing a stored program for organismic adaptation in external environments". (Campbell, 1960, fn 2, p.380)

Thus, these evolutionary epistemologists are calling evolutionarily developed - cognitive or otherwise - bodily structures, physiological mechanisms, cognitive processes etc., as 'knowledge' as there is a 'fit' between these mechanisms and the world / ecological niche to which these mechanisms and processes are adapted. (See Chapter 1, Sec.2)

Evolutionary epistemologists' analysis of knowledge seems to show that they are paraphrasing the evolutionary theory by employing the terminology of traditional epistemology, than actually pursuing traditional epistemology. Sometimes, evolutionary epistemology is being criticized as ‘epistemology in name only’. Michael Bradie (1994), as well as Paul Thagard (1980) point out that the analogy between evolution and knowledge progression is spurious, as they employ different processes. For example, evolution is not goal directed while knowledge gaining by an individual learner or the scientific group is goal driven. Evolutionary epistemologies are also criticized as these are epistemologically irrelevant since these are not concerned with ‘norms’ (Dretske, 1971).

Knowledge as adaptation: Evolutionary epistemologists do not just construe adaptation to be knowledge but also construe vice versa i.e., knowledge gain (whether in individual learning or group of scientists engaged in science) to be employing an evolutionary process. To this end they developed a model and metaphor, of knowledge progression, based on evolutionary theory - Selection Theory or Blind Variation and Selective Retention model. (See Chapter 2, Sec.2). As the Darwinian selectionist account is the only materialist account of ‘fit’ between organisms and their ecology, Campbell (1974) believes that a ‘general selection’ account is the only explanation for a fit between the ‘knowers’ beliefs’ and the ‘known’, if one wants to be a materialist, naturalist about the process of knowledge. Campbell (1974b), Popper (1968, 1972), Stephen Toulmin (1972), David Hull (1988a,b) and Henry Plotkin (1994) and others applied selectionist metaphors and models to explain the growth of knowledge; but some evolutionary epistemologists like Michael Ruse (1986), Nicholas Rescher (1977) and Adolf Heschl (2001) eschew selectionist accounts, although they agree that knowledge processes are based in and constrained by evolutionary origins.

Although selectionist account is well-argued for (e.g., Campbell, 1974b; Cziko, 1995; Heylighen, 2000) its validity is yet to be empirically verified (Hull, 1988). Plotkin (1991) argues that Gerald Edelman's (1987) Neural Darwinism is the evidence for selectionism and Hull, Langman and Glenn (2001) also provide evidence for a general selectionist account from the domains of immune system functioning and 'behaviour analysis'.

As pointed out by Michael Bradie (1994) evolutionary epistemology is not merely the attempt to understand knowing via the use of metaphors drawn from evolutionary biology but also an attempt to understand biological processes in terms of metaphors drawn from epistemology (Campbell, 1960).

The primary effort of evolutionary epistemologists is the exchange of analogy, models and terminology between evolutionary theory and epistemology than a concern to solve the traditional epistemological problems. Various evolutionary epistemologists had varying degrees of inclinations toward solving traditional epistemological problems. (See Chapter 1, Sec.1)

As pointed out by Bradie (1989), traditional normative epistemology and evolutionary epistemology have entirely different questions as their focus. Traditional epistemology had the following concerns: for Plato - difference between knowledge and beliefs; for Descartes - the achievement of certainty; and for Russell - the problem of our knowledge of the external world. But, evolutionary epistemologists had different concerns: for Popper - the growth of knowledge and the continuity of animal and human knowledge; and for Campbell - the growth of knowledge and the 'fit' of belief and the referent.

Bartley (1987) identified a contradiction between justificationalism of traditional epistemology and non-justificational nature of Darwinian theory of natural selection. As evolutionary processes are nonjustificational, their analogue i.e., growth of knowledge is also nonjustificational.[1]

Thus, evolutionary epistemology distanced itself from traditional epistemological concerns and they have reconfigured the questions in epistemology and have developed their own ways to address them. It has acquired an attitude of science in that it is attempting to employ the evolutionary theory to solve epistemological problems and thereby is relying on ideas available in evolutionary biology (Plotkin, 1987). The scope of evolutionary epistemology is expressed by Valerie Gray Hardcastle (1993, p. 174):

> Today, the enterprise of working out the details and the implications of the hypothesis that complex thought processes evolved by natural selection along with more 'physical' structures and functions fall under the heading of "evolutionary epistemology". Its modern roots lie in the ruminations of both philosophers about evolution (e.g. Popper 1968, 1972; Toulmin 1972) and evolutionists about philosophy (e.g. Campbell 1960, 1974; Lorenz 1977, 1982), but evolutionary epistemology has since expanded to include not only evolutionary biology and philosophy, but also cognitive psychology, developmental neuroscience, and artificial life programming.
>
> Some philosophers hope (and expect) that the principles of evolutionary biology (augmented by theories in cognitive psychology and facts uncovered in developmental neuroscience) will shed light on some of traditional problems in epistemology. The underlying assumption is that Darwinian natural selection led to our present ability to garner reliable facts about the world. Philosophers look to biology to tell them how that occurred, psychology to specify more exactly what those capacities are, and the developmental sciences to sort out the degree to which nature determines our thought processes and nurture shapes them. Armed with these data, they would then presumably be in a better position to answer such questions as: What exactly is knowledge? And how do we know when we have it?

[1] Bradie (1989) criticizes Bartley's usage of the term 'justification' or 'nonjustification' to natural processes like evolution.

A characterization of evolutionary epistemology can be done by using the schema provided by Bradie (1994) where he differentiates between ontogeny and phylogeny and, evolution of epistemological mechanisms (EEM) and evolution of theories (EET). Synthesizing this classification with Campbell's (1997) division of evolutionary epistemology (see Chapter 1, Sec.2) can give us the breadth of evolutionary epistemology.

	Knowledge of an individual	Science
(phylogenetic) 'products' of evolution	(1) e.g., brain and sensory mechanisms; Kant's *a priori* categories	(2) e.g., shared norms of science
(ontogenetic) 'processes' employing selection	(3) e.g., trial and error learning; Neural Darwinism	(4) e.g., selection processes in science

Boxes (1) and (2) in the above table explain knowledge mechanisms - like brain and sensory physiology - and innate (socially) shared norms and concepts as the products of evolution. Boxes (3) and (4) explain knowledge progression in the individual life-time and they also portray that individual's learning and scientific progress employ abstract selection processes.

Most evolutionists agree with (1) and (2) positions which hold that our knowledge mechanisms are products of evolution (e.g., Ruse, 1986; Rescher, 1977; Bradie, 1994; Heschl, 2001), but there is less consensus on the (3) and (4) positions, which suggest that knowledge progression is selectionist in nature. But, Campbell (1960, 1974b), Cziko (1995), Hull, Langman and Glenn (2001) argued and gathered evidence for ontogenetic selection proceses, with respect to knowledge/cognition[2]. (See Chapter 3)

[According to Bradie's (1986) classification, box (1) indicates Evolutionary Epistemology of Mechanisms (EEM) and boxes (2) and (4) indicate Evolutionary Epistemology of Theories (EET). In Campbell's (1997) classification, box (2) indicates General Selection Theory (GST)].

My dissertation focuses mainly on EEM and GST versions of Evolutionary Epistemology. Chapter 1 introduces the descriptive epistemological assumptions of Campbell; Chapter 2 focuses on Campbell's arguments favoring anti-foundationalism and selectionism; Chapter 3 pictures how Campbell is elucidating his general selectionist ideas to explain knowledge processes, particularly Perception and Creativity. My dissertation concludes how Campbell's naturalistic evolutionary epistemology is developed or supported by later evolutionary epistemologists and what repercussions it can have on understanding knowledge processes – both in the domains of (naturalistic) epistemology and cognitive science.

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[2] Hull argues for an *abstract* selectionist model, whereas Toulmin argues for a direct analogy between evolution and science progression.

Chapter 1: Evolutionary Epistemology of Donald T. Campbell

Introduction

This chapter introduces Evolutionary Epistemology, particularly the ideas of Donald T. Campbell. In Section 1, Evolutionary Epistemology is introduced as a species of naturalized epistemology. Section 2 provides an account of several types of Evolutionary Epistemology, especially the Campbellian typology of Evolutionary Epistemology. Section 3 briefly introduces the notion of *selectionism* and the 'units and levels of selection' debate. Section 4 elucidates Campbell's account of *descriptive epistemology* and identifies the assumptions he makes to propose his specific version of Evolutionary Epistemology.

Section 1: Naturalized Epistemology and Evolutionary Epistemology

Epistemology is concerned with "knowledge", especially knowledge concerning the empirical world. Traditionally epistemology is understood as a quest for answering two very general questions. These are: (1) what is knowledge? and (2) how is knowledge possible? It is generally accepted that an answer to the first question also alerts us to seek an answer to the question of justification of beliefs. This is a quest for grounds for 'certainty of beliefs'. It is normative in character and seeks clarity for epistemological concepts, such as "justification", "truth" etc. It is normative because traditionally the enterprise is not just concerned with description of beliefs, but it asks for the fulfilment of epistemological values like 'justification', 'truth', 'reliability' etc., so that the beliefs under consideration acquire the status of "knowledge". In the history of epistemology both 'rationalists' like Descartes and 'empiricists' like Locke strived to develop a "first philosophy", attainment of which can guide our knowledge acquisition or pursuing science. But, Quine (1969) questioned this possibility and proposed that epistemology should be considered as a science to be studied as any other natural or physical science. Quine says:

> Epistemology, or something like it, simply falls into place as a chapter of psychology and hence of natural science. (Quine, 1969, p.273)

So most, but not all, versions of naturalistic epistemologies (e.g., Quine, 1969, Kornblith, 1985, 2002) study and *describe* the knowledge processes empirically, as they occur in the world, without focusing on any or some of the epistemological value(s), mentioned above.

Evolutionary Epistemology (E.E) is a naturalistic approach to epistemology, according to which human beings' and other organisms' capacities for knowledge and belief are the products of biological evolution (as well as social evolution). As a naturalistic program, evolutionary epistemology emphasizes on methods of natural science and findings of evolutionary biology, cognitive psychology etc., in addressing epistemological problems such as growth of knowledge, belief-world correspondence or coherence etc. Thus, E.E is mostly *descriptive* or *explanatory* in character, as opposed to normative nature of traditional epistemology. But, some naturalistic epistemologies are normative as much as descriptive. Nathalie Gontier (2006a) suggests that evolutionary epistemologies must exemplify a normative framework. This framework will be based on and analogical to biological evolutionary thinking. And this framework is actually employed in scientific method. An example of such a framework is Popper's methodology of science. Popper's *Logic of Scientific Discovery* (1973) not just describes scientific progress, but it also prescribes methodology for science. Basing on analogy to natural selection in organic evolution, Popper proposed 'falsificationism' i.e., every scientific hypothesis or conjecture should be falsifiable and if that hypothesis is falsified in the test, then it is eliminated.

Bradie and Harms (2008) conceive three possible configurations of the relationship between naturalistic and traditional normative epistemologies. First, naturalistic epistemology and traditional normative epistemology are construed as competitors i.e., both compete in giving solutions for the same problems. A group of naturalistic epistemologists including Riedl (1984) defends this position. Second, naturalistic epistemology is taken to be a successor discipline to traditional normative epistemology i.e., naturalistic epistemology transcends traditional normative epistemological concerns suggesting that these latter concerns are either irrelevant or unanswerable or uninteresting. Some leading naturalistic philosophers including Munz (1993) take this position. Third, naturalistic epistemology is complementary to normative epistemology i.e., naturalistic epistemology is concerned about description and empirical aspects of knowing and normative epistemology is concerned about norms of knowing; and there can be mutual exchange of ideas. Several naturalistic epistemologists including Campbell (1974b) take this position.

According to Bradie and Harms (2008),

> At best, the evolutionary analyses serve to rule out normative approaches which are either implausible or inconsistent with an evolutionary origin of human understanding.

E.E endorses a *comparative* (Campbell, 1959) as opposed to an *anthropomorphic* approach to knowledge. In an *anthropomorphic,* approach knowledge is understood to be linguistic (propositional) or a human-bounded characteristic. Gontier (2006a) suggests that classical western philosophy was anthropomorphic. This led to regarding language as the means of knowledge about the world, and thereby considering every knowledge relation and every form of thinking as a language relation. But, with Wittgenstein's (1989) incisive criticisms and the failures of logical positivism to make good the promissory notes, linguistic primacy in epistemology has been questioned, especially by naturalistic epistemologies. Also, comparative approaches consider that all organisms can show behavior that is cognitively based (Gontier, 2006b) because “every relation that an organism engages in with its environment is regarded as a cognitive relation, a knowledge relation, this knowledge itself being the result of the workings of natural selection” (Gontier, 2006a, p.10). She says:

> E.E studies how knowledge about the environment is gained across different species, and what knowledge-gaining mechanisms arise in biological organisms through time enabling these organisms to cope with their environment. This means that within E.E not only human cognition but all sorts of behavior that organisms at all levels in biological evolution display (ranging from instinctive bahavior to cultural behavior or even chemotaxis – that is to say, communication between cells) are regarded as devices that are put to use to gain knowledge. (Gontier, 2006b)

Some thinkers like Maturana and Varela (1980), Heschl (1990, 2002) consider that “Life = Cognition” i.e., life itself is cognition. According to them, all living creatures have cognition, irrespective of whether they have language or consciousness or even nervous system or not. Pamela Lyon (2006) argues that the study of Cognition should start from the principles of biology, (applicable also to lower level organisms), as opposed to mere human case. She calls it the *biogenic approach* to cognition as opposed to traditional *anthropogenic* approaches to cognition.

Section 2: Types of Evolutionary Epistemology

The term “Evolutionary epistemology” was first coined by Donald T. Campbell, an American social psychologist. He identified four types of evolutionary epistemology:

1. *Evolutionary origins of Kant's a priori categories*: According to this view, *a priori* categories of perception and intuition are the products of biological evolution. Campbell identifies scientists and philosophers like Charles Darwin (1838-39), Herbert Spencer (1897), William James (1890), Hans Vaihinger (1911), Konrad Lorenz (1941, 1973), Rupert Riedl (1982, 1984), Gerhard Vollmer (1975, 1985), and Engels (1989), among others, as holding a

view which is similar to or strongly compatible with the view mentioned above. Bradie (1986) designates this type of view as E.E.M (Evolutionary Epistemology of Mechanisms). According to E.E.M, knowledge / cognition mechanisms like brain and sensory systems are the products of biological evolution. As evolutionarily adapted capacities, these mechanisms are generators and maintainers of reliable knowledge (Bradie and Harms, 2008). If these mechanisms were not reliable, species possessing them might have been extinct. Not just these knowledge mechanisms are phylogenetically inherited, but they also embody *expectations / presumptions* about the world. Kant's categories like space, time, causation etc., are interpreted as innate adaptations our minds now possess.

2. *Analogies between biological evolution and the 'evolution' of scientific theories*: This view is categorised by Bradie (1986) as E.E.T (Evolutionary Epistemology of Theories), according to which growth of scientific theories is explained by way of analogy with biological evolution. According to this view, a lot of competing theories will be proposed to explain phenomena in the world. But, only one or some of them are accepted by the scientists and all others are eliminated. Popper (1959), Toulmin (1967, 1972, 1981), Hull (1988a,b) and Richards (1987) hold some version of this position.

3. *Shared innate perceptual reification of middle-sized objects:* According to this position, every organism of a species shares the characteristic which facilitates perceptual reification of external objects. Perceptual reification is a result of species-specific ability to identify or categorize the world into 'entities', which are stable and significant for the organisms. This innate, as well as learnt, ability to reify objects makes the transfer of language and culture possible through ostentions. Campbell and Paller (1989) argue that the capacity to reify the world is inbuilt into our neural mechanisms (Campbell, 1987) such that, we can identify, for example, some one's face even if seen from different angles. Our visual mechanism generates

three dimensional perceptions of objects, although image of the objects on the retina are two dimensional.

4. *General selection theory:* This position approaches epistemology from an abstract "selectionist" scheme and it proposes that biological evolution through natural selection as only one of the exemplars of selectionist mechanisms, and the other exemplars being acquired immunity (Jerne, 1955; Burnet, 1957), trial and error learning (Thorndike, 1898; Ashby, 1952; Pringle, 1951), Creativity (Campbell, 1960; Simonton, 1998, 1999a,b) and brain development (Edelman, 1987; Changeux, 1985; Calvin, 1987; Gazzaniga, 1992; Sperber, 2001). Darden and Cain (1989), and Hull, Glenn and Langman (2001) and others argued for an *abstract,* generalized selectionist scheme. According to this generalization project, many processes, like the ones mentioned above, employ selectionist processes in their operation i.e., there will be 'variation' of particular units and 'selection' by particular criteria and the iteration of this cycle in the process. This position avoids the position suggested in 2 i.e., employing too close an analogy between science and biological evolution, thereby carrying over many details to the former from the latter that are inappropriate. General selection theory focuses, e.g., while explaining trial-and-error learning, on blindness or non-prescience and variation of trials, and selection by reinforcement (Skinner, 1981) than borrowing details of the genetics into selectionist abstract model of it[1]. In evolution, the unit of selection is the phenotype and the unit of retention is the genotype, but in learning and other knowledge processes we cannot find genotype and phenotype differentiation, although selectionist scheme is applied. Early evolutionary epistemologists such as Simmel (1895) and Baldwin (1909) have called this position as 'Selection theory'. Gary Cziko (1995) provides an extensive survey of the many exemplars of a general selection theory.

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[1] See Chapter 2 for more details.

5. *Constructivist evolutionary epistemology*: Wuketits (1997) argues for the need for a constructivist approach in E.E and points out that Campbell himself contributed much to it, by emphasizing on vicarious / internal selectors. Wuketits (1997) provides five basic assumptions of this approach: (a) the cognitive capacities of any organism are limited; (b) these limitations are mainly the result of organismic, functional constraints; (c) as active systems, organisms explore those aspects of 'reality' that are relevant to their survival; (d) the act of perception always includes an interpretation of the perceived object; (e) this interpretation is based on the organism's own experience that is constrained by the evolutionary pathways of its species. Wuketits (1997, 2006), Riegler (2006), and Diettrich (1994), among others, defend this position. In similar lines with it, Oeser and Seitelberger (1988) proposed *neuroepistemology,* emphasizing constructive nature of the brain.

Wuketits finds the constructivist approach to be *non*-adaptationist, but not *anti*-adaptationist, emphasizing organism's 'adaptability' in contrast to environmental pressure to adapt. This position agrees with the view that there is 'adaptation' between organism and the environment. But, it disagrees that this 'adaptation' is achieved solely by environmental selection (on passive organism). Constructivists believe that, as exemplified by *niche construction* behavior (Lewontin 1982, 2000), organisms *actively shape their own environments* and *achieve fit between themselves and their environments*. Campbell (1991) and Bickhard and Campbell (2000) recognise the explanatory and modelling significance of notions like non-equilibrium thermodynamics, dissipative structures, non-linear dynamics, self-organizing systems, helon theory, and perhaps catastrophe and chaos theories in epistemology – which Campbell (1991) called as *autopoietic evolutionary epistemology.* He says that both autopoietic and selectionist evolutionary epistemologies are required and they are complementary. Hahlweg and Hooker (1989), Christensen and Hooker (1999) argue for the complementarity of selectionist and systemic processes.

Evolution as knowledge process: I think that the notion "evolution itself is a knowledge / cognition process" (Wuketits, 1986; Lorenz, 1977; Plotkin, 1994) should also be viewed as an important notion in evolutionary epistemology. Campbell (1959 and 1974b) treated adaptive organic form - any process providing a stored program for an organism's adaptation with external environments - as 'knowledge'[2]. This means that the *adaptations* organisms acquire in the course of their evolution exhibit the 'knowledge' of their environment, i.e., for example, the stream-lined body shape of a dolphin exhibits the 'knowledge' of hydrodynamics and the shape of a horse's hoof shows the 'knowledge' of the steppe it adapted to. With evolution, there is growth of 'knowledge', as adaptation.

Section 3: Selectionism and Units and Levels of selection

In biology, there is a distinction made between *ontogeny* and *phylogeny*. Phylogeny is about changes in the population of species i.e., changes occurring in the species through generations. Ontogeny is concerned with an individual organism's life-span development. The term 'evolution' is traditionally used exclusively for phylogenetic changes i.e., change of frequency of genotype in a population of species. Natural selection occurs at the phylogenetic level. But, with E.E, especially with 'General Selection Theory', selectionist mechanisms have been implicated also at the level of ontogeny. Cziko (1995) called it as *with-in* organisms' selection as opposed to (phylogenetic) *among* organisms' selection. Plotkin (1994) called it (ontogenetic) *secondary heuristic* as opposed to (phylogenetic) primary heuristic. Most cited example for this is the immune system (Edelman, 1987; Hull, Langman and Glenn, 2001). This means that knowledge mechanisms, of an individual, like perception, learning, creativity, and brain processes etc., employ 'selectionist' mechanisms in their operation. Whereas phylogenetic selection makes species adapted across generations,

[2] Campbell (1959 and 1974b) treated the adaptive organic form as 'knowledge'. But, his 1995 modification refutes this, as he believed that it is an obstacle in making contact with the traditions of philosophical epistemology. But, Plotkin (1997) argues for Campbell's earlier position (in Campbell, 1997).

ontogenetic selection mechanisms make individual organisms adapted in their own life times. Gontier comments that with E.E natural selection got *internalized* (within the organism itself), thereby raising questions about the *units and levels of selection* (Brandon, 1982; Brandon and Burian, 1984; Gontier, 2010). In neo-Darwinism / Modern synthesis (Ayala, 1978; Maynard-Smith, 1993; Mayr, 1978), organisms (and thus genes) are conceived to be the units of selection and environment is the level of selection. If the brain is considered to employ selection process (as advocated by Edelman, 1987), then, neural groups will be units of selection and neural activity is the level of selection. Dawkins (1982, 1983, 2000) even argued that selection occurs within the genotype i.e., there is a competition among genes within the genome. Okasha (2001) argues for group selection.[3] According to this view it is the group of individuals that is the unit of selection rather than individuals. For example, in social insects like ants and bees many sterile ones are present. Although they cannot reproduce they are pervasively present, implying their contribution to the nest or colony and thus they were selected. Some social animals, for example birds, show altruism i.e., they face danger to rescue other individuals of their group implying group level selection, than primacy of individuals' selection.

Section 4.1: Campbell's notions of descriptive epistemology

Campbell (1959) proposed a *comparative psychology* of knowledge processes according to which, for example, a rat's maze learning and a scientist's theory building will have the same epistemological status. Both involve a mechanism of progressive adaptation through blind variation and selective survival, (but not the evolutionary sequences *per se)* i.e., trial-and-error-learning.[4]

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[3] Complicated picture arises when E.E.T is considered, where theories are the units of selection and scientific community is the level of selection.

[4] Chapter 2.1 elaborates this point

Traditionally epistemology dealt with problems of 'knowing' i.e., truth, validity and justification of knowledge. But, Campbell (1988) expanded the domain of epistemology to cover *psychological hypotheses* as to how we know – how we see, or learn, and *sociological hypotheses* as to how we share and edit beliefs to achieve science and other socially shared beliefs of possible validity. Thus, he is proposing a *descriptive epistemology* which:

> .... is first of all descriptive of how people go about it when they think they are acquiring knowledge, or how animals go about perceiving and learning when we think they are acquiring knowledge. At this level we are practicing psychology, physiology, and sociology without necessarily engaging in epistemological issues. But I also want descriptive epistemology to include the theory of how these processes could produce truth or useful approximations to it. (Campbell, 1988, p.440)

According to Campbell (1988, p.393), “an evolutionary epistemology would be at minimum an epistemology taking cognizance of and compatible with man's status as a product of biological and social evolution”.

Campbell (1960, 1997) argues that between our ancestral virus-type organism and a present era physicist, there is a tremendous 'knowledge gain' about the environment.[5] We humans arrived at this place from a highly limited background only due to evolutionary cumulation of knowledge/adaptations. He says:

> In bulk, the knowledge gained between the virus-type ancestor and the physicist has represented cumulated inductive achievements; stage by stage expansions of knowledge beyond what could have been deductively derived from what had been previously known. It has represented repeated `breakouts' from the limits of available wisdom ... (Campbell, 1987a, p.92)

In the *induction* process new knowledge is acquired, but the premises do not guarantee the truth or success of the new knowledge. Likewise, in evolution, new knowledge/adaptation comes from the previous forms; but by blind mutations and recombination. Previous form

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[5] Being a bahaviorist, he considered even the virus's behavior as a form of knowledge.

does not guarantee the success of next generation's adaptation. It is the environmental selection that decides the fate of the adapted form.

Simply put, Campbell observes that in the course of evolution of life on earth (from unicellular ancestor to our present era), there is a growth of knowledge embodied by organisms. All these occurred, as proposed by *modern synthesis* or *neo-Darwinism* of evolution, by natural selection among variant organisms and inheritance of selected variety and cycle of this process in generations. Lamarckism is refuted and there is no adaptation instructed by the environment. Also, there is no designer of the evolution. So, all adaptations in species evolution come from blind mutations and natural selection; thus this adaptive knowledge gain is attributed to blind variations and selection.

This is in line with the notion of ‘evolution as knowledge process’ i.e., in the course of evolution there is increasing adaptation and organisms increasingly gain and embody knowledge of the world in their behaviors and physiological structures. Campbell (1960) called this knowledge gain in the course of evolution as ‘cumulated inductive achievement’.

Section 4.2: Assumptions made by Campbell

Campbell was inspired by epistemological *skepticism.* He acknowledges the arguments of skeptics in showing the lack of certainty of knowledge. Campbell (1988) cites the following arguments against certainty and unequivocal communication of knowledge: Plato's 'prisoner of the cave', Descartes' program of doubt, Berkeley's solipsism, Hume's argument against induction, Kant's unknowability of the *Ding an Sich,* Bacon’s analysis of “idols” or “false images” that plague human thought, Quine's indeterminancy of translation and Popper's analysis of ‘falsification’.

Campbell develops his epistemology basing, broadly, on two main aspects: (a) Selectionism and (b) Anti-foundationalism.

Selectionism emphasises on trial-and-error nature of knowledge processes. Anti-foundationalism proposes that our knowledge mechanisms are not perfect and the resultant knowledge is fallible; so knowledge is always revised and approximates 'truth'.

	Anti-foundationalism	Selectionism
Descriptive basis:	*Indirectness* of sensory knowledge	Darwinism
Analytic basis:	Hume's problem of induction and Kant's distinction between *noumena-phenomena*	Meno's dilemma

Descriptive basis of 'selectionism' is, as proposed by Darwinian evolutionary basis of knowledge mechanisms, both phylogenetic and ontogenetic.

Analytic basis of 'selectionism' is based on the notion that 'selection' among variations is the 'only' materialist account of 'growth' and 'fit' of knowledge to the world. As Pallbo (1997) explained Meno's dilemma, new knowledge is always due to 'selection' among variation. Plato's 'Meno's dilemma' implies the problem of explanation of the source of knowledge. If the knowledge is said to be based on older knowledge, it cannot be said as new as it is already based in older knowledge. Plato resorts to saying that every knowledge is based on older knowledge. But, we know that new knowledge is possible which goes beyond older knowledge and it can be successfully explained by selectionist account.

Descriptive basis of anti-foundationalism is based on neural and evolutionary basis of knowledge mechanisms. Knowledge processes are necessarily embodied by neural and other bodily structures which limit the infallibility and directness of knowledge. The knowledge mechanisms are evolved from primitive organisms and they are adapted to past environments rather than present environment. So, these mechanisms cause correct knowledge in some environments while leading to erroneous knowledge in other environments.

Analytic basis of anti-foundationalism is based on arguments of epistemological skeptics like Descartes, Hume, Kant etc.

Thus, Campbell makes the following assumptions in his epistemology.

Hypothetical realism: Campbell (1988) says that he is some kind of a realist, some kind of a critical, hypothetical, corrigible, scientific realist; he is against direct realism, naive realism, and epistemological complacency. His position is not essentially different from Popper's 'critical realism'. Campbell says:

> An “external” world is hypothesized in general, and specific entities and processes are hypothesized in particular, and the observable implications of these hypotheses (or hypostatizations or reifications) are sought out for verification. No part of the hypotheses has any “justification” or validity prior to, or other than through, the testing of these implications. Both in specific and in general they are always to some degree tentative. The original source of the hypotheses has nothing to do with their validity: in some sense they were originally blind guesses or a chance mutations. (Campbell, 1959, p.156)

Campbell rejects constructivist and nihilistic approaches which believe that our beliefs about the world are mere constructions of the mind.

Anti-foundationalism and coherence: Campbell says:

> I am fallibilist... No part of our system of knowlege is immune to correction. There are no firm building blocks, either as indubitable and therefore valid axioms, or in any set of posits that are unequivocal once made. Nor are there even any unequivocal experiences or explicit operations on which to found a certainty of communication in lieu of a certainty of knowing. (Campbell, 1988, p.444)

So, there is no first philosophy; but the tactic is to employ Quine's (1951) coherence strategy of belief revision or holistic omni-fallibilist trust i.e., according to him we are like sailors who must repair a rotting ship while it is afloat at sea. We depend on the relative soundness of all of the other planks while we replace a particularly weak one. Each of the planks we now depend on may have to be replaced in future. No one of them is a foundation, nor is a point of certainty, no one of them is incorrigible. Campbell (1969) says that even in a more analytic activity, such as geometry, it is clear historically that the stability lies in the collective bulk of the theorems, while the supposedly "fundamental" axioms being continually subject to revision.

"**We are cousins to the amoeba**": Campbell says,

> While not escaping an interest in primitive fundamentals to knowledge, no primitives are accepted which are not also appropriate to the knowledge processes of the white rat and paramecium. Man's knowledge processes are undoubtedly more complex and efficient than those of his lowly cousins, but they are not expected to be more primitive nor more fundamental. In particular, no immediate, incorrigible, or directly given knowledge is invoked: At all levels knowledge is indirectly, inferentially, and fallibly achieved. (Campbell, 1959, p.157)

Thus, he accepted those analytic epistemologies as legitimate, which had identified human knowledge being based in evolutionary beginnings and development from lower level organisms.

"**Epistemology of other one**": Campbell says,

> I am doing epistemology of other knowers, not attempting to justify my own knowledge to myself, although freely using my own experience as a source of clues ..." (Campbell, 1988, p.445)

Being a behaviorist, he is employing third person perspective to epistemology, as he believes that the "primitives" of knowledge cannot be sought in "raw feels" or in "phenomenal givens" or in any "incorrigible" elements.

Epistemological dualism: According to Campbell (1959), there is a difference between what is knowable and what is known. Knowledge always constitutes indirect and fallible constructions that never completely correspond with the thing in itself.

Perspectivism / relativism: Campbell (1959) cites the notions of Bertalanffy (1955) and von Uexkull (1920). According to their notions, various organisms (of a species) perceive or reify various aspects of their environments. It is to say that, even if two organisms are living in the same ecology, their 'living world' may differ i.e. their perspectives of the same surroundings may vary.

Section 4.3: Normative aspects in Campbell's epistemology

Campbell (1997) defined knowledge as "*undefeated justified true belief*". Knowledge is always incomplete and fallible. The norm he accepts for knowledge is '*competence of reference'*. Knowledge progresses, but never reaches the absolute truth. Organisms' main purpose of gaining knowledge is to manipulate to adapt to the world. Their knowledge is limited to 'survival relevance', but not for an ultimate 'truth'. In a sense, *pragmatic* value guides knowledge acquisition. But Campbell (1974b, p.431) rejects utilitarian conventionalism, utilitarian nominalism, utilitarian subjectivism, or instrumentalism, as he believes in the hypothetical realism (but not naive, direct realism). He accepts 'correspondence' as the goal of knowledge, but he points out that 'coherence' or the 'selection' is the means to it.

Campbell (1956a) identifies three alternative explanations for the adaptive 'fit' between organismic structure or knowledge and environmental possibilities: (a) providentialism, (b) instructionism, (c) selectionism.

Providentialism explains 'fit' by employing a detailed *a priori* planning of a prescient deity. Providentialism is to be rejected as it is non-naturalistic. Instructionism explains 'fit' by employing appropriate or corrective structural modifications based on experience with the environment in question. This may be rejected as it employs prescience and Lamarckism. Selectionism explains 'fit' by employing variation and selection mechanism, in which variations or modifications are blind, are random, are individually non appropriate, are not of the order of corrections. But by chance there do occur those which provide better 'fit', and these survive and are duplicated. Selectionism is to be accepted as it is the only possible and plausible mechanistic, materialistic, naturalistic account of 'fit'.

Campbell (1988) also rejects 'ontological nihilism' (and radical constructivism ?) in favour of hypothetical realism. According to him, the world directly (or vicariously) participates in the belief formation or knowledge acquisition; knowledge is not just arbitrarily constructed. As Kant had clarified, there exists a gap between *noumena* and *phenomena* (Campbell, 1987) and perspectivism about knowledge of the world is inevitable. Thus, direct realism is impossible. This does not lead to 'ontological nihilism', which proposes that correspondence of knowledge and the world is impossible and knowledge is mere arbitrary construction. But Campbell argues against this position and proposes hypothetical realism, which explains the coherence of knowledge in spite of the impossibility of correspondence. Coherence is possible because of the co-selection (directly or vicariously) of knowledge by referent i.e., the world and the innate or learnt 'reliable' presumptions. Competence of reference can be explained by hypothetical realism, in spite of impossibility of direct realism (foundationalism) or ontological nihilism.

Campbell concludes that the 'knowledge gain' is (a) not entailed i.e., not deducible from previous one, (b) invented contingently (by exploiting coincidence), (c) not instructed,

(d) not perfect i.e., it is corrigible and (e) indirect, mediated i.e., no direct realism or clairvoyance is possible.

Chapter 2 explains how knowledge gain and ‘fit’ between the organism and the world comes about, in spite of non-foundationalism, through the process of selectionism.

Chapter 2: General Selection Theory

Introduction

This chapter focuses on a selectionist account of knowledge i.e., the General Selection Theory proposed by Donald T Campbell. Section 1 focuses on the rationale for selectionist explanations in biology and their import to individual's knowledge acquisition processes. Section 2 brings out the core of Campbell's ideas i.e., the Blind-Variation-and-Selective-Retention (BVSR) schema provided by him. In Section 3, I discuss knowledge processes as they are hierarchized based on evolutionary history. Section 4 throws light on evolutionary causation of knowledge mechanisms that organisms possess - i.e., downward causation through selection.

Section 1: Ontogenetic Selection

Popper (1959) argued that the central problem of epistemology has always been the problem of growth of knowledge. He gave *selective elimination* (through conjectures and refutations) logic to explain expansion of knowledge and scientific discoveries. At any time, there will be many theories to explain phenomena in the world. But, one of them will be preferred over others. This preference, Popper says, is due to survival of the fittest theory. A theory is preferred or selected by exposing all the competing theories to real life application and eliminating those theories which are falsified. Popper (1963) identified *trial-and-error learning* by humans and animals as illustrating his basic logic of inference i.e., natural selection. According to him, scientific progress and also human as well as animal trial-and-error learning (analogically) follow a process of evolution through natural selection. Campbell took this inspiration, while proposing his 'General Selection Theory'. It is "all-purpose physicalist (a.k.a materialist, mechanist, naturalist) solution to puzzles of 'design'"

(Campbell and Paller, 1989, p.232). For Darwin, the perceived 'fit' between animal form and environmental opportunity was the ‘design’ puzzle. For epistemologists, the ‘design’ puzzle will be the 'fit' between the belief and its referent. Campbell's ‘General Selection theory’ is an attempt to explain (a) the problem of growth of knowledge; and (b) puzzles of ‘fit’ or ‘design’ in epistemology, naturalistically.

In the natural / organic world, there is a ‘design’ between the form of an organism and the environment it lives in. For example, organisms hunting in the day time have eyes , which opportunistically use light rays reflected from the objects to perceive the objects; while some nocturnal animals ‘perceive’ objects through echolocation (i.e., by sending sound waves and sensing the objects from these reflected waves). There are plenty of examples, in biology, illustrating the ‘fit’ between the particular form and / or behavioral tendency that an organism possesses and the environment it lives in, in the name of *adaptation.*

Natural theologist Paley (1802) was puzzled by this ‘fit’ between organisms and their environments; and attributed it to the handy work of God. His argument was based on ‘watchmaker analogy’; as a watch’s complexity and function make one to posit the existence of an intelligent watchmaker, the complexity and design found in the nature warrants one to attribute it to the causal role of a (intelligent) deity. This sort of argument still continues in the name of ‘intelligent design’. If there is a complex design, there should be an intelligent designer (i.e. the cause should be intelligent) to cause the design, which is too complex to be formed by mere accident.

Darwin answered the ‘design’ puzzle *naturalistically*. His theory of natural selection (from plenty of variations) and accumulation of adaptations through inheritance through many generations, can explain how ‘fit’ has come about between organisms and their environments. Natural selection, as such, does not *cause* the ‘fit’, but it does winnow-out the unfit. Fit comes free, mechanically, without the intervention of any intelligent, purposeful agency. As Dawkins (1996) pointed out, adaptation is not a one-step process, but a successive cumulation through large eons of generations. So, complex adaptations can accumulate in the course of time, although their beginnings were simple.

Campbell extends this Darwinian argument further, by saying that any ‘fit’ e.g. the ‘fit’ between an agent’s belief and the corresponding referent; the ‘fit’ between theory and the fact it purports to explain etc., also require a ‘selectionist’ explanation. Darwin explained how *adaptations* i.e., the ‘fit’ between organism and its environment are evolutionarily bestowed. The explanations of E.E.M (Evolutionary Epistemology of Mechanisms) theorists end here. We have to go further. The ‘fit’ between knowledge mechanisms and the world are neither due to ‘God's will’ nor due to ‘clairvoyant powers’ of omnipotent ‘Dear Old Mother Natural Selection’. Our eyes are adaptive; but phylogenetic evolution is not sufficient to explain the design problem of how a *momentary* perceptually-based belief about the presence of a specific object could ‘fit’ with the actual presence of that object. This requires again a selection mechanism, which involves the object, either directly or vicariously, as one of the co-selectors.[1] Natural evolution is not clairvoyant as it is mechanically impossible to have provided us with prescient ‘fit’, bestowed beforehand. Campbell rejects *foundational* mechanisms for knowledge. Descartes' ‘God's will’ or E.E.M theorists’ ‘evolutionary product’ does not suffice. Evolutionarily acquired knowledge is based on past environments and present adaptation to changing or changed environment needs ontogenetic (selection) processes.

[1] Campbell (1997) compares this analysis to Goldman's (1986) causal theory, of justification of belief, which is based on the ‘reliability’ of belief forming processes. Goldman suggests that our visual beliefs are justified because the visual mechanism is reliable, as also argued by the epistemologists who accept E.E.M. Also, that visual belief is, at least, in part, justified if the referent of the belief has a causal role in the belief formation.

Plotkin (1994) argues that species face "uncertain futures problem" while evolving. This has a parallel in epistemology - Hume's "induction problem". It says that, whatever is true so far may turn out to be false in the future; so, we have no conclusively firm grounds to believe our past or present beliefs. (Hume also said that our reliance on our beliefs is based on *animal faith,* which can be said to be evolutionarily bestowed, making successful survival possible.)

But, Campbell is optimistic about the possibility of knowledge i.e., the 'fit' between belief and the referent is possible. But, this is not the result of any innate *foundational* mechanisms. As 'fit' between organismic form and its environmental opportunity arises through the natural selection, without the mediation of any prescient mechanism, the 'fit' between beliefs and their respective referents can be attained without foundational mechanisms – but through selectionist mechanisms. Here, he is employing selectionist explanation at two levels. The first level is phylogenetic i.e. the natural selection that occurred in ancestors provide present organisms with a "general sort of wisdom" (in the form of anticipation / expectation) of 'useful' 'stabilities' of the environment and also the knowledge / cognition achieving mechanisms. This is not a 'real gain of knowledge', as it depends on already achieved wisdom. At the second level, the selection mechanisms occur again in the phylogenetically inherited anticipatory wisdom and knowledge / cognition operations. They include perception, trial-and-error learning and scientific enquiry etc., which short cut the selection by the life and death winnowing of genetic variants. Adaptations in the course of phylogenetic evolution occur across generations. But, some ontogenetic adaptations, like learning, occur at the time course of individual life-span. So, these mechanisms like learning make some adaptations possible within the short time span, than phylogenetic eons.

According to Campbell, phylogenetically inherited form or behavior cannot be called 'knowledge', but may be called 'wisdom'; and at the next level(s) of selection occurring within the constraints of this 'wisdom', knowledge (gain) occurs. Knowledge gain is always due to selection among variations.

Section 2: Blind-Variation-and-Selective-Retention scheme

Campbell proposes Blind-Variation-and-Selective-Retention (BVSR) process acting at every knowledge progression. He agrees that it is his dogma; and justifies that there is no other alternative to explain true gains of knowledge, naturalistically. According to Campbell (1960), the BVSR scheme is *metatheoretical,* which provides an understanding of marvellously purposive processes like learning without the introduction of teleological metaphysics or of pseudocausal processes working backward in time. It provides an abstract, general logic of selectionist processes and it does not require importing every detail of evolutionary biology.

According to Campbell (1988, p.402), the basic selectionist dogma can be captured by the following four theses:

1. A blind-variation-and-selective-retention process is fundamental to all inductive achievements, to all genuine increases in knowledge, to all increases in 'fit' of system to environment.

2. In such a process there are three essentials features: (a) mechanisms for introducing variation; (b) consistent selection processes; and (c) mechanisms for preserving and / or propagating the selected variations. Note that in general the preservation and generation mechanisms are inherently at odds, and each must be compromised.

3. The many processes which shortcut a more full blind-variation-and-selective-retention process are in themselves inductive achievements, containing wisdom about the environment achieved originally by blind variation and selective retention.

4. In addition, such shortcut processes as mentioned in (3) contain, in their own operations a blind-variation-and-selective-retention process at some level, substituting for overt locomotor exploration or the life-and-death winnowing of organic evolution.

Every case of knowledge gain requires employment of the BVSR mechanism, at some level (among nested hierarchical knowledge processes). The ontogenetic knowledge mechanisms (e.g., perception, learning etc.,) are the product of phylogenetic BVSR processes. Selection among mutant variants (of organisms) involves higher level selection mechanism, under the constraints of which ontogenetic knowledge mechanisms employ lower level BVSR mechanisms. Through phylogenetic BVSR processes, organisms develop 'internal models' of the world by which these organisms can anticipate the regularities of the world. The internal world models involved in ontogenetic knowledge processes themselves undergo evolution, through phylogenetic BVSR processes. These internalized models about the world also employ BVSR mechanisms and substitute for the locomotor BVSR mechanisms making the locomotion goal-directed.

Campbell (1960, 1974b) provides three important connotations of the term 'blind': (a) variations (such as mutant organisms in organic evolution and trials in the trial-and-error learning) emitted be independent of the environmental conditions of the occasion of their occurrence; (b) the occurrence of trials individually be uncorrelated with the solution, in that specific correct trials are no more likely to occur at any one point in a series of trials than another, nor more than specific incorrect trials. (Our observation shows that learners make intelligent, anticipatory responses; this means that the person is making use of already achieved knowledge, perhaps of a *general* sort. The anticipatory responses of that person represent prior general knowledge, transferred from previous learning or inherited as a product of the mutation and selective survival process), (c) the notion that a variation subsequent to an incorrect trial is a 'correction' of the previous trial or makes use of the direction of error of the previous one, be rejected.[2] (Insofar as mechanisms do seem to operate in this fashion, there must be operating a substitutive process carrying on the blind search at another level, may be vicariously).[3]

Campbell makes a comparison between *trial-and-error learning* and the BVSR scheme.[4] For example, the rat that is learning the maze makes several trials to learn the correct (actually reinforcing) solution. The actual solution is one of the many trials it makes. The solution gets its status, as a solution, because it is reinforced by the external world (here, the experimenter). So, the solution also was as blind (may not be random) as the other unlearnt (i.e. un-reinforced) trials.

General Selection Theory (G.S.T.) asserts that variation-and-selective-retention processes operate at a number of hierarchically organized loci or domains in nature, and that all improvements in 'fit' between systems and their environments are attributable to the operation of these selection processes.

Section 2.1: Vicarious knowledge processes

According to Campbell, phylogenetic evolution gives rise to ontogenetic mechanisms. These mechanisms have the following two characteristics:

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[2] But, Popper (in Radnitzky and Bartley, 1987) emphasizes on feedback from error, in knowledge processes.
[3] See Burtsev (2008) for differences between 'feedback logic and 'evolutionary' logic; and how vicarious selection process leads to learning without feedback.
[4] Campbell got this inspiration from the works of Ashby (1952), Baldwin (1900), Pringle (1951). But, Bradie (1994) questions the analogy between the BVSR scheme and trial-and-error learning.

a) These mechanisms possess general sort *wisdom* as anticipation/expectation of environmental certainties. Following Brunswik (1955), Riedl (1979) and Riedl *et al* (1992) speak of the '*ratiomorphic apparatus'* i.e., human beings feature a system of innate forms of ideations that allows the anticipation of space, time, comparability, causality, finality, and a form of subjective probability or propensity. Lorenz (1973, 1977) called these inborn structures *innate teaching mechanisms,* and analyzed Kant's (1781) *a priori* categories in this line. Campbell (1987b) tried to give a neurological account of these anticipatory processes.

b) These mechanisms also employ BVSR mechanism at some level, to go beyond *presumptive* wisdom and *gain* knowledge.

Campbell (1956a,b) explains how vicarious knowledge processes like vision and learning could have evolved. For example, a primitive protozoon does not have sensory mechanisms to perceive the surrounding world; its motor efforts are the only means of knowing the world. It learns of an obstacle when it stumbles upon it and cannot go any further. It distinguishes food from non-food only after ingesting things. But, this way of knowing is risky as it may stumble upon its predator or it may ingest a poisonous substance.

We can imagine a course of evolution for such an organism in which sensory mechanisms would evolve for sensing the environment prior to a total body commitment. Such 'feelers' make organism's knowledge acquisition less risky and they provide with economy in exploration by total body. In this way, sense organs would evolve as 'trial' motor organs, substituting for main body involvement in knowledge acquisition. Thus, knowledge acquisition becomes 'indirect' through the mediation of sensory mechanisms. By employing vicarious knowledge processes which substitute for direct bodily contact with environments (which can be hostile), evolution has provided organisms with adaptive knowledge mechanisms; thus they sustained.

Being ‘indirect’, vicarious knowledge processes may give imprecise knowledge. But, this does not happen always as these vicarious mechanisms are endowed with wisdom of the environment, in the course of evolution. Campbell explains how vision could have acquired 'presumptions' about the 'stabilities' of the world. On earth, objects that are impervious to locomotion in general also reflect or diffuse certain electromagnetic waves. Both water and air are transparent, in coincident parallel with their locomotor penetrability. This persistent ecological condition over the eons has made possible the development of organisms able to anticipate the presence and location of solid objects through visual mechanism based upon the opaqueness of the object to light. The accidental encountering with and systematic cumulations around this coincidence have provided in vision a wonderful substitute for blind motor exploration.

Campbell also points out that there is regularity in the world and this regularity is represented by sensory mechanisms. He says:

> The development of vision was predicated upon an environment populated with stable, solid, clear-cut entities – that it could never have developed in a world of fuzzy-edged amoeboid clouds or in a completely fluid homogeneous material space. (Campbell, 1959, p.175)

Thus, organisms know the world (without 'direct' contact with it), by employing vicarious knowledge mechanisms, which have evolutionarily (but coincidentally) acquired the 'assumptions' about the world. Although vicarious knowledge acquisition is 'indirect', this acquisition process gives most of the time reliable knowledge, as it got well-winnowed assumptions about the world, in the course of evolution.

The criteria of selection involved in biological evolution are external to the organism or to the species. By the evolutionary stage at which learning is possible, much of this once-external criteria have been internalized as the sense receptors for pleasure and pain. These sense receptors act as representatives of general truths about organism-environment relations achieved initially by the mutation-selection process. Such internalized criteria are more precise, have a more higher "selection ratio" than does mutation-selection, but also represent less direct encounters with environmental realities and thus are a less fundamental knowledge processes.[5]

Campbell identified ten levels[6] of knowledge processes, with BVSR operation at each level. At each level some *criteria* are phylogenetically (and also from previous learning) set. These criteria select *trials* at the lower level. Campbell ordered these levels in the sequence of the evolution of behavioral / cognitive mechanisms.

Each level (or node) has a characteristic B.V.S.R and each level has *presumptions* about the nature of the world, acquired from phylogenetic evolution. These selectionist mechanisms can be considered as substitutes of organic natural selection, which causes knowledge gain but by winnowing-out unfit organisms. These vicarious knowledge processes also cause knowledge gain, but without the involvement of winnowing-out of organisms, and in the time scale of the life span of an individual organism.

Organic natural selection causes adaptation of organisms to general environmental certainties; whereas the vicarious knowledge mechanisms cause 'fit' of organisms to *specific,* and changing aspects of the environment.

In the levels of vicarious knowledge processes: (a) indirectness of sensory knowledge increases i.e., 'selective role' of the world decreases, (b) number of 'presumptions' increases, (c) cognitive economy increases, (d) 'phenomenal' feeling of directness or intelligent

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[5] Heylighen (2000) provides three classes of selective criteria: (1) Objective criteria like distinctiveness, invariance and controllability; (2) Subjective criteria like individual utility, coherence, complexity and novelty; and (3) Intersubjective criteria such as formality, conformity, 'infectiousness' or publicity, expressivity, collective utility and authority.

[6] Plotkin and Odling-Smee (1981) also give multiple-level account of selection processes.

response increases, (e) precision also increases. These are ordered, roughly, on the basis of history of evolution of knowledge processes – knowledge of primitive unicellular organisms to knowledge at the level of humans' science.

Section 3: Nested hierarchical vicarious BVSR processes

1. **Non-mnemonic problem solving**: At this level, blind *locomotions* of the organism are the trials, which are selected by *local* environment within which it is fumbling.

Jennings (1906) has shown that the paramecium produces blind locomotor activity until a nourishing or non-noxious environmental setting is found. This environmental criterion selects the paramecium's locomotions. But, paramecium does not have memory to retain this solution. When it is hungry again, it attempts locomotion and also ingestion in all directions until satiated by the some part of its environment.

The presuppositions organisms (here, the paramecium) are endowed with (from phylogenetic evolution) at this level are, for example, that the environment has penetrable and impenetrable portions and moving away from an impenetrable region can be beneficial, as the probability of stumbling upon food increases.

2. **Vicarious locomotor devices**: In this mode of knowledge acquisition, the organism produces locomotions, but *vicariously*, which will be selected by the *local* environment.

Here, locomotions occur vicariously by employing *distance receptors*. For example, echolocation devices of porpoises, bats, and cave birds emit blind sweep of sound waves which are selectively reflected by nearby objects; thus making these organisms know the world without the need of direct bodily contact with the external world (which can be fatal in certain environments). Sonar and radar also employ similar mechanisms. Campbell believes that our vision is as indirect as echolocation, although it is phenomenally felt to be direct and it lacks active broadcast of waves.

The presumption organisms have at this level: The objects in the environment, which are opaque to sound waves emitted by organisms and light waves received by organisms, are impenetrable. Also, there are presumptions leading to achievement of reifying and reidentifying stable discrete objects[7].

3. **Habit** and 4. **Instinct**: According to Campbell, habit and instinct have similar epistemological status. While the former involves trial-and-error during ontogeny; the latter involves similar trial-and- error of whole mutant organisms during phylogeny.

According to Campbell instincts can be conceived as general *drive states* and *reinforcing conditions* which select trial-and-error learning (and visual search) responses. In the service of these general reinforcers, specific objects and situations become learned goals and sub-goals, learned selectors of more specific responses. And, the execution of habit and instinct requires vision as a vicarious process. Presumption of organism at this level: Approach or seek pleasurable objects and events; and avoid painful objects and events.

5. **Visually supported thought**: At this level trial and error (potential) locomotions done *vicariously in thought* are selected by the local environment which is also *vicariously represented by vision*. The *insightful problem solving* in chimpanzees studied by Kohler (1925) is interpreted by Campbell in this line. Here, trials are produced at the level of ‘thought’ and the selection criteria that do selection are the visual stimuli.

[7] See Chapter 3, Sec 1.3 for details.

6. **Mnemonically supported thought**: At this level, blindly performed *thought trials* are being selected by *memory / knowledge criteria*. Here, vision is not employed. Both, thought trials and knowledge criteria are *vicars / substitutes* for external state of affairs.

For example, Poincare (1913) explained mathematical creativity[8] in this line. The criterion of *mathematical beauty* selects from a blind permuting of ideas, usually unconscious.

7. **Socially vicarious exploration**: Observational learning and Imitation: In social animals, the observing animal learns from the *model* animal. But, this process is not direct as it seems. As Baldwin (1906) analyzes this process, the learner acquires *criterion image* by observing, which he learns to match by trial and error of matchings.

Presumptions involved at this level: for example, the observer believes that the model is also exploring the same world in which he is living and locomoting; the observer believes that the model is capable of learning and also the world is learnable.

8. **Language**: At this level Campbell explains the communication among social insects like bees, ants and termites, comparing to human language. They communicate using dance patterns, sonic, supersonic or odor-trail means, in which the scout ant or bee communicate to the follower with neither the illustrative locomotion nor the environment explored being present, not even visually-vicariously present. Their communications exhibit the social function of economy of cognition in a way quite analogous to human language. Human language learning involves trial-and-error through 'ostension' and it is nested in lower level vision.[9]

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[8] See Chapter 3, Sec.2 for more details.
[9] See Chapter 3, Sec. 1.3 for more details.

9. **Cultural cumulation**: Campbell provides some variation and selective retention processes leading to advances or changes in technology and culture. They include: (a) selective survival of complete social organizations, (b) selective borrowing of technology and culture from other cultures, (c) differential imitation of a heterogeneity of models from within the culture, (d) selective learning, (e) selective elevation of different persons to leadership and educational roles and so on. Campbell stresses that such selective criteria are highly vicarious, and could readily become dysfunctional in a changing environment.

10. **Science**: Campbell notes that science grows rapidly around laboratories, around discoveries which make the testing of hypotheses easier, which provide sharp and consistent selective systems. He explains ubiquitous 'simultaneous inventions' as exhibiting selective mechanisms in science. If many scientists are trying variations on the same corpus of current scientific knowledge, and if their trials are being edited by the same stable external reality, then the selected variations are apt to be similar, the same discovery encountered independently by numerous workers.

Variety of trial-and-error processes in science include, (a) an exploratory experimentalist within a given laboratory introducing variations on every parameter and combination he can think of, without attention to theory. (b) At the opposite extreme from this blind laboratory exploration is Popper's view of the natural selection of scientific theories, a trial and error of mathematical and logical models in competition with each other in the adequacy with which they solve empirical puzzles, that is, in the adequacy with which they fit the totality of scientific data and also meet the separate requirements of being theories or solutions. (c) Intermediate is Toulmin's (1967) evolutionary model of scientific development, which makes explicit analogue to population genetics and the concept of evolution as a shift in the composition of gene pool shared by a population, rather than specified in an individual. In Toulmin's analogy, for genes are substituted 'competing intellectual variants', concepts, beliefs, interpretations of specific fact, facts given special importance, etc., and the individual scientists are the carriers. Kuhn (1962) and Ackermann (1970) also explain history of science by borrowing analogies from organic evolution through natural selection.

BVSR processes are 'scale-invariant' i.e., they happen at all levels. These processes are seen in both temporal scale i.e., phylogeny and ontogeny, and spatial scale i.e., cell, organism and society. These knowledge processes are not just hierarchical, but also nested. For example, habit and instinct require vision for their execution; language learning and imitation also require vision. Culture and science are nested in language and imitation. The higher level knowledge processes like science and culture are emergents from lower level organ and organism systems, in the course of evolution; and these higher level emergents have causal role in selecting and changing lower level processes like vision and language. Thus, we possess shared innate concepts, norms and values due to selective downward causation by higher level processes like culture.

Section 4: Downward Causation

Campbell agrees that he is a *reductionist,* but not a '*microparticulate-derivationist'* who believes that all the phenomena of the world are revealed in the interactions studied by the subatomic physicists. He is an *emergentist,* but not a *'vitalist'.*

Campbell believes that the organisational levels of *molecule, cell, tissue, organ, organism, breeding population, species,* in some instances *social system* are factual realities rather than arbitrary conveniences of classification and each of the higher orders organises the real units of the lower level.

Allmost all natural and physical sciences are 'reductionist', including evolutionary biology. They contend that higher level properties are caused by lower level elements. For example, in biology, phenotypes are considered to be caused by lower level genotypes; and in psychology, behavior is considered to be caused by brain dynamics. In reductionist *scala natura*, causal flow is unidirectional.

Campbell (1974a) identified two reductionist principles:

1. All processes at the higher levels are restrained by and act in conformity to the laws of lower levels, including the levels of subatomic physics.

2. The teleonomic achievements at higher levels require for their implementation specific lower-level mechanisms and processes. Explanation is not complete until these micromechanisms have been specified.

Although Campbell agrees with these points, he says that they are not enough to explain *biological systems*, which involve the operation of natural selection. Thus, he adds two more points to a physical model of causation in biology:

3. Emergence: Biological evolution in its meandering exploration of segments of the universe encounters laws, operating as selective systems, which are not described by the laws of physics and inorganic chemistry, and which will not be described by the future substitutes for the present approximations of physics and inorganic chemistry.

4. Downward causation: Where natural selection operates through life and death at a higher level of organisation, the laws of the higher-level selection system determine in part the distribution of lower-level events and substances. Description of an intermediate-level phenomenon is not completed by describing its possibility and implementation in lower-level

terms. Its presence, prevalence or distribution (all needed for a complete explanation of biological phenomena) will often require reference to laws at a higher level of organisation as well. Paraphrasing point 1, all processes at the lower levels of a hierarchy are restrained by and act in conformity to the laws of the higher levels. (Campbell, 1974a, p.180)

Campbell is proposing downward causation *through natural selection.* As Mayr (1988) suggested, Campbell is explaining adaptations, not just by *proximal causes*, but also by *distal* or *ultimate* causes. In the course of evolution, emergent higher level processes come into existence and these emergents have causal influence on lower level processes.

Campbell provides a concrete example to illustrate downward causation: consider the anatomy of the jaws of a worker termite or ant. The hinge surfaces and the muscle attachments agree with Archimedes' laws of levers, that is, with macromechanics. They are optimally designed to apply the maximum force at a useful distance from the hinge. A modern engineer could make little, if any, improvement on their design for the uses of gnawing wood, picking up seeds, etc., given the structural materials at hand. This is a kind of conformity to physics, but a different kind than is involved in the molecular, atomic, strong and weak coupling processes underlying the formation of the particular proteins of the muscle and shell of which the system is constructed. The laws of levers are one part of the complex selective system operating at the level of whole organisms. Selection at that level has optimised viability, and has thus optimised the form of parts of organisms, for the worker termite and ant and for their solitary ancestors. We need the laws of levers, *and organism level selection* (the reductionist's translation for 'organismic purpose'), to explain the particular distribution of proteins found in the jaw and *hence* the DNA templates guiding their production. (The occasional non-functional mutant forms of jaws conform just as loyally to the laws of levers and biochemistry as do the more frequent functional forms.)

If we now consider the jaw of a soldier termite or ant, a still more striking case of emergence and downward causation is encountered. In many of the highly dimorphic or polymorphic species, the soldier jaws are so specialised for piercing enemy ants and termites with huge multipronged antler-pincers that the soldier cannot feed itself and has to be fed by workers. The soldier's jaws and the distribution of protein therein (and the particular ribonucleic acid chains that provide the templates for the proteins) require for their explanation certain laws of sociology centering around division-of-labour social organisation.

Thus, Campbell says:

> We have no grounds for anticipating that the microparticulate laws, even when perfected, will eliminate the need for macrodetermination involving laws unique to the higher levels of biological and social organization. (Campbell, 1990b, p.5)

He makes this point more plausible by explaining possibility of *dysfunctional mutations.* He points out that in the classic 50 years of *drosophila* research, many more harmful mutations than beneficial ones were discovered. Also is the classic case of *cave fish* becoming blind when vision loses its survival value, when mutations interfering with effective vision cease to be eliminated. Mutations are quasi-entropic and they drift toward dysfunctionality in the absence of selection. He says:

> .... the *dysfunctional mutations are at least as lawful outcomes of microparticulate laws as are the normal genes. The laws of physics do not choose between them.* The distributional fact that the normal gene with the functional expression is more prevalent cannot be explained by particle physics. This prevalence is due to selection at the whole-animal (multiple cellular, multiple molecule, multiple atomic) levels, a selection that has affected the distribution of the particular variants of all lower units. This is the “downward causation” via selection. It is a local instance of macrolevel determination of the *distribution* of microlevel events and entities. (Campbell, 1990b, p.6)

Thus, in the course of evolution new realities like culture, society, science etc., emerge and they become realities for themselves i.e., they have causal roles[10]. These realities through natural selection causally influence lower level mechanisms like vision, language and instincts. In the course of evolution, nested hierarchical knowledge processes come into existence.

Chapter 3, by providing specific examples – perception and creativity -, explains how BVSR processes are involved in knowledge processes.

[10] Bickhard and Campbell (2000) argue that emergents have causal properties;but, Kim (1992) doubts whether emergents have causal efficacy.

Chapter 3: A Selectionist Account of Knowledge

Introduction

This chapter provides a selectionist account of Perception and Creativity. Section 1 deals with perception, especially how perception substitutes for trial-and-error locomotion and how it guides locomotion. Section 2 provides a selectionist explanation of creative achievements. Here, thought is shown to employ 'vicarious selection', making adaptations with the world intelligent.

Section 1: Perception

Section 1.1: Non-foundationalism in perception

As Campbell's aim is to give a 'mechanistic' account of knowledge, he treats perception as non-foundational, underjustificational and non-realistic.[1] According to Campbell, perceptual achievement i.e. a 'fit' between a perceptual belief and the world is not 'direct'. No 'clairvoyant' i.e., prescient perception is possible and perception employs mechanisms which are sometimes prone to error. In the line of Descartes' argument, we can say that an evil demon using implanted electrodes could produce a perceptual belief in a perceiver, which (s)he takes as real. Campbell (in Campbell and Paller, 1989) cites examples like phantom limbs and non-iconic, identical, neural transmission codes for warmth and cold as illustrating illusion proneness of our perceptual systems.

Further, our perceptual neurology contains many 'monitor-modulate distortion correctors' (Campbell, 1987b) which modify sensory input on the basis of evolved 'presumptions', improving the validity of perception in normal environments, but also increasing the proneness to illusion, in atypical conditions. Campbell (1988) cites

[1] See Chapter 1 Sec.4 for more details.

Helmholtz's (Cohen and Elkana, 1977) list of imperfections of the eye and his concept of unconscious inference as a correction to direct realism.

Evolutionary epistemology of mechanisms (E.E.M) version still leaves unexplained how vision could operate so as to generate the competent (if incomplete) perceptual achievement of a specific physical object. Selection theory is to be applied to this task also. *Biological evolution cannot produce a clairvoyant visual process.* All it can do is to assemble indirect indicators and initially arbitrary[2] assumptions, all in the form of finite physical mechanisms.

Perceptual mechanisms are physically embodied in some substance, some vehicular carrier - like the eye. This vehicle will have its own physical nature and limitations. Perception, (like any other knowledge) at its realized best, is some compromise vehicular characteristics between referent attributes. But, we can never completely eliminate vehicular restriction and bias for embodied knowledge.

Campbell (1997) developed some general principles: the vehicular substance that carries knowledge is unavoidably separate from and alien to the referents of that knowledge – the vehicle is a different substance with different structural characteristics. Complete sensitivity in depiction, reflection, transmission, or recording of the referent is precluded by the structural requirements of the vehicle: for example, if the vehicle is completely flexible, it lacks the rigidity to hold together the picture it carries. These vehicle-structure requirements produce not only restrictions on fineness of detail, but also bias and limitations of knowledge. Keeping the vehicle intact becomes a requirement in rivalry with the requirement of validly mapping the referent. The requirement of vehicle maintenance becomes a structural requirement operating as a selective factor in the winnowing of knowledge representations.

[2] According to Darwinists, physical mechanisms involved in vision can only originate by genetic mutations and recombination. These mutations are random; so they are characterized as 'arbitrary'.

Thus, for example, the way the eyes are physiologically constructed influences its functioning.

Vision, e.g., is based on inferences based on contrasts in superficial reflections. Its anatomy and physiology show nothing like ‘direct’ transmission of ‘knowledge’ of ‘external’ objects, but instead highly presumptive unconscious constructions. In Muller-Lyer illusion situation, we employ implicit presumptions of environmental relations built into the nervous system by learning or genetic heredity, to the effect that obtuse and acute angles in the plane of vision are most likely generated by rectangular solids (Segall et al. 1966; Stewart, 1973). The Duncker (1929) dot-and-frame illusion may be more convincing. In an otherwise totally dark room is a large luminous frame with a luminous dot within. The frame is moved several inches to the right. The observer instead perceives the dot move several inches to the left. The perceptual system has built-in preconscious decision trees that convert the evidence of relative motion into an inference of absolute motion. The presumption used here is: in case of doubt, it is the small fragment of the visual field that has moved, and the large bulk that has remained still. This is an excellent general rule, but wrong in the ecologically atypical setting of Duncker’s laboratory.

Although we are prone to illusions, we correct it basing on other beliefs. For example, if we experience Muller-Lyer illusion, we can correct that illusion by scaling each line with a ruler. Here, we doubt our earlier belief, by trusting ruler scaling and some assumptions like – the lengths of the lines have remained relatively constant during the measurement process, the ruler was rigid rather than elastic etc.

Campbell calls this as ‘coherence strategy of belief revision’, as explained by Quine (1951). We trust the great bulk of our beliefs, while revising as few as possible. But, no belief is incorrigible and foundational. Quine’s holistic omnifallibilist trust holds for the operation of vision. A single photocell firing has a profound equivocality (over and above the multiplicity of posited objects which might have generated it) due to static in the air and nonsemantic firing in the nervous system. Our million fold photocell eyes have cross-footing inhibitional winnowing which (on the basis of predominant immediate context) inhibit further transmissions of solitary, out-of-step activations (Campbell, 1987b). The eye thus works even though any retinal cell activation may be in error on any one occasion.

Section 1.2: Perception and Locomotion

In line with his General Selection Theory, Campbell, identifies learning or habit formation and also its execution as involving trial-and-error, which is analogical to the Blind-Variation-and-Selective-Retention (BVSR) scheme. He credits cyberneticians, Ashby (1952) and Pringle (1951), Baldwin (1900) and for making this analogy explicit. He also notes that *learning theories* of behaviorists like Hull, Skinner and Guthrie and *Gestaltish* theories of Tolman and Meier involve a random trial and error component (Campbell, 1954). Campbell notes:

> In terms of the rudiments of the general selective survival model, habit formation would be based upon (a) random variation of emitted behavior, (b) *selective* survival of certain variations, and (c) retention and duplication of surviving variations. In terms of conceptual traditions in psychology, this translates into a random trial-and-error learning model. (Campbell, 1956b, p. 332)

Organisms achieve behavioral fit with their environment through trial-and-error learning. Campbell (1954) differentiates between *body-consistent* and *object-consistent* learning[3]. For example, when a rat learns the maze; it does not learn fixed muscle movements, without the consideration of maze characteristics. Even if the rat has learnt maze on plane surface, it can exhibit same learning, while swimming in the maze also, which require different set of

[3] According to Campbell (1956a), the learned response is to be essentially defined in terms of a shift in the organism-environment relationship (such as objects moved, places reached, regions entered by an organism) rather than a motor response defined in terms of organism or body parameters alone (like specific muscle contractions or movements).

muscle movements. This adaptive fit in the execution of habits has been called *molar* by Tolman (1932) and others. It represents *acts,* not *movements,* or *advertent* rather than *inadvertent* responses in Guthrie's (1952) terminologies. Brunswick (1952) has designated it as consisting of *distal* responses rather than *proximal* ones. Skinner (1938) called it *operant* response.

According to Campbell, this *object-consistent* responding gives rise to a problem: how can the adaptive fit in the execution of habits (or in the execution of adaptive instincts for that matter), be explained without resorting to *teleological pseudo-explanation?* Campbell proposes blind trial-and-error again as an explanation here. For example, if a blind person has learnt to walk in well-known house; (s)he can make fixed (body-consistent) responses to reach from one place to other. But, if the furniture in the room has changed place, then (s)he cannot make fixed locomotions but change them by feedback of bodily collision or cane movements. Thus, blind trial-and-error cane movements can lead to object-consistent behavior on the part of the blind person. Likewise, a normal person can achieve object-consistent behavior with the trial-and-error mechanism of vision, which doesnot require teleological prescience. Campbell says:

> But most object-consistent responses have a smooth, accurate, guided quality which seems quite out of keeping with the prescribed random trial-and-error process. .... perception serves this function of trial-and-error exploration, substituting for the motor trial-and-error found in the blind object-consistent response. (Campbell 1956b, p.335)

It is probably the easiest to accept this point of view for an organ of vicarious exploration like an insect's antenna, or the blind person's cane. The analogy of the radar screen as an aiming device is of help. The radar beams scan the sky in a blind sweep, blind in that it is not modified by any prior knowledge of the location of objects. When in this search a beam reflects from a plane, a gun is then appropriately aimed. The trial and error of a radar beam has substituted for a trial and error of expensive bullets. In a parallel way, a ship's radar vicariously explores the waterways, by a trial and error of radar beams learning the location of obstacles that might otherwise have been located by a trial and error of ship movements and collisions.

It is an easy transition from the radar model to the bat's supersonic echo location - in which sound waves emitted in all directions provide the substitute random trial-and-error process. Similarly, the lateral line organ of fishes seems to have the purpose of registering waves of water pressure change in such a fashion as to locate objects in terms of the echo of the fish's own swimming, and Pumphrey (1950) has suggested the radar and echo-location analogy for this process.

The case for vision is the most important, but cannot be made with the clarity and completion possible for the radar and echo-location examples, since the emitting process is missing. However, the notion of vision as a surrogate trial-and-error process seems to be not only required by the formal model but supported by other considerations. If in visual search the gross eye movements are not blindly searching, it is because other sources of information such as touch, memory, or hearing have been employed to narrow the range of search. Hebb (1949) has assembled impressive data on the active searching movements that typically characterize the simplest seeing process, and his facts belie the implicit notion of the passive, fixed-focus eye implicit in both Gestalt and conditioning theories. But even without temporally extended scanning, the eye in a single glance provides spatial information which can substitute for motor trial and error, which can lead to smooth, guided, object-consistent responses. Campbell explains below how perception employs selection or trial-and-error:

> ... the radar beam presents in its ever-repeated scanning sweeps multiple alternative loci for reflection. .... The rods and the cones of a fixed-focus eye can be regarded as the simultaneous presentation of a myriad of alternative loci for possible excitation, blindly available in that their location or availability does not anticipate the location of objects, except as this glance has been preceded by other glances and other sources of information. We could build a radar device in this manner, so that instead of one scanning beam of varying direction, it had a million simultaneously operating beam emitters and receivers, all of fixed aim.

> ...... The learning capacity of the radar lies in the range of directions in which it sends its beams. The learning capacity of the eye lies in the range of possibilities which it makes simultaneously available to selective excitation. Thus even without the emitting mechanism of radar, major portions of the model seem appropriate. Vision can be seen as providing data about the spatial environment intersubstitutable with what might be learned by blind trial and error. It is to be understood similarly in a deterministic way, with no appeals to prescience. It retains the basic epistemology of trying a lot of things and seeing what works. (Campbell, 1956b, p.336)

Campbell analyses the concept of *feedback*, here. When a blind person makes object-consistent responses, it is mainly through feedback from cane movements. In this case, the emphasis is on the *after*-feedback of the results of the motor movements. But, in perceptual locomotion the responses are not guided by its own effect; but the locomotion is guided by the results of a *prior substitutive* output and feedback. Campbell says:

> Thus the radar controlled anti-aircraft missile is not guided by feedback from the projectile's location or outcome, but rather by the feedback from a prior output of electromagnetic waves. The movement of the radar-guided ship is not controlled by feedback of the ship's contacts and collisions with other objects, but rather by the feedback of the contacts and collisions of the exploratory, substituting radar beam. Perception is seen as controlling guided distal responses in this same trial-in-advance way. (Campbell, 1956b, p. 337)

Thus, perception *vicariously* informs the organism, in equivalence to locomotor exploration. In vicarious trial-and-error operation of perception, Campbell says that there is a vicarious search of a vicariously (through memory) represented environment. And while the process is instigated by the visible objects of the choice point, it is not conceived as a search of them, or learning about them. In contrast, the notion of perception as substitute trial and error refers to visual search as a guide to motor response, as a substitute for blind exploratory locomotion, limited to the visually accessible environment. This process may go on in the execution of well-learned habits or in the execution of instincts.

Here, Campbell attempts a marriage between the *cognitivism* of Gestaltism and the trial-and-error learning of behaviorists. Kohler explained learning without motor trial-and-error as *insight learning.* But, Campbell explained it in behaviorist terms as vicarious visual trial-and-error learning. Thus, in higher animals with vicarious knowledge mechanisms like vision and memory, environmental winnowing-out of locomotory trials is less direct (although phenomenally, learning is felt to be direct).

Section 1.3: Nestedness of vision and language

According to Campbell, language is also non-foundational. He tries to answer the *puzzle of shared reference* i.e. how do two persons come to effectively share reference and thereby verbally transmit often valid beliefs about “cat”, “on”, and “mat”? This problem is highlighted first by Quine (1960) in the setting of radical translation; Campbell extends it to explain language learning. Campbell and Paller (1989) emphasise on ostension to explain shared reference. Ostension is unavoidably equivocal, as both Quine (1960) and Wittgenstein (1953) have emphasized. But, shared reference through ostension is possible mainly because, ostension provides a selective restraint, whereby the referent, through perception, has some likelihood of participating in the selection of the language learner’s guesses. In subsequent ostensive instances, and the learner’s use of the term, the mentor or learner may recognize that the learner’s hypothesis as to the word’s meaning is wrong and new guesses as to word meaning can be generated. The occurrence of “rational errors” on the part of children’s language use is symptomatic of this trial- and-error process (Campbell, 1988). The equivocality holds for children learning to speak (and protohumans inventing a language for the first time) fully as much as for the radically uninformed translator.

Language learning is speeded up and made nearly error-free by the shared innate and learned tendencies to reify middle-sized physical objects and boundable acts. For example, without hesitation or awareness of alternatives, the child and the translator guesses that “gavagai” means “rabbit”, rather than rabbit-aspect, rabbit-part, rabbit-moment, transient sense data, direction of pointing etc., (during ostension or translation for a rabbit). The perceptual reification of independent objects and events will have been naturally selected for the usefulness available when stable discreteness, manipulability, and reoccurrence are typical, thus making possible approximately adaptive learning about them. It is around such pervasively shared reifications that the foundations for usefully shared linguistic reference can be built.

Campbell contrasts with the views of Cassirer, Shapir and Whorf, who believe that language learning comes first, and arbitrarily determines all of the perceptual entification of the world. But, this view fails to explain achievement of shared reference (Campbell, 1989). For Campbell and Paller (1989) the way the world is (through innate reification) has edited the ostensively transmissible vocabulary, leading to *interpersonal sharing of competent reference.*

Section 2: Creativity

Section 2.1: Selectionist account of Creativity[4] and Thought

In his paper, '*Blind variation and Selective retention in Creative thought as in Other knowledge processes' (1960),* Campbell talks about creativity. What he developed here, is not a 'theory of' creativity; but an 'orientation to', or a 'perspective on' creative thought processes. The expected contribution of this sort of thinking is to "provide understanding of marvelously purposive processes without the introduction of teleological metaphysics or of pseudocausal processes working backward in time" (Campbell, 1987a, p.109).

According to Campbell, the most fundamental and primitive knowledge mechanism is *exploratory locomotion.* In the course of evolution, this locomotion is internalized within the organism. Creative thought is such an internalized, *vicarious* knowledge process, in which the trial-and-error locomotion in the environment is substituted by the trial-and-error thought

[4] Simonton (1998, 1999a, b) supports Campbell's selectionist account of creativity, while Gabora (2011) criticizes this.

attempts or processes; and the environment is also substituted by the thought *criteria*. Examples for the thought criteria include Poincare's (1913) aesthetic criteria and the Gestalt qualities of wholeness, symmetry and organized structure. Thus, creative thought is substitutive *'natural selection'* within the mind.

In the paper cited above, Campbell quotes and analyses the ideas of the following thinkers as proposing trial-and-error locomotion at the level of thought: Bain (1874), Souriau (1881), Ashby (1952), Poincare (1908, 1913) etc.

In the history of psychology, behaviorists explained animal problem solving as a matter of overt locomotor trial-and-error. But, Gestaltists criticized behaviorist explanations and proposed 'insight' as a *cognitive* mechanism behind animal problem solving. For Campbell, Gestaltists are descriptively correct, although epistemologically trial-and-error element is required (as it is fundamental to any discovery or knowledge gain). He formulated the animal problem solving as exhibiting substitutive/vicarious trial-and-error in thought, such that locomotion, which is guided by this vicarious thought output, seems to be insightful or prescient.

Explaining thought as trial-and-error, does not imply that the organism is passive; instead *active* generation and checking of thought-trials, hypotheses, or molar responses is envisaged. Even though, the organism is active, no 'direct' knowledge is possible to it; 'insight' is a phenomenal counter part of the successful completion of a perhaps unconscious blind-variation cycle.

Campbell explains 'creative achievements' of (so-called) genius people, in the line of trial-and-error epistemology. Campbell says:

> Just as we do not impute special "foresight" to a successful mutant allele over an unsuccessful one, so in many cases of discovery, we should *not* expect marvelous consequents to have had equally marvelous antecedents. (Campbell, 1987a, p.103)

(We attribute genius on the part of a person for his/her creative act, because of our deeply rooted tendency toward causal perception). But, the creative output was actually one of the blind trials the person performed and it is the environmental selective conditions that made the difference between a hit and a miss.

Section 2.2: Intelligence and individual differences

Selectionist account does not deny individual differences in creative intellect. People differ in the following ways, which constrain their creativity: (a) they may differ in the accuracy and detail of their representations of the external world, of possible locomotions in it or manipulations of its elements, and of the selective criteria. Differences in this accuracy of representation correspond to differences in degree of information and intelligence; (b) thinkers can differ in the number and range of variations in thought trials produced. The more numerous and the more varied such trials, the greater the chance of success; (c) there are individual differences in editing talent i.e., the precise application of a selective criterion which weeds out the overwhelming bulk of inadequate trials. There are individual differences in the number of selective criteria people possess; (d) there are individual differences in the competence of retention, cumulation, and transmission of the encountered solutions.

Campbell tries to answer the criticisms made against accidentalist interpretation of creativity. For example, (in presenting his case for adding ‘heuristics’ to the program of the ‘Logic Theorist’ and to emphasise the inadequacy of blind trial and error), Simon (1957) posed the challenge of ‘British Museum Algorithm’ i.e., the possibility of a group of trained chimpanzees typing at random producing by chance in the course of a million years all of the books in the British Museum. Campbell defends accidentalist scheme by saying that the objections to them are parallel to objections to the theory of natural selection in evolution. As far as natural selection is successful, the BVSR scheme in epistemology is also successful. Campbell says:

> the tremendous number of nonproductive thought trials on the part of the total intellectual community must not be underestimated. Think of what a small proportion of thought becomes conscious, and of conscious thought what a small proportion gets uttered, what a still smaller fragment gets published, and what a small proportion what is published is used by the next intellectual generation. There is a tremendous wastefulness, slowness, and a rarity of achievement.
>
> In biological evolution and in thought, the number of variations explored is greatly reduced by having *selective criteria imposed at every step.* Thus mutant variations on nonadaptive variations of the previous generation are never tested – even though many wonderful combinations may be missed therefore. ... It is this strategy of cumulating selected outcomes from a blind variation, and then exploring further blind variations only for this highly select stem, that,.....,makes the improbable inevitable in organic evolution. This strategy is unavoidable for organic evolution, but can obviously be relaxed in thought processes and in machine problem solving. However, the Pandora's box of permutations opened up by such relaxation can be used to infer that, in general, thought-trials are selected or rejected within one or two removes of the established base from which they start. In constructing our "universal library" we stop work on any volume as soon as it is gibberish. (Campbell, 1987a, p.105)

'Intelligent' variations require an explanation for how these variations or hypotheses came to be wise-in-advance. That most hypotheses are wise, but, they reflect already achieved knowledge or, at least, wise restrictions on the search space. Such wisdom does not, however, explain further advances in knowledge. That hypotheses, even if not wise, are far from random; but, wise or stupid, *restraints* on the search space do not explain novel solutions. Poincare, James, Jevons and the others (Campbell, 1960; 1974b) emphasize the profuse mental generation of alternative concepts, mostly wrong.

Section 2.3: Computer Problem Solving

Like thinking, computer problem solving requires vicarious explorations of a vicarious representation of the environment, with the exploratory trials being selected by criteria which are vicarious representatives of solution requirements or external realities. For Campbell, if discovery or expansions of knowledge are achieved, blind variation is requisite. Simon (1957) rejects this and says that the problem solving of computers is not completely random or blind; but it employs 'intelligent guess' based on 'heuristics'. Campbell (1974b) answers that the 'intelligent guess', insofar as it is appropriate, represents already achieved wisdom of a more general sort, and as such, this 'intelligent guess' does not in any sense explain an innovative solution. Insofar as the 'intelligent guess' is inappropriate, it limits areas of search in which a solution might be found, and rules out classes of possible solutions. Insofar as the 'intelligent guess' represents a partial general truth, some unusual solutions are ruled out. Simon's 'heuristics' are such partial truths, and a computer which would generate its own heuristics would have to do so by a blind trial and error of heuristic principles, selection from which would represent achieved general knowledge. Heuristics greatly reduce the total search space, but without at all violating the requirement of blindness.

Thus, all sorts of new knowledge gain employ the BVSR processes.

Conclusion

Evolutionary epistemology is trying to do to epistemology, what Darwinian theory has done to evolutionary biology. Darwinian natural selection theory explained ‘fit’ between organisms and their environments without the requirement of any teleological causal agency. Likewise, evolutionary epistemology strongly argued that the ‘fit’ between belief and referent i.e., the ‘fit’ between knower and the known is to be explained in non-teleological terms. For evolutionary epistemology, the concept, ‘truth’, in epistemology and the concept, ‘fit’, in biology are analogous. ‘Knowledge’ is analogous to ‘adaptation’. Knowledge gain that occurs in individual learning and science progression are adaptation processes, explanation of which requires a selectionist, non-teleological account. Evolutionary epistemology of Campbell has attempted to do this successfully.

Campbell agrees with epistemological *skepticism*, but he derives a different conclusion from that of the skeptics. While skeptics doubt the possibility of knowledge, Campbell has argued that the knowledge is possible and he did it by employing his selectionist theory which can account for the possibility of new knowledge that goes beyond old knowledge – without requirement of any foundational mechanisms.

Kant has argued for the *noumena* - *phenomena* gap in knowledge, and evolutionary biology has identified that the adaptation of an organism to its environment to be ‘satisficing’ rather than absolute. As Locke argued that our knowledge of the world is not directly gained, but sensory mediation is required; likewise, in evolution there occur no direct adaptations as contended by Lamarckism, but all adaptations are indirect, mediated by mutation and selection processes. The role of the world in our knowledge processes is ‘as a selector’. Those beliefs that are contradicting the true states of affairs are falsified and eliminated;

likewise, in evolution, organisms that are not possessing environmentally suitable traits are eliminated.

All these analogies brought out by Evolutionary epistemology of Campbell offer a new understanding of Knowledge. Evolutionary epistemology has shown that all knowledge is verisimilitudinal i.e., progressive and an approximate truth. But, this does not mean that knowledge is not a 'fit' with the world. Evolutionary epistemology proposes perspectivism and pragmatism which say that our knowledge is limited to that range of external states of affairs which has survival significance and beyond that range, our knowledge processes has to employ trial-and-error. By pointing out the contingent and chance factors involved in the 'fit' between beliefs and the world, Campbell alerts us to non-foundationalism. Our knowledge is not founded in any infalliable method, but we have to use selectionist trial-and-error to reach new knowledge.

Campbell's non-teleological explanation of how the 'competence of reference' i.e., the 'fit' between the belief and the world is reached can be helpful for mechanistic insights in epistemology and cognitive science. Campbell's detailed explanation of perception (1956a,b), creativity (1960) and computer problem-solving (1974b) are examples of this. He proposes that a system – natural or artificial – can increase the chance of 'fit' with the world by producing more varied and more numerous trials. Some of these trials are selected by the world, leading to 'fit'. The system at the next time is not required to produce varied and numerous trials, if the world is 'internalized' as a 'vicarious selector'. Systems can be built which embody Blind-Variation-and-Selective-Retention, vicarious selective criteria or value criteria and nested hierarchical networks leading to successful execution of old knowledge and also successful acquisition of new knowledge. He believed that his BVSR account is an all-purpose explanation of 'fit' that can explain the knowledge gain of lower organisms as well as higher level processes like the knowledge acquiring in Science, and also the adaptive fit of artificial systems. His scheme can explain intelligent, purposeful and goal-directed behaviour mechanistically.

Campbell's Cybernetic Behaviourism (Campbell, 1975) explains how intelligent behavior comes about by employing blind selection processes. (Phylogenetic) evolution is not goal-directed, but the internal selection is. Phylogenetic evolution and ontogenetic learning set goals on the part of the organisms, fulfillment of which becomes organisms' motive. These goals are the representative of the external states of affairs and satisfying them enhances survival. Thus, the world represented as internal 'criteria' selects blind guesses the organism produces, all this process happening in the mind / thought. Higher level organisms' knowledge processes, at different levels, possess vicarious criteria comprising of a reference signal or template for the goal state. (These criteria may have phenomenological dimension of pleasure or pain). These vicarious criteria are hierarchically arranged at all levels of knowledge processes. Each level employs selection process in which trials are selected by these internal criteria and the result is feed-forwarded to the next higher level. Thus, this higher level exploits the lower level output, making its responses purposive and intelligent. If the organism has to attain new knowledge at this level it has to employ the BVSR process, as the lower level BVSR mechanism can only provide old knowledge and new knowledge at any level needs new BVSR process, although using lower level BVSR's wisdom.

All new knowledge is not blind, as previous learning might have helped. To clarify this, Cziko (2001) identified three different types of behavioral knowledge – (a) instinct, (b) learned behavior and (3) invention. There is a range of constraint of phylogenetic evolution among these – instinct is mostly based in phylogenetic evolution, while learned behavior is less constrained by phylogeny and invention is the least constrained. Instinct and learned behavior provide 'wisdom' for the new invention, making it less blind (but not clairvoyant). Selectionist scheme is still employed as instincts came about by phylogenetic evolution i.e., among-organism BVSR process; learned behavior has arisen from wisdom of instincts and ontogenetic learning i.e., prior within-organism BVSR mechanism; and the current 'invention' received wisdom from instincts and experience of prior learning but goes beyond them by employing the current BVSR process. The current and prior knowledge constrain future inventions, but they also employ the BVSR process to lead to new knowledge.

Campbell, through the concept of 'downward causation', explained how the regularities in the world are internalized in our minds and knowledge mechanisms. He emphasised not just on biological evolution, but also on social evolution because of which we internalized social norms and share them with other fellow beings. These internalized schemas, concepts or *ratiomorphic* anticipations constrain our learning and knowledge. Lorenz (1941, 1977) explained how Kant's notion of *a priori* categories can be understood to be evolutionarily based. Shepard (2001) talks about how regularities in the world are internalized in the knowledge processes, due to evolution. Cooper (2003) argues that human reason and logic are evolutionarily based. Heschl (2002) strongly argues for phylogenetic basis of knowledge, citing empirical evidence.

Campbell identified at least four factors involved in the knowledge processes at the human level. These are internal selectors (Campbell, 1987b), referent (Campbell, 1993), historicity (Campbell, 1997) and society/culture (Campbell, 1993). They are co-selectors i.e., they all have role as selectors in the BVSR knowledge process. The innate as well learned presumptions embodied in neurological / bodily internal selectors, past and present social downward causation and the present referent or the world etc., participate in the present trial-and-error of knowledge process. Knowledge processes in all hierarchies are highly nested.

Campbell's Evolutionary epistemology sought to provide non-teleological explanation to all puzzles of 'fit', whether animal's or human's, whether natural or artificial, whether goal-directed or non-purposive. He successfully applied ‘General Selection Theory’ and his version of ‘Evolutionary Epistemology of Mechanisms’ account to explain growth of knowledge and the puzzle of ‘fit’.

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