Research proposal submitted to the FWO by F. Heylighen, W. Callebaut and J. Bernheim:

Evolutionary transitions: foundation for an evolutionary-systemic worldview

BACKGROUND AND MOTIVATION

Fast technological developments and the process of globalisation bring about an entangled dynamic of contradictory forces: integration and differentiation, competition and co-operation, individualism and solidarity. Our society seems to be in a very unstable transitional phase, so that it is difficult to conceive how the desired result—a sustainable, integrated world system respecting individual and collective diversity (Heylighen, 2003; Stewart, 2000)—will come about.

The ever accelerating changes and growing complexity in society produce a lot of uncertainty, anxiety, and alienation (Geyer, 1992). Sociological research seems to indicate that the feelings of insecurity and distrust are strongest among the people who least profess belief in a religious or philosophical world view (Elchardus, 1998). Psychologists researching life satisfaction, on the other hand, have found that having such beliefs increases well-being, by providing a sense of life's meaning, feelings of hope and trust, a long-term perspective on life's woes, and a sense of belonging to a larger whole (Myers, 1993). World views offer a coherent set of answers to these universal issues (Aerts, Apostel et al., 1994; Heylighen, 2000b).

However, the traditional systems of belief (religions, such as Catholicism, or ideologies, such as communism) seem to have been eroded by deep-going social changes. Although scientific knowledge has perhaps played the most important part in this loss of authority, science itself offers a meagre alternative, as it does not provide unequivocal answers to the ultimate questions, and is fragmented into ever more specialist subdisciplines, thus losing view of the whole. Moreover, the reigning scientific ideology is still based largely on Newtonian reductionism, which does not allow room for values, meaning or encompassing wholes. These reasons compel us to focus on developing a new world view, by integrating the results of the different scientific and philosophical approaches in the spirit of Leo Apostel (Aerts et al., 1994).

The only systematic attempt at transdisciplinary integration that has had a certain degree of success is General Systems Theory (von Bertalanffy, 1973). It starts from the notion of a system or a synergetic whole, characterised by emergent properties, which cannot be reduced to the properties of the parts. However, systems theory has until now largely remained descriptive and static, analysing and classifying systems at different levels of complexity, without explaining how these systems originated.

The theory of evolution by natural selection, on the other hand, was created precisely to explain how complex living systems came into being (Dawkins, 1989). Recently, this Darwinian view has diffused from biology to an ever growing variety of other disciplines: computer science, medicine, economics, anthropology, chemistry, and most recently even cosmology. Evolutionary thought thus offers a remarkable potential for the development of a transdisciplinary world view (Heylighen, 2000b; Callebaut, 1996). This applies in particular to the fundamental questions: Where do we come from? Where are we going to? What is the meaning of life? Socio-biology and evolutionary psychology even offer scientifically supported and verifiable explanations for apparently purely subjective phenomena, such as human relationships, emotions, values and morals.

The problem remains that (neo-)Darwinism is in essence reductionist, since it dissects all phenomena into separate components (organisms or genes) (Dawkins, 1989), subjected to external forces (selection by the environment), just like in Newtonian mechanics. Qualitatively novel, emergent phenomena remain unexplained. Together with the success of the Darwinian paradigm, criticism of it has also increased, and critics have pointed to processes such as self-organisation, co-evolution, epigenesis, and symbiosis that do not seem to fit into this framework (Callebaut, 1998; Heylighen, 1999).

AIM

We believe that the outlined problems of fragmentation can be tackled by synthesising evolutionary theory and the systems approach. We intend to approach this synthesis through its core issue, namely the analysis and understanding of evolutionary transitions or metasystem transitions (Maynard-Smith & Szathmary, 1995; Heylighen, 2000a; Michod, 1999), i.e. the fundamental processes through which an emergent system arises.

Examples include the origin of life, the transition from individual genes to chromosomes, prokaryotes to eukaryotes, unicellular to multicellular organisms, and individuals to societies. Common property of such transitions is that systems which initially were able to survive and reproduce autonomously, consequently have become dependent on a larger synergetic whole. A number of these wholes can in a later stage again be joined together, forming a supersystem of an even higher order. Subsequent transitions explain the fundamentally hierarchical evolution of complex systems, and indicate the general trend of increasing complexity, organisation and synergy that characterises evolution (Stewart, 2000; Heylighen, 1999).

The present project wishes to synthesise the different approaches to this issue, which have developed largely independently (Heylighen, 2000a) in disciplines such as biology, cybernetics, artificial life and political science. We intend to keep the resulting model as simple and general as possible, in order to serve as a foundation for an evolutionary-systemic world view (Heylighen, 2000b). Our focus will be on the general dynamics of the evolution of complex organisation, and on the sometimes contradictory values this entails, that implicitly drive social and biological systems. Thus, our analysis should contribute to a better understanding of the very complex dynamics of integration and differentiation, competition and solidarity that characterise the present process of globalization (Stewart, 2000).

WORKING HYPOTHESES

Building on our earlier work with the respected evolutionary philosopher Donald T. Campbell (Heylighen & Campbell, 1995) and the recent contributions of Stewart (2000), we propose the following general hypotheses as a starting point for addressing the issue.

According to Darwinian principles individual systems are fundamentally "selfish" (Dawkins, 1989), meaning that they have been selected to maximise their own fitness, and not the fitness of the group to which they belong. In a hierarchically structured system, every level is subject to selection, but these selective pressures are often inconsistent or even competitive, since what maximises fitness for a part is not always what is best for the whole. This produces an inherent tension, which can be found e.g. in the ambivalence of human psychology, which constantly vacillates between selfishness and altruism, or competition and co-operation. The same tensions can be found at other levels of complexity, such as the cell which must "choose" between submission to the organism (e.g. by undergoing apoptosis—"programmed suicide") and the opportunity to maximally reproduce, giving rise to a tumour.

Evolutionary theorists have recently presented different models that explain how selfish components can still manage to form a supersystem that is fit on the group level, in spite of the contradictory forces exerted on them. Michod (1999), e.g., has attempted to calculate how strong the respective selective pressures are, in order to determine under what circumstances the evolutionary dynamics will lead to metaystem transitions. In this project we aim to analyse evolutionary integration primarily in a qualitative way, as a process of self-organisation within a group of mutually adapting, co-evolving units. This may offer a deeper understanding of the spontaneous emergence of a co-operative system (Callebaut, 1998; Heylighen, 1999; Gross & Lenaerts, 2002).

There remains, however, a major obstacle to overcome. While it may be to the benefit of all the members of a collective to cooperate, the largest benefit will accrue to the "free riders"(Dawkins, 1989; Heylighen & Campbell, 1995), who profit from the effort of others without investing anything in return. Since components constantly undergo variation, free riders are bound to appear sooner or later. Because of their higher individual fitness, they will sooner or later outcompete the earnest co-operators, and thus destroy the supersystem from within—unless some control mechanism constrains their freedom. Such control mechanisms have been observed at all biological and social complexity levels (Maynard Smith & Szathmary, 1995; Stewart, 2000), but as yet we lack a general explanation of their origin. A number of partial explanations have been proposed for specific cases, such as kin selection, reciprocal altruism, interiorised morals, market mechanisms, or state institutions (Heylighen & Campbell, 1995).

A combination of the "selfish" perspective of evolutionary theory and the "synergetic" perspective of systems theory and self-organization leads us to the following, apparently more general model. Consider a system (defined in the most general, functional sense) that coevolves with a group of components, but is intrinsically different from them, so that it can constantly adapt to any variation, and thus stay ahead in any on-going arms race. This system could be an external, physically separate "intruder", such as bacterium or virus, or an emergent, self-organizing mode of activity that governs the behavior of the components ("slaving" according to Haken's (1978) synergetics), such as a pattern of Bénard rolls that directs the rotation of fluid molecules. This system will initially be purely selfish, and thus maximally exploit the components in order to secure its own survival, acting like a functional "parasite".

However, parasites who wholly depend on their host for survival and reproduction tend to evolve into mutualists (Dawkins, 1989), as it is to their benefit to keep the host as fit as possible. If the hosts form a group or collective, then it will be advantageous for the "parasite" to maximise the co-operation or synergy between the individual "hosts" and thus their collective fitness, e.g. in terms of productivity. Thus, the "parasite" evolves into what Stewart (2000) calls a "manager", or what we have called a control mechanism, which suppresses free riding. The symbiosis between "parasite" and "hosts" eventually becomes so intimate that they are no longer distinguishable as separate systems, but only as functional levels within an efficiently organised whole. Examples of such transformations are RNA molecules that take over the control of an autocatalytic cycle during the origin of life, bacteria entering eukaryotic cells and turning into mitochondria, or totalitarian dictatures, ideologies or religions that after a period of time evolve into more or less enlightened governance systems (Stewart, 2000). The newly formed higher-order system is stable as long as the interiorized control mechanisms (e.g. the immune system) evolve as fast as the free riders (e.g. tumour cells), or external parasites (e.g. viruses) so that it does not lag behind in the arms race.

METHODOLOGY

Testing and elaborating these hypotheses requires an in-depth study of the literature concerning control mechanisms and their evolution at the different social and biological levels which we shall do in the first stage of the project (2004-2005). Maynard Smith & Szathmáry (1995), among others, have already collected much data that can be used. Ideally, it should be possible to fit every known metasystem transition smoothly into the proposed abstract explanatory scheme. In practice, though, existing models and data are complex, incomplete and often inconsistent, emphasising the need for a detailed examination and a conceptual analysis at a high level of abstraction.

Depending on how well the data supports the model changes will be introduced and the model will be adjusted or extended, possibly by incorporating complementary mechanisms suggested by other researchers such as Michod, Stewart, and Turchin. Close co-operation, joint workshops, working visits and exchanges with these researchers will be organised to achieve the objectives. As with our previous research, we shall present preliminary results of the project as soon as feasible to the international scientific community working in this domain, by means of working reports, email discussion fora and the Principia Cybernetica web site, thus ensuring immediate feedback by colleagues theoreticians and domain experts.

In a second stage (2006), as a complementary test and elaboration of our model, we plan to develop a detailed computer simulation of our model, thus extending recent work on hierarchical evolution in the field of artificial life (Gross & Lenaerts, 2002). For this we intend to start from the KEBA system developed by Gershenson (2002), a virtual environment in which agents interact with each other and their surroundings, while being subjected to variation and selection. By changing the rules according to which the agents interact, it should be possible to create an evolutionary dynamics (Michod, 1999) that culminates in a metasystem transition in which the agents start to cooperate, thus becoming part of an integrated system. In this way, different variants of the hypotheses can be implemented and visualised, allowing us to explicitly compare their explanatory and predictive value, their advantages and drawbacks.

In a last stage (ending in 2007) all results of the project will be integrated and presented in the form of a doctoral thesis, scientific and popularising articles and a monograph. An attempt will be made to formulate the basic concepts and principles of an integrated world view in a way accessible even to non-specialists. A first step in this direction is the course "Complexity and Evolution", taught by F. Heylighen to the students of philosophy and ethics at the VUB.

COORDINATION BETWEEN THE PARTICIPANTS

The project will be coordinated within the interfaculty and interuniversity (VUB, UG, KUL) centre Leo Apostel and led by F. Heylighen (supported by the other staff of the centre, such as D. Aerts, A. Riegler, J. Broekaert) with an emphasis on the development of the theoretical model. The subsequent computer implementations will be also supervised by F. Heylighen. W. Callebout will lead a research group on evolution and philosophy at the LUC which will critically discuss, evaluate and elaborate the proposed model and world view. J. Bernheim, at the Department of Human Ecology of the VUB, will formulate descriptions and perform analyses of biological and biomedical systems on which the model could be tested, and further clarify the ethical implications of the proposed world view. All participants in the project will remain in direct communication by means of specially created discussion system via the web and email.

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