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Degenerative Techno-Cognitive Niches

Unforeseen Dangers of the Hyper-Technological Paradigm

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Abstract

The aim of this paper is to connect studies in *cognitive niches* with the diffusion of high-technologies, cyborgs and robots, so to obtain a new framework for analyzing some dilemmas of future technological developments. Digital technologies dramatically boosted the niche constructing dynamics by allowing the construction of new informational environments and by the introduction of synthetic-minds that are able to carry on niche construction and maintenance activities side-to-side with human beings. Cognitive niches, structured to ease the environmental selective pressure, may progressively degenerate causing an increase in selective pressure and hence a reduction in welfare for the individuals: yet, when the failure is caused exactly by what was meant to benefit the population, and when the reversal of niche is (or seems to be) unfeasible, it is possible to individuate a “degenerative niche.”

Keywords: Cognitive niches; maladaptation; financial systems.

Cognitive Niches: from Biological to Technological Cultures

In order to understand the concept of “degenerative niche” one must be fairly acquainted with the notion of *cognitive niche*: the first section of this paper is devoted to a brief analysis of the cognitive niches theory, some of its assumptions and theoretical consequences. In a nutshell, a cognitive niche consists in a series of externalizations of knowledge into the environment, for instance through material culture, resulting in a modification of the selective pressure that an organism has to face (Odling-Smee, Laland, & Feldman, 2003; Magnani, 2009). The fact of championing cognitive niche construction could be seen as what intrinsically characterizes human beings (which are individuated by the theory as *eco-cognitive engineers*). The rest of the paper will then focus on the notion of degenerative niche: a cognitive niche that becomes maladaptive *because* of the externalized knowledge structures that primarily did (or were thought to) cause the beneficial trade-off in selective pressure.

Building Cognitive Niches

A recent book by Odling-Smee, Laland and Feldman (Odling-Smee et al., 2003) offers a full analysis of the concept of cognitive niche from a biological and evolutionary perspective. “Niche construction should be regarded, after natural selection, as a second major participant in evolution. [...] Niche construction is a potent evolutionary agent because it introduces feedback into the evolutionary dynamics”

(Odling-Smee et al., 2003, p. 2).¹ By modifying their environment and by their affecting, and partly controlling, some of the energy and matter flows in their ecosystems, organisms (not only humans) are able to modify some of the natural selection pressure present in their local selective environments, as well as in the selective environments of other organisms.

In brief, the general inheritance system (natural selection among organisms influences which individuals will survive to pass their genes on to the next generation) is usually regarded as the only inheritance system to play a fundamental role in biological evolution; nevertheless, where niche construction plays a role in various generations, a second inheritance system occurs, also called *ecological inheritance* by Odling-Smee. In the life of organisms, the first system occurs through a univocal endowment through the process of reproduction (sexual for example): on the contrary, the second system can in principle be performed by any organism towards any other organism (“ecological” but not necessarily “genetic” relatives), at any stage of their lifetime. Why? Because organisms adapt to their environments, but also adapt to environments *as* they are modified by themselves or other organisms.² From this perspective, acquired characteristics can play a role in the evolutionary process, even if in a non-Lamarckian way, through their influence on selective environments via niche construction.

It has to be noted that cultural niche construction alters selection not only at the genetic level, but also at the ontogenetic and cultural levels as well: with a broader explanatory reach than sociobiology and evolutionary psychology, the theory of niche construction simultaneously explains the role of cultural aspects (transmitted ideas), behavior, and ecologically persistence inheritance. Of course niche construction may also depend on learning. It is interesting to note that sev-

¹Attention is drawn for the first time to the idea of niche construction by important researchers like Schrödinger, Mayr, Lewontin, Dawkins, and Waddington. Firstly in the field of physics and subsequently in the field of the theory of evolution itself. Waddington particularly stressed the influence of organism development.

²This perspective has generated some controversies, since the extent to which modifications count as niche-construction is not clear, thus entering the evolutionary scene. The main objection regards how far individual or even collective actions can really have ecological effects, whether they are integrated or merely aggregated changes. On this point, see (Sterelny, 2005) and the more critical view held by (Dawkins, 2004). For a reply to these objections, see (Laland, Odling-Smee, & Feldman, 2005).

eral species, many vertebrates for example, have evolved a capacity to learn from other individuals and to transmit this knowledge, thereby activating a kind of proto-cultural process which also affects niche construction skills: it seems that in hominids this kind of cultural transmission of acquired niche-constructing traits was ubiquitous, and this explains their success in building, maintaining, and transmitting the various cognitive niches in terms of systems of coalition enforcement. “This demonstrates how cultural processes are not just a product of human genetic evolution, but also a cause of human genetic evolution” (Odling-Smee et al., 2003, p. 27). From this viewpoint the notion of *docility* (Simon, 1993) acquires an explanatory role in describing the way human beings manage ecological and social resources to make their own decisions.

Indeed, the shift from the ecological relevance to the constructed niche to the cognitive one is explicated by Tooby & DeVore, Clark, and Pinker (Tooby & DeVore, 1987; Clark, 2005; Pinker, 2010). Clark’s definition of cognitive niche is the one that fits our argument the best:

[Cognitive niche construction is] the process by which animals build physical structures that transform problem spaces in ways that aid (or sometimes impede) thinking and reasoning about some target domain or domains. These physical structures combine with appropriate culturally transmitted practices to enhance problem-solving, and (in the most dramatic cases) to make possible whole new forms of thought and reason (p. 256 – 257).

Cognitive niche construction, which can be rightly considered as a subkind of ecological niche construction, still involves the modification of an organism’s or a species’ environment (by the same organism or species), but is aimed at the implementation of knowledge-based externalizations, which in turn have an epistemic relevance for the agent and the organism. In the cognitive niche, an externalization becomes a mediation: both information production and transfer are dependent on various *mediating structures*, which are the result of more or less powerful cognitive delegations, namely, niche construction activities. Of course, it is hard to develop and articulate a rich culture as humans did, and still do, without effective mediating systems (writing, artifacts, material culture, etc.).

The line dividing merely ecological from cognitive niches can be set at different points, depending on how keenly the researcher extends to animals other than humans the ability to modify the environment so that it better supports cognitive operations.³ Some originally examples of cognitive niches can be:

³Clark himself refers to the possibility that “animals build physical structures that transform problem spaces in ways that aid (or sometimes impede) thinking and reasoning” (Clark, 2005, p. 256), but in the same paper he brings forward the example of the spacial organization of glasses employed by a bartender to remember orders, and presents no animal examples.

- Modifications impressed on the material culture to support memory and share informations, such as notches on bones and woods to count, cave painting to record the nearby wildlife, and so on (Mithen, 1996).
- Language as a cognitive support allowing a scaffolding of cognitive operations on one’s surrounding (Clark, 2005).
- Hunting as a complex of strategies, know-how (also biologicals about the species of preys and predators) and tools (Mithen, 1989; Bingham, 2000).

While other, more intuitive ones can be:

- Traffic signals and markings on the tarmac to help drivers solve problems relating to circulation and the behavior to engage with other drivers.
- A school as a physical building aimed at conveying knowledge, in which every class (with particularly disposed desks, blackboards, computer, instruments) instantiates a cognitive niche aimed at providing support for a knowledge-dissemination problem.

Virtualized and High-Tech Cognitive Niches

The theory of cognitive niches is extremely valuable because it affords us not only to understand traditional human “cultural” development (roughly from the Stone Age to the twentieth century), but its frame can be extended to comprehend hyper-technological cultures as well: the of cognitive niches we sketched out so far could be say to work at least until the Fifties of past century, then something changed. Until the computer age, a cognitive niche could be satisfactorily described as a relationship between *biota*, *abiota* and dead organic matter (DOM). Either you are alive, and then you *can be a constructor*, either you are not, and then you are *constructed*. What is constructible is the *object* of cognitive niche construction: it is the target and the materiel on which the externalization of knowledge was built. And that would be it. Since the computational revolution, though, cognitive niche construction was enhanced by something that was neither biota, nor abiota or DOM: it was the category of *constructed constructors*.

The main effects of this enhancement belong to two categories: first, the so-called “virtualization” produced a multiplication of cognitive niches that go beyond traditional ecologies, their ontologies and what they can afford. Computers and internet allowed the creation of a “sub-environment” (Bertolotti & Cinerari, 2013) that is able to interact with our natural environment (or to simulate it), but that can be manipulated in a much easier way, also because it is ontologically consistent with the way knowledge is expressed: this is to say, the environment and its modifications are expressed in the same coding.⁴

⁴Think of virtual realities such as Second Life: avatars can easily “create” things because there is no gap between information and matter. Matter is reduced to coding, and the only space requirement is available memory to host the coding.

Secondly, but perhaps more importantly, the activity of high-tech niche construction involves the production of more or less complicated “artificial minds” (Magnani, 2007a). Understood for the sake of this paper within the notion of eco-cognitive engineering, the notion of artificial mind is interesting: it can be seen as a help, or as a “maid-mind,” but the aim is the same, that is to obtain a new kind of eco-cognitive engineer that contributes to the activity of niche-construction.

Virtual niches, and high-technological niches, are populated by a number of *constructed constructors*, that is by agencies that were constructed externalizing knowledge on abiotia materiel, but can actively engage a more or less extended range of active behavior within the niche. These new actors can either chiefly serve either as assessors, maintainers and mediators of existing externalizations, or as engineers of new externalizing solutions in the niche, or as full-right agents in the cognitive niche.

These actors need not be “material:” those interacting within traditional cognitive niches (such as driving aid systems) tend to be material, but can be embodied in the coding of a software, for instance in the form of anti-malware or a virtual assistant, and yet be able of causing significative modification to the global structure of the niche. In all of these cases, the crucial feature is the presence of non-human cognitive agents, usually embedded within a cognitive niche, that are able to:

- Assess a situation.
- Make an appraisal.
- Take a decision based on that appraisal.

The final decision, which is usually the contribution to the cognitive nice is meant to be for the good of the human user – or at least of some human users, as in the case of “intelligent” weaponry (Krishnan, 2009). As already stressed, the revolutionary steps consisted in the assumption of non-biological material to the status of actor in a cognitive niche. It is not the same as stating that, for the first time, the new status was given to something different than a human being: animals have traditionally been actors of cognitive niches, also as assessors and decision makers (a trivial example: watchdogs are expected to be able to tell a friend from a foe), but animals are part of the biota, they are trained and not constructed, and do sometimes actively resist niche construction activity. Conversely, in high-tech cognitive niches new actors are introduced, and they are shaped precisely as their creators want them to be.

One related feature of technocognitive niches is the presence of *cyborgs* (Clark, 2003; Magnani, 2007b). This is not the place for a discussion of cyborgs, but they are worth mentioning because not only we witness on the one hand the delegation of cognitive niche construction to artificial agency (for maintenance tasks, surveillance, alert), but on the other hand biological agents, the traditional constructors, are further and further *hybridized* with wearable technological artifacts, so

that the limit situation could be described as a combination of robotic niche construction activity and cyborg niche construction activity: consider an architect, or a medic, acting in her cognitive niche and manipulating her environment not only relying on her own cognition, but – in a partly seamless way – elaborate on data that are being fed to her by a wearable computing device. In other words, the high-tech cognitive niche could be seen as supporting artificial decision maker and hybridized (part biota and part abiotia) decision maker.⁵

Of course, there would be much more to say about high and hyper-technological cognitive niches, first of all about the abundance of available information stored in the environment, its accessibility and ubiquity and so on (Bertolotti & Cinerari, 2013), but that would transcend the scope of this paper. What we mean to focus on is how, since the dawn of material culture onwards (Mithen, 1996), human beings built cognitive niches by externalizing knowledge onto their surroundings. Technological developments are still part of material culture, and supported this externalization just as stone and paper did: it is a matter of a quantitative enhancement, and not qualitative. The qualitative jump comes with the delegation of niche-construction activities, that is to say of *decision making*, to artificial (abiotia) within the niche. This, in our opinion, is the boost afforded to niche construction by the computational era, and furthermore by artificial intelligence. Selective pressure is dramatically affected if the agents that counteract it to make it more favorable to human life are not only human but also technologically crafted “minions.”

Degenerative Niches

What happens, though, when artificial-minds *as* eco-cognitive engineers cease to collaborate with human beings? Actually, the question is not accurate, since it would bean to imbue them not only with passive moral rights, but also of an intentional moral will not to cooperate: more properly asked, could it happen that such agents *keep pursuing the tasks they were endowed with by their human programmers in a way that is not beneficial to human beings anymore?* In order to answer this question, we must not forget that the essence of niche construction is in fact to lessen selective pressure, not to increase it making life more difficult or simply unsustainable: degenerative niches need not be necessarily high-technology niches. In fact, the conditions for the emergence of a degenerative niche are simple: the niche must turn maladaptive because of some of the structures that chiefly achieved (or were thought to achieve) the ease in selective pressure; and,

⁵For a fuller discussion of the cyborg notion, refer to Bertolotti & Magnani, *Reintroducing the Cyborg Concept to Explain Internet-Related Safety Issues*, in this volume. The heart of the relevance of the notion of cyborg for the discussion of technocognitive niches is this: Dennett (2003) famously commented that experiments such as Libet’s simply prove that we are not excluded from our decision making loop, but we are the *whole* loop, that cannot be reduced to the “mere” consciousness. Consequently, technological hybridization turns biological niche constructors into beings that are even wider *loops* comprehending organic and cybernetic processing, thus able to intervene on the niche in a different way than a simply biological agent.

the more the conditions cause by the cognitive niches grow sever, the harder it gets to revert and dismantle the cognitive niche. Within an hyper-technological niche, as we will see, the degenerative phase can acquire some peculiar characteristics – that depend on the discussion we just sketched out about high and hyper-technological niches – but cognitive niches have already happened to turn the change of selective pressure *against* the human beings who had engineered them.

A much illuminating example is provided by anthropologist Steven Mithen (Mithen, 2004, pp. 47–48), as he describes a population, called the Natufians, that lived in Eastern Mediterranean from 13.000 to 9.800 years ago. To make a long story short, the essence of Mithen’s theory is that Natufians’ eventual disappearance was caused by their way of picking which preys to hunt. Hunting can be rightfully considered a cognitive niche, inasmuch as it copes with problem-solving issues concerning technical skills and information on which prey should be preferably killed. Archeological evidence suggests that the Natufians “solved” the problem hunting large gazelle males while sparing most females, thus enacting the knowledge that the perpetuation of the population is guaranteed as long as females outnumber males. While initially granting the welfare of the group, over centuries this practice – embedded in the hunting cognitive niche – caused the progressive reduction of the average size of the gazelle (larger males were killed before they had the chance to reproduce), which led to a decrease of the hunting population’s welfare, until all the resources of the area were exploited and the remaining Natufians had to leave the impoverished area forever.

A *degenerative* cognitive niche is different from a simply *maladaptive* niche. The irreversibility (actual or perceived), on the one hand, and the progressive nature of the phenomenon should be retained as fundamental traits of a degenerative niche: it is very hard to acknowledge one has entered a degenerative niche before one feels the effects on her own ability to live well, or survive – and then, sticking to the same habits (without attempting a renegotiation of the niche) appears to be still the less damaging way out. Conversely, a niche can be acknowledged to be maladaptive and such acknowledgment can spark a revolution within the niche itself. As far as hyper-technological cognitive niche are concerned, we are still far from the degenerative scenarios portrayed by science-fiction, but this should not prevent us from attempting a reading of certain contemporary phenomena through the frame of techno-cognitive degenerative niches. Many examples could be made, but the financial systems seem one of fittest to understand the phenomenon and its risks.

Hyper-Technological Degenerative Niches: Neo-Liberal Finance

In order to explain why finance is a hyper-technological cognitive niche, we must first spend a few word stating why finance can be rightfully considered to be a cognitive niche. A cognitive niche is a space that is either modified for problem-

solving or to act as a repository of problem-solving techniques: the notion of space need not be physical, but rather refers to the cognitive niche as the product of an externalization process, which in turn needs to be maintained. In this sense, finance can be seen as a cognitive niche, for the reasons we shall briefly explain. Finance responds to a problem-solving need, that is the need to provide money to enterprises, offer remuneration to investors, let investors know where it is wiser to invest, facilitate commerce, and on the overall promote the increase of wealth: all of these tasks can be defined cognitive, *qua* acts of cognitions, understood as the ability to display a smart behavior in response to certain environmental features. If we denied this, and appeal to a more specific definition of human cognition, then few instances of cognitive niche would be accepted, starting from Clark’s rudimental example of the bartender: indeed, the discourse about cognitive niches clearly partakes of wide notion of cognition, consistent with the extended and distributed paradigms rather than with a neurological notion of cognition.

Finance is not only a cognitive niche, but one of the best examples of hyper-technological cognitive niche, as it is greatly virtualized and its actors are not only human beings but software and algorithms (such as those for risk-assessment) and other forms of robotic intelligence. This, in turn, means that the human agents involved are significantly cyborgized (cf. footnote 5), as the cognitive tasks they perform without external delegation are nevertheless seamlessly based on the output of computational intelligences. Can the description of finance as a hyper-technological cognitive niche foster a theoretical understand of the crisis that we are just beginning to recover from?

In the early 2000s, financiers believed that, through our integrated financial systems, we could fragment and disperse loan risk so much as to make that risk completely negligible. Risk itself would magically disappear in the ecstasy of post-structuralist communications [...]. Like a starship, financial risk would at last achieve escape velocity and reach the financial galactic beyond. And so we created the giant Ponzi scheme known as the international financial system based on almost infinite hedging and fund fragmentation and dispersal, all made possible by our integrated global financial technologies. Like pre-enlightenment financial alchemists, we could turn base sub-prime loans into gold. Instead, we found that we turned it into a global bank debt crisis and eventually a sovereign catastrophe. (Stapleton, 2012, p. 5)

Stapleton’s analysis is unforgiving. Or even better, it is “curiously” forgiving inasmuch as he does not approach the crisis from the financial point of view, but from that of hyper-technological cognitive niches. Focusing on the crack of the Anglo-Irish Bank, he claims that the fault is not to be found in masterminds of crime or cognitive “slackerism,” but rather in the decision-making system that was cyborg-like, shared between humans and the computers they had – themselves – programmed.

What was the role of management information systems in all this? It was surely these systems that facilitated financial imprudence and light tough regulation, simultaneously providing a sense of a controlled and well-monitored business. Rather than deliver solid management information to support wise decision-making processes, the systems not only failed, but created an illusion that all was well. [...] Thus, management does not gain a real-time, true and integrated picture of their firm. Instead, technology and culture operating together in this Faustian tryst produce the very opposite effect: an illusion of prudence and effective risk management. A technoculture of deceit, of hiding and cover-ups, is therefore potentially enabled by our technology-cultural system. (p. 6)

Whereas it had long since been theorized that crises are endemic to the structure of capitalism, those crises following speculative bubbles such as the 1929 one that caused the Great Depression, and the the 2008 subprime loans one that turned into the latest global crisis, seem to be shifting from something structural to something that is jeopardizing the welfare (and potentially the survival) of those who populate and maintain the niche.

Albeit they did not use the term “degenerative niche,” since they are not adopting the niche theory at all, many economists (for instance in the Post-Keynesian school) have argued about the intrinsic unstable nature of financial markets (seminal work of Minsky) and have stressed the pervasiveness and the disruptive nature of an excessively *financialized* economic system. Neoclassical finance considers economical agents as entirely rational (and this trust was extended to the hybrid and artificial agents of the past few decades), and – basing on this philosophically uncertain assumption – developed models that too often mix up “risk,” as something that can be *measured*, and Keynes’ concept of fundamental “immeasurable uncertainty.”⁶

Minsky, in 1963, claimed that financial markets are intrinsically unstable because of debt structured built by economical agents (namely Ponzi schemes), that will sooner or later cause the collapse of the whole system (Minsky, 1963).

Recently, when the latest economical crisis was far from exploding, Structural Keynesian economist James Crotty showed that:

NFCs [US large Nonfinancial Corporations] were eventually placed in a *neoliberal paradox*: intense product market competition made it impossible for most NFCs to achieve high earnings most of the time, but financial markets demanded that NFCs generate ever-increasing earnings and ever-increasing payout ratios to financial

agents or face falling stock prices and the threat of hostile takeover (Crotty, 2003, p. 1).

For the sake of brevity, we have to make very short a story that would be much longer. We have a cognitive niche (finance) which impose itself over market competition, but which cannot make the necessary gains from market competition (which conversely it impairs), therefore it creates some proper schemes for increasing its welfare by assuming counterintuitive principles such as the rationality of economical agents and the illusion of control by calculating risk through unrealistic mathematical models. It is not necessarily to postulate evil, this is how cognitive niches work: furthermore, as argued by Stapleton, the reliance on an artifactual hyper-technological niche blissfully blinded (and still blinds) many operators: finance in many cases is not a mere self-fulfilling prophecy, but a prophecy that aims at being self-fulfilling, but falls short of it because prophets are not even human but cyborgs or artificial intelligences.

Actually, the description of finance we just sketched out, which is quite an approximation but consistent with serious economical analyses, is not that different from adopting the hunting decision to kill the biggest gazelle males, so to get more food *and* let the population of preys thrive by not subtracting females to the herds. Too bad history proved the Natufians wrong: human beings have an innate desire to have their cake *and* eat it. A certain kind of degenerative niche can be seen as the externalization of this desire. In particular, hyper-technological cognitive niches can make the actualization of this desire as something more possible, and at least at the beginning they make it happen: human beings have a conscience, most of them anyway, but computational intelligences, if “properly” programmed, can create whole systems of meaning and whole possibilities of action which, albeit in traditional cognitive niches they would be quickly debunked as unfeasible, do appear as viable.

Finance as a degenerative niche plays the same game: as everybody witnessed, current politics, aimed at *regulating* markets, coupled with generous insertions of liquidity from the Federal Reserve and European Central Bank, have not achieved a stable recovery yet. According to economists such as Palley, the only way out would be to revert the financialization of the entire world economy (Palley, 2007).⁷

Employing a notion introduced by Woods (2013), cognitive niches can be seen as affected by “doxastic irresistibility,” that is the desperate need to believe what is commonly said. This, summed to a tendency towards resilience and persistence that is vital for the maintenance of cognitive niches, triggers a sclerotization of degenerative niches (Magnani, 2011, chapters 4 and 5): the more they fail in offering a positive trade-off in selective pressure, the harder human beings cling to them. Each time the current financial crisis seems to

⁶For specific events (for instance a roulette table) we can calculate the probability of the outcome. Conversely for others – such as catastrophes and other events, which have been often used as the underlying of many derivatives instruments – we just cannot measure the probability of the outcome.

⁷We are talking about dismantling a cognitive niche. History shows that, in order to break the resilience of a cognitive niche, significant impetus is required: for instance, massive invasions, cataclysms and similar things.

be touching an all-time low, neoliberal think-tanks (such as the Tea Party movement in the US) call for harsher neoliberal politics. Telling people “It has worked till now, it will recover and work again” – notwithstanding the epistemic scarcity of inductive reasoning – is more welcome than alternatives such as “This is not working anymore, we have to look somewhere else for a solution.”

Conclusion

The aim of this paper was to present the issue of degenerative cognitive niches, and to examine – through the example of contemporary finance – how the degenerative paradigm could apply to hyper-technological cognitive niches without analyzing science-fictional issues. Degenerative cognitive niches differ from simply maladaptive ones since they embed an element of inescapability (perceived or real, apparent or transparent) that prevents the users of the niche from actively searching a way to modify the niche in order to achieve a better balance. Referring to hyper-technological cognitive niches, the issue becomes crucial inasmuch as the niche is populated by a new category, produced by technological advancement, that is *constructed constructors* transcending the traditional separation between *biota* and *abiota* within the ecological and cognitive niche. Those new agents, together with their hybridization with biological human agents, face the risk of jeopardizing from the cognitive level (i.e. the ability to assess a situation and react smartly) the function of the niche itself, thought at an inapparent level, thus originating a degenerative cognitive niche.

References

Bertolotti, T., & Cinerari, C. (2013). The gospel according to google: The future of religious niches and technological spirituality. *European Journal of Science and Theology*, 9(1), 41–53.

Bingham, P. M. (2000). Human evolution and human history: a complete theory. *Evolutionary Anthropology*, 9, 248–257.

Clark, A. (2003). *Natural-Born Cyborgs. Minds, Technologies, and the Future of Human Intelligence*. Oxford: Oxford University Press.

Clark, A. (2005). World, niche and super-niche: How language makes minds matter more. *Theoria*, 54, 255 – 268.

Crotty, J. (2003, July). *The neoliberal paradox: The impact of destructive product market competition and impatient finance on nonfinancial corporations in the neoliberal era*. Research Brief 2003-5 of the PERI - Political Economy Research Institute, University of Massachusetts-Amherst.

Dawkins, R. (2004). Extended phenotype - but not extended. A reply to Laland, Turner and Jablonka. *Biology and Philosophy*, 19, 377–397.

Dennett, D. (2003). *Freedom Evolves*. New York: Viking.

Krishnan, A. (2009). *Killer robots: Legality and ethicality of autonomous weapons*. Burlington, VT: Ashgate.

Laland, K. N., Odling-Smee, F. J., & Feldman, M. W. (2005). On the breath and significance of niche construction: a re-

ply to Griffiths, Okasha and Sterelny. *Biology and Philosophy*, 20, 37–55.

Magnani, L. (2007a). Semiotic brains and artificial minds. How brains make up material cognitive systems. In R. Gudwin & J. Queiroz (Eds.), *Semiotics and Intelligent Systems Development* (pp. 1–41). Hershey, PA: Idea Group Inc.

Magnani, L. (2007b). *Morality in a Technological World. Knowledge as Duty*. Cambridge: Cambridge University Press.

Magnani, L. (2009). *Abductive Cognition: The Epistemological and Eco-Cognitive Dimensions of Hypothetical Reasoning*. Berlin/Heidelberg: Springer.

Magnani, L. (2011). *Understanding Violence. Morality, Religion, and Violence Intertwined: a Philosophical Stance*. Berlin/Heidelberg: Springer.

Minsky, H. P. (1963). Can ‘it’ happen again? In D. Carson (Ed.), *Banking and monetary studies*. Illinois: Homewood.

Mithen, S. (1989). To hunt or to paint? Animals and art in the upper paleolithic. *Man*, 23, 671–695.

Mithen, S. (1996). *The Prehistory of the Mind. A Search for the Origins of Art, Religion, and Science*. London: Thames and Hudson.

Mithen, S. (2004). *After the ice: A global human history, 20,000 - 5000 bc*. Cambridge (MA): Harvard University Press.

Odling-Smee, F. J., Laland, K. N., & Feldman, M. W. (2003). *Niche Construction. The Neglected Process in Evolution*. Princeton, NJ: Princeton University Press.

Palley, T. I. (2007). *Financialization: What it is and why it matters*. Working Paper No. 25, The Levy Institute and Economics for Democratic and Open Societies Washington D.C.

Pinker, S. (2010). The cognitive niche: Coevolution of intelligence, sociality, and language. *Proceedings of the National Academy of Sciences, USA*, 17(Suppl. 2), 8993 – 8999.

Simon, H. (1993). Altruism and economics. *The American Economic Review*, 83(2), 156–161.

Stapleton, T. (2012). Zarathustra and beyond: exploring culture and values online. *AI & Society*, DOI 10.1007/s00146-012-0412-4.

Sterelny, K. (2005). Made by each other: organisms and their environment. *Biology and Philosophy*, 20, 21–36.

Tooby, J., & DeVore, I. (1987). The reconstruction of hominid behavioral evolution through strategic modeling. In W. G. Kinzey (Ed.), *Primate Models of Hominid Behavior* (pp. 183–237). Albany: Suny Press.

Woods, J. (2013). *Errors of Reasoning. Naturalizing the Logic of Inference*. London: College Publications.