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Evolving the future: Toward a science of intentional change

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Abstract: Humans possess great capacity for behavioral and cultural change, but our ability to manage change is still limited. This article has two major objectives: first, to sketch a basic science of intentional change centered on evolution; second, to provide examples of intentional behavioral and cultural change from the applied behavioral sciences, which are largely unknown to the basic sciences community.

All species have evolved mechanisms of phenotypic plasticity that enable them to respond adaptively to their environments. Some mechanisms of phenotypic plasticity count as evolutionary processes in their own right. The human capacity for symbolic thought provides an inheritance system having the same kind of combinatorial diversity as does genetic recombination and antibody formation. Taking these propositions seriously allows an integration of major traditions within the basic behavioral sciences, such as behaviorism, social constructivism, social psychology, cognitive psychology, and evolutionary psychology, which are often isolated and even conceptualized as opposed to one another.

The applied behavioral sciences include well-validated examples of successfully managing behavioral and cultural change at scales ranging from individuals to small groups to large populations. However, these examples are largely unknown beyond their disciplinary boundaries, for lack of a unifying theoretical framework. Viewed from an evolutionary perspective, they are examples of managing evolved mechanisms of phenotypic plasticity, including open-ended processes of variation and selection.

Once the many branches of the basic and applied behavioral sciences become conceptually unified, we are closer to a science of intentional change than one might think.

Keywords: acceptance and commitment therapy; applied behavioral sciences; cultural evolution; evolution; evolutionary psychology; prevention science; standard social science model

1. Introduction

Change is the mantra of modern life. We embrace change as a virtue but are desperate to escape from undesired changes that appear beyond our control. We crave positive change at all levels: individuals seeking to improve themselves, neighborhoods seeking a greater sense of community, nations attempting to function as corporate units, the multinational community attempting to manage the global economy and the environment.

Science should be an important agent of change, and it is; but it is responsible for as many unwanted changes as those we desire. Even the desired changes can be like wishes granted in folk tales, which end up regretted in retrospect. Despite some notable successes, some of which we highlight in this article, our ability to change our behavioral and cultural practices lags far behind our ability to manipulate the physical environment. No examples of scientifically guided social change can compare to putting a man on the moon.

In this article we ask what a science of positive behavioral and cultural change would look like and what steps might be required to achieve it. We begin with the basic suggestion that evolution must be at the center of any science of

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change. After all, the study of evolution is the study of how organisms change in relation to their environments, not only by genetics but also by mechanisms of phenotypic plasticity that evolved by genetic evolution, including some that count as evolutionary processes in their own right (Calvin 1987; Jablonka & Lamb 2006; Richerson & Boyd 2005). A solid foundation in evolutionary theory can also help us understand why some changes we desire, which count as adaptations in the evolutionary sense of the word, can turn out to be bad for long-term human welfare. Left unmanaged, evolutionary processes often take us where we would prefer not to go. The only solution to this problem is to become wise managers of evolutionary processes (Wilson 2011c).

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The first step – appreciating the central importance of evolution – reveals how many steps remain to achieve a mature science of behavioral and cultural change. The study of evolution in relation to human affairs has a long and tortuous history that led many to abandon and even oppose the enterprise altogether (Ehrenreich & McIntosh 1997; Sahlins 1976; Segerstrale 2001). Using evolution to inform public policy earned such a bad reputation that "social Darwinism" came to signify the justification of social inequality (Hofstadter 1959/1992; Leonard 2009). Evolution became a pariah concept to avoid as a conceptual foundation for the study of human behavior and culture for most of the twentieth century. The implicit assumption was that evolution explained the rest of life, our physical bodies, and a few basic instincts such as the urge to eat and have sex, but had little to say about our rich behavioral and cultural diversity.

The reception to E. O. Wilson's 1975 book *Sociobiology* provides an example of this intellectual apartheid. The purpose of *Sociobiology* was to show that a single science of social behavior could apply to all species, from microbes to insects to primates. It was celebrated as a triumph except for the final chapter on humans, which created a storm of controversy (Segerstrale 2001). Only during the late 1980s did terms such as *evolutionary psychology* and *evolutionary anthropology* enter the scientific lexicon, signifying a renewed attempt to place the study of human behavior and culture on an evolutionary foundation.

As a result, an enormous amount of integration must occur before a science of human behavioral and cultural change can center on evolution. This integration needs to be a two-way street, involving not only contributions of evolutionary theory to the human-related disciplines but also the reverse. For example, core evolutionary theory needs to expand beyond genetics to include other inheritance systems, such as environmentally induced changes in gene expression (epigenetics), mechanisms of social learning found in many species, and the human capacity for symbolic thought that results in an almost unlimited variety of cognitive constructions, each motivating a suite of behaviors subject to selection (Jablonka & Lamb 2006; Penn et al. 2008).

We will argue that the first steps toward integration, represented by a configuration of ideas that most people associate with evolutionary psychology, was only the beginning and in some ways led in the wrong direction. In particular, the polarized distinction between evolutionary psychology and the *standard social science model* (Pinker 1997; 2002; Tooby & Cosmides 1992) was a wrong turn we must correct. A mature EP needs to include elements of the SSSM associated with major thinkers such as Emile Durkheim, B. F. Skinner, and Clifford Geertz. Only when we depolarize the distinction between EP and the SSSM can a science of change occur (Bolhuis et al. 2011; Buller 2005; Scher & Rauscher 2002; Wilson 2002b).

In section 2 of this article we will attempt to accomplish this depolarization to provide a broader evolutionary foundation for the human behavioral and social sciences. In section 3 we will review examples of scientifically based and validated programs that accomplish change on three

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scales: individuals, small groups, and large populations. We draw these examples from branches of the applied behavioral sciences that, like diamonds in the sand, have remained largely hidden from evolutionary science and the basic human behavioral sciences. The examples provide a much needed body of empirical information to balance evolutionary theorizing, which is frequently criticized for remaining at the speculative "just so" storytelling stage. Indeed, the randomized control trials and other high-quality real-world experiments described in section 2 can be regarded as a refined variation-and-selection process with faster and more accurate feedback on effectiveness than other mechanisms of cultural evolution. When viewed from an evolutionary perspective, they emerge as examples of wisely managing evolutionary processes to accomplish significant improvement in human well-being. We are closer to a science of intentional change than one might think.

2. Toward a basic science of change

The ability to change behavioral and cultural practices in practical terms can profit from a basic scientific understanding of behavioral and cultural change. The human behavioral sciences are currently in disarray on the subject of change. Every discipline has its own configuration of ideas that seldom relate to other disciplines or to modern evolutionary science. We will focus on a major dichotomy that all human-related disciplines must confront: On the one hand, human behavior and culture appear elaborately flexible. On the other, as with all species, the human brain is an elaborate product of genetic evolution. These two facts often appear in opposition to each other, as if evolution implies genetic determinism, which in turn implies an incapacity for change over short time intervals. Once this misformulation is accepted, then the capacity for short-term change becomes conceptualized as outside the orbit of evolutionary theory.

Although the tension between genetic innateness and the capacity for short-term change exists in all branches of the human behavioral sciences, we will focus on two major branches: the behaviorist tradition associated with B. F. Skinner and the configuration of ideas that arose in the late 1980s under the label *evolutionary psychology*. Those merit special attention because of the history of the behaviorist tradition in academic psychology, even before EP made the scene, and because EP came about in a way that seemed to exclude the standard social science model (SSSM) centered on behaviorism in psychology and so-called blank slate traditions in anthropology associated with figures such as Durkheim and Geertz (e.g., Pinker 1997; 2002; Tooby & Cosmides 1992). Reconciling the differences between the behaviorist tradition and EP can go a long way toward reconciling the apparent paradox of genetic innateness and the capacity for short-term change in all branches of the human behavioral sciences.

2.1. B. F. Skinner: Evolutionary psychologist

In the abstract of his influential article "Selection by Consequences," Skinner framed his version of behaviorism in terms of evolution:

> Selection by consequences is a causal mode found only in living things, or in machines made by living things. It was first recognized in natural selection, but it also accounts for the shaping and maintenance of the behavior of the individual and the evolution of cultures. In all three of these fields, it replaces explanations based on the causal modes of classical mechanics. The replacement is strongly resisted. Natural selection has now made its case, but similar delays in recognizing the role of selection in the other fields could deprive us of valuable help in solving the problems which confront us. (Skinner 1981, p. 501)

Although the term *evolutionary psychology* had not yet been coined, Skinner's passage leaves no doubt that he regarded the open-ended capacity for behavioral and cultural change as both (1) a product of genetic evolution and (2) an evolutionary process in its own right. It is therefore ironic that when Tooby and Cosmides (1992) formulated their version of EP, they set it apart from the SSSM that included the Skinnerian tradition (see also Pinker 1997; 2002).

Long before Tooby and Cosmides's version of EP made the scene, the so-called cognitive revolution had largely displaced behaviorism in academic psychology. Cognitive theorists stressed that the enormous complexity of the mind needed direct study, in contrast to Skinner's insistence on focusing on the functional relations of environment and behavior (Brewer 1974; Bruner 1973). The central metaphor of the cognitive revolution was that the mind is like a computer that we must understand in mechanistic detail to know how it works. However, those who study computers would never restrict themselves to input–output relationships: They would study the machinery and the software. Cognitive psychologists faulted behaviorists for not following the same path.

One of the seeds of the cognitive revolution, which took root in Tooby and Cosmides's version of EP, was a challenge to what most perceived to be the extreme domain generality of behavioral approaches. An example is Martin Seligman's (1970) influential article on the "generality of the laws of learning." Seligman reviewed a body of evidence showing that the parameters of learning processes had to be viewed in light of the evolutionary preparedness of organisms to relate particular events. For example, taste aversion (Garcia et al. 1966) challenged the idea that immediacy per se is key in stimulus pairings in classical conditioning, because illness could follow by tens of hours and still induce aversion to ecologically sensible food-related cues. Seligman recognized that this kind of specialized learning could evolve by altering the parameters of classical conditioning, but his preferred interpretation was that general learning processes themselves were not useful: "[W]e have reason to suspect that the laws of learning discovered using lever pressing and salivation may not hold" (p. 417).

Even more important was the conclusion that no general process account was possible in the area of human language and cognition. Pointing to evidence that seemed to show that human language requires no elaborate training for its production, Seligman concluded, "instrumental and classical conditioning are not adequate for an analysis of language" (p. 414). What interests us in this context is how these concerns quickly led to abandoning the idea that general learning process accounts were possible. For example, in an influential chapter that helped launch the "cognitive revolution," William Brewer (1974) concluded, "*all* the results of the traditional conditioning literature are due to the operation of higher mental processes, as assumed in cognitive theory, and…there is not and never has been *any* convincing evidence for unconscious, automatic mechanisms in the conditioning of adult human beings" (p. 27, italics added).

The concern over the limits of domain generality in cognitive psychology redoubled as EP arrived as a self-described discipline, including the influential volume *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (Barkow et al. 1992; see also Pinker 1997; 2002). The thrust of EP was that the mind is neither a blank slate nor a general-purpose computer. The mind is a collection of many special-purpose computers that evolved genetically to solve specific problems pertaining to survival and reproduction in ancestral environments. This claim became known as "massive modularity" (Buller 2005; Buller & Hardcastle 2000; Carruthers 2006; Fodor 1983; 2000).

Tooby and Cosmides's (1992) chapter in *The Adapted Mind*, titled "The Psychological Foundations of Culture," which did much to define the field of EP, described domain-general learning (the applicability of general cognitive processes, whether viewed behaviorally or cognitively) as nearly a theoretical impossibility. Too many environmental inputs can be processed in too many ways for a domain-general learning machine to work, whether designed by humans or by natural selection. The most intelligent machines humans have designed are highly task specific. Tax preparation software provides a good example: It requires exactly the right environmental input, which it processes in exactly the right way, to calculate one's taxes accurately. It is impressively flexible at its specific task but utterly incapable of doing anything else. According to Tooby and Cosmides, natural selection is constrained just as human engineers are in creating complex machines or programming software, leaving massive modularity as the only theoretical possibility for the design of the mind.

In discussing cultural evolution, Tooby and Cosmides observed that behavioral differences among human populations do not necessarily signify the cultural transmission of learned information. Instead, they can reflect massively modular minds responding to different environmental cues without any learning or social transmission whatsoever. They called this instinctive response to the environment "evoked" culture, in contrast to the social transmission of learned information, or "transmitted" culture. They did not deny the existence of transmitted culture, but had little to say about it.

An article titled "Evolutionary Psychology: A Primer" (Cosmides & Tooby 1997) pares their vision to its bare essentials. The human mind is described as "a set of information-processing machines that were designed by natural selection to solve adaptive problems faced by our hunter-gatherer ancestors." Because our modern skull houses a Stone-Age mind, "the key to understanding how the modern mind works is to realize that its circuits were not designed to solve the day-to-day problems of a modern American – they were designed to solve the day-to-day problems of our hunter-gatherer ancestors." Evolutionary psychology is described as "relentlessly past-oriented" – meaning our genetic past, not our cultural or individual past.

In this fashion, the concept of *elaborate innateness* that became associated with EP sat in opposition to the *open-ended capacity for change* that became associated with what Tooby and Cosmides branded the SSSM. In our opinion, this is a profound mistake needing correction to achieve an integrated science of change.

2.2. Evolution as a domain-general process

Ironically, although Tooby and Cosmides praised genetic evolution as a domain-general process, capable of adapting organisms to virtually any environment, they failed to generalize this insight to include other evolutionary processes. If they had, their critique of the "blank slate" traditions in the human behavioral sciences would have appeared in a new light.

Evolutionists routinely rely upon a blank slate assumption of their own when they reason about adaptation and natural selection. They predict the adaptations that would evolve by natural selection, given heritable variation and a sufficient number of generations. For example, they confidently predict that many species inhabiting desert environments will evolve to be sandy colored to conceal themselves from their predators and prey. This prediction can be made without any knowledge of the genes or physical composition of the species. Insofar as the physical makeup of organisms results in heritable variation, that is the extent to which it can be ignored in predicting the molding action of natural selection. The phenotypic properties of organisms are caused by selection and merely permitted by heritable variation (Campbell 1990; Wilson 1988).

Evolutionists know that heritable variation is not omnipresent and a sufficient number of generations often has not elapsed for species to become fully adapted to their environments. Hence, they easily back away from their blank slate assumption. A fully rounded evolutionary perspective requires equal attention to functional design, proximate mechanisms, developmental pathways, and phylogenetic histories (Tinbergen 1963). Nevertheless, blank slate adaptationist reasoning remains one of the most powerful tools in the evolutionary toolkit, and Tooby and Cosmides use it liberally to develop their vision of EP.

The point that Skinner was making with his key phrase "selection by consequences" was that evolution goes beyond genetic evolution. Insofar as individual learning and cultural change count as evolutionary processes, a blank slate assumption can be made about what evolves on the basis of the molding action of selection, which is permitted but not caused by the proximate mechanisms underlying the evolutionary processes (what Skinner called "causal modes of classical mechanics" in the abstract quoted above). This is also what Durkheim perceived for cultural evolution when he wrote in 1895 that "individual natures are merely the indeterminate material that the social factor molds and transforms" (Durkeim 1895/1982, p. 106). These insights are fully justified from an evolutionary perspective, to the extent that learning and cultural change qualify as evolutionary processes.

Against this background, debates about the existence of domain-general cognitive mechanisms can be seen to be largely misplaced. Genetic evolution is a domain-general process, but the mechanisms of genetic inheritance are many and specific in their functions (e.g., error correction mechanisms, transcription mechanisms). The question is not whether the *mechanisms* qualify as domain general, but whether they result in heritable variation, which allows the *evolutionary process* to be domain general. These points apply to learning and culture as well as genetic evolution. Tooby and Cosmides could be correct about massive modularity and still would be wrong to reject the blank slate assumption for learning and culture – insofar as massive modularity leads to nongenetic mechanisms of inheritance.

In short, the error of theorists such as Cosmides and Tooby was to ignore (or at least greatly downplay) the possibility that the complex special-purpose adaptations that evolved by genetic evolution resulted in nongenetic mechanisms of inheritance, capable of rapidly adapting people to their current environments in a domain-general fashion. When this error is corrected, the blank slate traditions represented by authors such as Skinner and Durkheim can be seen as fully compatible with modern evolutionary theory. It is not our purpose to argue that EP is totally in error or that the blank slate traditions are right in every detail, however. The point is to establish a middle ground that includes the valid elements of both positions – to depolarize the distinction between EP and the SSSM.

Apart from the particular school of thought known as EP, there is a long tradition of thinking about the immune system, brain development, learning, culture, and science (as a particular form of culture) as evolutionary processes that result in adaptations to current environments according to their respective criteria of selection (e.g., Boyd & Richerson 1985; Calvin 1987; Campbell 1960; Edelman 1988; Edelman & Tononi 2000; Farmer & Packard 1987; Jablonka & Lamb 2006; Plotkin 1994; 2003; 2007; Richerson & Boyd 2005; Wilson 1990; 1995). Evolutionary processes that rely on nongenetic inheritance mechanisms either evolved genetically or were created by humans, as Skinner appreciated in the abstract quoted above. The term *Darwin machine* aptly describes an evolutionary process built by evolution (Calvin 1987; Plotkin 1994). The word *Darwin* signifies that an open-ended process of variation and selection is at work, capable of producing adaptations to current environments that might never have previously existed. The word *machine* here means only in the limited sense that complex but systematic processes are required to create heritable phenotypic variation and to select traits that are genetically adaptive on average. (We caution against other connotations of the word that do not capture the open-ended nature of "Darwin machine.") Properly understood, these two words reconcile the apparent paradox of genetic innateness and the capacity for open-ended change over the short term.

2.3. Learning from the immune system about evolutionary psychology

By far, the best understood Darwin machine is the vertebrate immune system. It is a fabulously complex set of adaptations that evolved genetically to protect organisms against disease. It has many hallmarks of massive modularity, but it also has the open-ended capacity to rapidly evolve new defenses in the form of antibodies. If we can think about the human capacity for behavioral and cultural change as we do the immune system, we can begin to provide an appropriately broad foundation for a science of intentional change.

Immunologists distinguish between the innate and the adaptive components of the immune system (see Sompayrac 2008 for an excellent tutorial). The innate component is massively modular, much as Tooby and Cosmides describe for human psychology. Macrophages can sense and engulf foreign particles, for example, but they have no capacity to change their sensory abilities. The innate component of the immune system protects against most disease organisms but is helpless against those that manage to evade its automated defenses.

The adaptive component of the immune system includes the ability to create roughly 100 million different antibodies. Each antibody is like a highly specialized hand that can grab onto a narrow range of molecular shapes. Collectively, the 100 million antibodies can grab onto nearly any conceivable organic surface. When a given antibody grabs onto an invading disease organism, it signals the innate component of the immune system to attack; the antibody itself acts only as a tag. Simultaneously, the B-cells producing the antibody are stimulated to reproduce and to ramp up their production. A single B-cell in full production mode can produce about 2,000 unattached antibody molecules every second.

The variation-and-selection process employed by the adaptive component of the immune system enables the organism to adapt rapidly to diseases that have evaded the innate component of the immune system. In this sense, it is impressively domain general. Yet, not only does the adaptive component rely upon the innate component, it too is elaborately innate. One hundred million antibodies occur not by a happy accident but by an orchestrated process creating combinations of genes from highly polymorphic regions of the chromosomes. Other genetically evolved processes are required for the antibodies that bind to antigens to signal the innate component of the immune system, for the B-cells producing the antibodies to reproduce and ramp up production, to keep the antibody circulating after elimination of the disease organism, and so on. The "machine" part of this Darwin machine is very complex indeed!

Against this background, we can begin to identify the valid and invalid elements of both EP and the SSSM in their polarized forms. The massive modularity thesis of Tooby and Cosmides is like a description of the innate component of the immune system without the adaptive component. On the other hand, Skinner's effort to explain as much as possible in terms of operant conditioning is like a description of the adaptive component of the immune system without the innate component. Combining the valid elements of both positions enables us to reconcile the concepts of elaborate innateness and an open-ended capacity for change.

The immune system offers an additional insight into the distinctively human capacity for behavioral and cultural change: It is inherently a *multi-agent cooperative system*. Dozens of specialized cell types coordinate their activities through a chemical signaling system to achieve the common goal of protecting the organism. Individuals with immune systems that failed to exhibit teamwork were not among our ancestors.

The capacity for open-ended learning at the individual level occurs in many species, as Skinner showed for pigeons and rats. The capacity for cultural transmission also exists in many species – more than one might imagine; it is a relatively new topic in animal behavior research (Hill 2010; Laland & Galef 2009; Laland &

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Hoppitt 2003; Page & Ryan 2006). However, the human capacity for behavioral and cultural change is so distinctive that it borders on unique (Deacon 1998; Jablonka & Lamb 2006; Penn et al. 2008). This might be because the human capacity requires a degree of teamwork among group members that most other vertebrate species lack. Human evolution increasingly is seen as a major transition, similar to the evolution of eukaryotic cells, multicellular organisms, and eusocial insect colonies (Boehm 1999; Maynard Smith & Szathmary 1995; Sober & Wilson 1998; Wilson 2011a). A major transition might have been required to evolve a multi-agent cooperative system for behavioral and cultural change comparable to the immune system.

The analogy between the immune system and other Darwin machines should not go too far. At a finer level of detail, the complex but systematic processes that create and select behavioral and cultural traits will differ from those that create and select antibodies. The main analogies that we wish to stress are (1) the reconciliation of elaborate genetic innateness with elaborate open-ended flexibility and (2) the need for some Darwin machines to be multi-agent cooperative systems.

2.4. The human symbolic inheritance system

Humans are most distinctive in their capacity for symbolic thought. The rudiments of symbolic thought might exist in other species, but humans possess a full-blown inheritance system with combinatorial possibilities to rival genetic inheritance (Deacon 1998; Jablonka & Lamb 2006; Pagel 2012; Pinker 2010; Tomasello 2008).

When a rat learns through experience to associate an object (such as food) in the environment with an arbitrary signal (such as a bell), notes similarities between physical objects, or detects sequences of apparent causes and effects, these relations are bound largely to the physical properties of the related events and direct experience. In human symbolic behavior, "tacit systems of higher-order relations at various levels of generality modulate how human subjects judge and discover novel relations within those domains" (Penn et al. 2008, p. 118). These higher-order relations are abstracted from immediate physical properties, becoming somewhat independent of them, and once established are maintained by their utility, coherence, and role in a social community. A classically conditioned response in a rat will weaken quickly when extinguished, which is clearly adaptive; it would not benefit the rat to continue expecting food at the sound of a bell when food is no longer forthcoming. Conversely, a person can hear the word *cheese* a million times in the absence of cheese and the relation will remain intact. The meaning of the word remains consistent due to its place in a network of symbolic relations, and every set of symbolic relations leads to a suite of behaviors that potentially influences survival and reproduction (Hayes et al. 2001). In this sense, a network of symbolic relations that regulates behavior is like a genotype that produces a phenotype. We will call it a "symbotype" to stress the comparison. Like genotypes, symbotypes evolve based on what they cause the organism to do, regardless of the direct correspondence between the mental and environmental relations. As an example, religious and superstitious beliefs might not correspond directly to anything that exists in the real world, but they might still be favored by selection, based on the behaviors they motivate in the real world.

Genotypes, symbotypes, and antibodies share something else: almost infinite variety, based on the recombination of their elements. Much as x genes with two alleles at each locus result in 2^x combinations, each potentially producing a different phenotype for selection to act on, a human symbolic system consisting of a few handfuls of "object→sign" relations will be able to derive thousands of combinations, each potentially resulting in a different phenotype for selection to act on (Deacon 1998).

Because the symbotype concept bears a superficial resemblance to the meme concept (Dawkins 1976), a brief comparison is in order. The term *meme* is sometimes used broadly to refer to any cultural trait. More narrow usages suggest that cultural traits resemble physical genes in various respects, such as functioning as "replicators," having a physical form inside the brain, or having the capacity to spread at the expense of their human hosts (Aunger 2002; Blackmore 1999). The most recent treatments of cultural evolution recognize the need for a term that describes cultural traits at the phenotypic level, but those treatments depart from other specific concepts that have been associated with the term *meme*. In particular, it is possible for the replication of cultural traits to be a systemic process without the need for gene-like replicators (Henrich et al. 2008; Laland & Brown 2011). The concept of "evolution without replicators" applies even to genetic evolution (Godfrey-Smith 2000). In any case, the term *symbotype* refers not to a single cultural trait but rather to a given set of symbolic relations, which results in an entire suite of phenotypic traits (the phenotype). The term does not presuppose any particular proximate mechanism for the symbotype and does not assume that the phenotype can be atomized into independent traits. Obviously, a great deal of future research will be required to clarify the concept of the symbotype, but it differs importantly from the concept of a meme.

However our symbolic inheritance system and its combinatorial properties arose, the result was a quantum jump in our capacity for open-ended behavioral and cultural change. The best way to see this is by standing back from the "trees" of single scientific studies to see the "forest" of human evolution. A single biological species spread out of Africa to inhabit the globe, adapting to all climatic zones and occupying hundreds of ecological niches, in just tens of thousands of years. Each culture has mental and physical toolkits for survival and reproduction that no individual could possibly learn in a lifetime. Then the advent of agriculture enabled the scale of human society to increase by many orders of magnitude, resulting in mega-societies unlike anything our species had previously experienced. The human cultural adaptive radiation is comparable in scope to the genetic adaptive radiations of major taxonomic groups such as mammals and dinosaurs (Pagel & Mace 2004). What else is required to conclude that humans have an elaborate capacity for open-ended behavioral and cultural change?

It is important to stress that the cultural inheritance system does not entirely supersede the other inheritance systems. Many human traits can change only by genetic evolution (e.g., the ability to digest lactose in adults; Holden & Mace 2009). Moreover, the four inheritance systems discussed by Jablonka and Lamb (2006) – genetic,

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epigenetics, learning, and symbolic thought – have been interacting with one another throughout our history as a species (Richerson & Boyd 2005). Genetic evolution and cultural evolution have been shaping each other for a very long time. It is therefore incorrect to say that cultural evolution serves to maximize genetic fitness, as if the latter can be defined without reference to the former.

2.5. The contribution of the human-related disciplines to core evolutionary theory

Evolution requires heritable variation, but the mechanism of inheritance need not be genetic. Most evolutionists will agree with this statement, yet the vast majority of evolutionary research has focused on genetic inheritance mechanisms – so much that for most people "evolution" is nearly synonymous with "genes." It is therefore important to expand core evolutionary theory beyond genetics to include other mechanisms of inheritance. Jablonka and Lamb (2006) have made an excellent start in their book *Evolution in Four Dimensions*. Starting with a concise historical account of why genetic inheritance became so central in evolutionary theory, they show how epigenetics, learned behavior, and symbolic systems also qualify as inheritance systems and how all four systems interact with one another to produce evolutionary change.

Epigenetics is a biological subject, but most of the research on learning and symbolic thought has occurred in the many human-related disciplines, including the humanities and the human behavioral sciences. Research in these disciplines is sometimes cognizant of evolutionary theory (including Skinner's key insight about selection by consequences), but more often it occurs without reference to evolution or in perceived opposition to it. A good example is the intellectual tradition of social constructivism, which has long appeared to be opposed to evolutionary accounts of human nature (Segerstrale 2001; Wilson 2005; 2009). Insofar as evolutionists failed to include symbolic inheritance systems in core evolutionary theory, social constructivists were right to point out that something was missing. Yet, social constructivists did not converge on the idea of cultural evolution as a Darwin machine comparable to the immune system and explore how that level of analysis interacts with genetic, epigenetic, and learning processes. Everyone was wrong, and progress requires movement on all sides. Evolutionists need to consult the human behavioral sciences and humanities respectfully – to discover what these disciplines know about learning and symbolic systems. Scientists and scholars from the human behavioral sciences and humanities will benefit by thinking about their work as inside the orbit of evolutionary theory, however irrelevant or wrong-headed evolution might have appeared in the past. This kind of integration is already occurring at a pace that is fast in cultural evolutionary terms – but it can go even faster. When complete, we will have a proper basic scientific foundation for an applied science of intentional change.

3. Toward an applied science of change

Like the basic human behavioral sciences and the humanities, the applied human behavioral sciences are a vast archipelago of disciplines that seldom communicate with one another. Outside the applied academic disciplines, commercial marketers and political strategists also attempt to influence behavioral and cultural change – often very successfully and not necessarily for the common good. The scientific caliber of any particular applied discipline, in terms of theoretical justification and empirical methods, ranges from exemplary to nonexistent. Explicit or implicit recognition of evolution is highly variable, and hardly any of the disciplines consider recent developments in evolutionary science. The disciplines, in turn, are largely unknown to modern evolutionary scientists.

One purpose of this target article is to bring some exemplary research programs in the applied behavioral sciences to the attention of evolutionary scientists, and vice versa. Benefits flow both ways. Evolutionary scientists might be surprised to learn of proven methods for accomplishing positive behavioral and cultural change at all scales, from individuals to large populations. The theories behind these methods are highly relevant to the development of core evolutionary theory, and the empirical results can help take evolutionary theorizing beyond the "just-so" storytelling stage. Applied behavioral scientists in any particular discipline might be surprised to learn how much it can benefit from integration with all other basic and applied disciplines, using evolution as the common theoretical framework. It is beyond the scope of this paper to provide a comprehensive review. Instead, we provide examples to illustrate the potential for a broader integration.

3.1. Change at the level of individuals

When the cognitive revolution dethroned behaviorism in academic psychology during the second half of the twentieth century, behaviorism did not disappear. Instead, it developed into a robust set of methods for accomplishing behavioral change in a variety of applied disciplines such as applied behavior analysis (Baer et al. 1968) and behavior therapy (Wolpe 1958). Behavior therapy was gradually supplemented (not replaced) by cognitive therapy, which in turn has been supplemented (not replaced) by acceptance and mindfulness–based techniques with proven efficacy (Hayes et al. 2011b; Hofmann et al. 2010), in what is sometimes called a "third wave" of cognitive behavioral methods (Hayes 2004). When the elements of behavioral, cognitive, and mindfulness-based therapies are examined in detail, they map impressively onto the elements of learning and symbolic thought as Darwin machines.

We begin with the enigma of how people with perfectly healthy brains and bodies can nevertheless become so dysfunctional that they seek therapy. One of the most basic facts about evolution is that it results in both dysfunctional and functional outcomes. Many products of evolution are not adaptive in any sense. Even traits that count as adaptive in the evolutionary sense of the word can be maladaptive from the standpoint of human welfare; for example, by benefiting some individuals at the expense of others (e.g., rape, murder, or selling addictive products such as tobacco to youth) or by achieving short-term goals at the expense of long-term goals (e.g., discounting the future). Another basic fact about evolution concerns path dependence. Evolution from a less adapted state to a more adapted state will not take place if the intermediate steps are not adaptive.

These dysfunctional outcomes of evolution can be expected no matter what the mechanism of inheritance.

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It follows that if learning qualifies as a Darwin machine, so that individuals can be regarded as open-ended evolving systems with their actions selected by consequences, then evolution will sometimes take them where they prefer not to go. These observations are elementary but can be new and insightful for those not accustomed to employing an evolutionary perspective.

In addition to dysfunctional outcomes common to all evolutionary processes, there are dysfunctional outcomes inherent to any Darwin machine built by genetic evolution. Operant and classical conditioning are learning processes that evolved during the early history of life (Ginsberg & Jablonka 2010). In operant conditioning, behaviors are selected not only by differential survival and reproduction but by reinforcers, which Skinner properly interpreted as genetically evolved adaptations that lead, on average, to the adoption of genetically adaptive behaviors. "On average" includes many exceptions. Moreover, the direct and immediate costs and benefits of behaviors more readily function as consequences that select behaviors, compared with those effects that are more diffuse, delayed, or indirect. Cascades of these more subtle effects of behaviors can easily outweigh direct effects, such that direct and immediate consequences are not always a reliable selection criterion for long-term adaptation.

Due to these dysfunctional consequences of learning as a Darwin machine, people who are functioning normally as evolutionary processes occasionally find themselves in highly dysfunctional states requiring therapy. Behavior therapy works by altering the selective environment; for example, by repeatedly exposing clients who fear spiders to the objects of their fear without adverse consequences so that they can acquire a wider range of responses than avoidance in a spider's presence (Craske & Barlow 2008). In this fashion, new, more flexible responses can extinguish and replace dysfunctional learned and repertoire-narrowing effects (fear and avoidance), in much the same way as occurs with other species. That many human phobias have clear links to dangers that existed in the genetic ancestral environment (e.g., spiders, snakes, heights, closed spaces, open spaces, and strangers) can be regarded as part of the innate component of the learning Darwin machine, analogous to the innate component of the immune system (Nesse & Williams 1995). Similarly, the generation of greater response variability during extinction of learned avoidance responses appears to be innate, extending across the animal world (Bouton et al. 2001).

Cognitive behavior therapy (CBT) goes beyond behavior therapy by encouraging clients to reconceptualize their problems (e.g., Beck 2011). In evolutionary terms, the reason that cognitive therapy adds value to behavior therapy is that people are influenced by a symbolic Darwin machine in addition to a learning Darwin machine. A laboratory rat would benefit from behavior therapy but not from therapy that employs symbolic language; a human benefits from both because the symbolic Darwin machine was added to the learning Darwin machine over human evolutionary history but did not replace it.

As an everyday example of overcoming a problem by reconceptualizing it, people who are anxious about flying can sometimes put themselves at ease by concentrating on the statistics showing that flying is much safer than driving. The symbolic representation of flying as safe can help counteract sensory input that it is dangerous (e.g., Flatt & King 2010). Everyday life is rife with examples of people who behave as they do because it makes sense in terms of a conceptual framework, such as a religion, a political ideology, or a scientific theory, not because of a history of operant conditioning of motor responses. Through organized examination and testing of beliefs in addition to behavior therapy methods, CBT uses this universal human capacity for therapeutic purposes, and it is one of the best empirically supported therapeutic interventions (INSERM 2004). For example, a panic-disordered client might be led to face fears in a systematic fashion (as in behavior therapy), but also learn to change their cognitive appraisals of the actual threats posed by fearsome situations (see Craske et al. 2000 for an empirically validated program of this kind). The cognitive change components might include educating patients about how catastrophic thoughts exacerbate panic symptoms and create a vicious cycle, helping to identify the negative cognitions associated with physical sensation triggers of recent panic attacks, and practicing replacement of maladaptive cognitions with noncatastrophic explanations. Research shows that just these cognitive elements alone are helpful, resulting in improved outcomes because of how patients appraise their symptoms (Meuret et al. 2010). Symbotypes can be changed directly in some cases, producing helpful phenotypic changes.

A variety of evidence-based practices have emerged over the last few decades that add regulation of the *impact* of symbotypes to this array of individual change methods, through such techniques as mindfulness meditation, attentional training, emotional acceptance, and deliberate use of perspective taking. In a direct analogy to the epigenetic regulation of gene expression, these methods use what we might call "episymbolic" processes to regulate the impact of symbotypes on behavior. The emphasis in these methods is on detaching oneself from the internal dialogue and becoming mindful of one's true values, rather than trying to solve problems by eliminating difficult thoughts and feelings. We will describe a particular kind of mindfulness-based therapy called "acceptance and commitment therapy" (ACT, pronounced as one word), in part because it is well-validated and in part because it rests on a strong theoretical foundation called "relational frame theory" (RFT), which can profitably be related to core evolutionary theory (Hayes et al. 2001). In general, however, the pattern of results we describe here primarily with ACT applies with equal force to all of the newer acceptance and mindfulness–based treatments, such as dialectical behavior therapy (Linehan 1993) and mindfulness-based cognitive therapy (MBCT; Segal et al. 2002). (For a recent review of such methods, see Hayes et al. 2011b.)

RFT derives from the functional contextual wing of behaviorism, but it acknowledges that Skinner failed in his quest to explain language and other forms of symbolic thought in terms of simple operant conditioning. Instead, humans have evolved specialized abilities for relating events (Penn et al. 2008); due to this evolved capacity, humans can learn to create networks of symbolic relations and transfer whole networks across contexts. Although this may begin in the mutual relation between speakers and listeners, human cognitive abilities carry arbitrary relational learning far beyond that situation. In normal humans, arbitrary learned relations of a particular kind between A and B and between B and C automatically result in predictable *derived* relations between B and A, C and A, A and C, and C and A. The ability to derive such relations when they have their bases in arbitrary cues and not physical properties seems to require multiple exemplars of the key relational tasks (Berens & Hayes 2007). For example, if a person learns in arbitrary matching to sample that three events are related in the order X < Y < Z, and if Y is then paired with a shock, Z will elicit *more* arousal than Y will, even though there were never any shocks paired with Z and there is no physical relationship between Y and Z (Dougher et al. 2007). The essence of metaphorical thinking is that a network of relations formed in one context (e.g., a rose) can transfer to another context (e.g., my love). Growing evidence indicates that the core ability to relate symbols and objects in this way when relationships are arbitrarily applicable is learned (e.g., Barnes-Holmes et al. 2004), beginning in infancy (e.g., Luciano et al. 2007). Whether these abilities are uniquely human or merely highly elaborated in humans is unclear, but the more important point is that RFT is beginning to delineate some of the proximate mechanisms of the symbolic Darwin machine that is necessary to expand core evolutionary theory.

An important concept from RFT that ACT uses is *cognitive fusion*, which we can understand in evolutionary terms as the loss of behavioral flexibility. The useful human capacity for creating networks of relations and transferring them across contexts can cause particular symbotypes to dominate over others, even when they are dysfunctional, especially when alternative symbotypes appear unavailable or the paths to them seem obscure. Using the venerable evolutionary metaphor of adaptive landscapes (Pigliucci & Kaplan 2006; Provine 1986; Wright 1932), in which altitude represents fitness, a dysfunctional symbotype is like a small peak separated from higher peaks by even more dysfunctional valleys. An example is the common tendency toward *experiential avoidance,* in which avoidant responses to aversive events are linked to their emotional and cognitive effects, spreading avoidance far beyond its original context (Hayes et al. 1996). Any number of symbolic connections can trigger a memory of a painful loss, fear of a panic attack, or the expectation of failure. Avoiding these connections and their emotional results is reinforcing over the short term but greatly reduces healthy behavioral variability over the long term. A depressed person who decides to stay in bed appears to be sensibly avoiding further pain, and initially feels a sense of relief, but later develops further depression and self-loathing. An alcoholic who takes the next drink feels better immediately and worse only later. In terms of the learning Darwin machine, the short-term transient benefits are more reinforcing than the long-term diffuse costs.

Deliberately trying to avoid a symbolically invoked experience can be counterproductive, because it increases attention focused on the experience and its likely negative outcomes. This often later elicits the experience itself, expanding the range of events associated with the aversive event. For example, trying not to think of a painful memory by listening to pleasant music will soon enough lead to the music itself invoking the memory (Wenzlaff & Wegner 2000). Experiential avoidance of painful private experience is arguably one of the most persistent and pathologically repertoire-narrowing processes known in human psychology (Hayes et al. 1996; 2006; Wenzlaff & Wegner 2000; see also Kashdan 2009) precisely because it creates an adaptive peak that prevents further healthy hill-climbing processes.

ACT uses acceptance and mindfulness methods to *increase healthy flexibility and variability in the person's actions* (emotional, cognitive, and behavioral) and examines values to *change the selection criterion for these actions.* In other words, ACT deliberately manages the variation-and-selection process, which makes it easy to relate to core evolutionary theory. ACT encourages people to identify their most important life goals and to keep them firmly in mind as criteria for selecting behaviors. At the same time, it promotes a mindful, open, and curious stance toward one's thoughts, feelings, and experiences, which reduces their automatic dysfunctional interference with the pursuit of important life goals.

It is no coincidence that some methods of ACT and other acceptance and mindfulness–based interventions converge with religious and meditational practices – systems that have been managing the variation-and-selection process for millennia (Wilson 2002a). Powerful metaphors and exercises help to manage the variation-and-selection process, altering the normal, automatic behavioral impact of difficult emotions and thoughts – in effect, adding symbolic systems that regulate the impact of symbolic events. Here is one ACT metaphor: Imagine that you are a chess player locked in a battle with an emotional archrival who requires all your concentration. Now imagine that you are the *chessboard*. The game continues, but you see it from a different perspective: You hold all of the emotional pieces, both painful and pleasant. The board can move but only by taking all the pieces with it. In another ACT metaphor, you imagine you are driving a bus toward a destination. Imaginary "people" on the bus are your own thoughts and feelings. These "passengers" are part of your history. They may not be what you would have chosen but at least in memory they are likely to come with you for the rest of your life. Instead of stopping the bus and trying in vain to get them to leave, your challenge is to reach your destination with them coming along for the ride.

ACT integrates metaphors such as these with experiential methods (e.g., exposure, contemplative practices) with the goal of changing the impact of negative symbotypes and creating new behavioral options in pursuit of one's most important life goals. Paradoxically, accepting that given thoughts and feelings might not go away can be an important step toward making them go away, in the sense that they become less salient and central because they are no longer the focus of attention or have the threatening implications that they once did. Equally important, when combined with the clarification of values, acceptance supports the key processes of increasing healthy variation and selection by chosen consequences, allowing the behavioral system to evolve.

Solving recalcitrant problems with the use of brief metaphors and exercises might seem too good to be true – until one takes the concept of a symbotype and its regulation seriously. Because evolutionists are familiar with the genotype-phenotype relationship, they fully expect that by changing the genotype (e.g., by inducing a mutation in DNA), or by changing the ability of the genotype to be transcribed or translated (e.g., by methylation of DNA), they can change the phenotype. Billions of dollars go into research showing

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the effects of genetic variation and the regulation of gene expression on phenotypic variation, or on developing techniques of "gene therapy" that involve changing the genes of an individual person or the expression of their genes. As soon as we start thinking about the symbotype-phenotype relationship as being similar to the genotype-phenotype relationship (which is itself an example of transferring a network of verbal relations across contexts), the idea of changing a wide range of behaviors with education or brief training in cognitive reappraisal (comparable to a single gene substitution) or with a metaphor or exercise that alters the impact of negative thoughts (comparable to blocking the RNA transcription of genes) becomes plausible – and a lot easier to accomplish than changing genes. Even better, we have no need to speculate, because CBT and modern acceptance and mindfulness–based therapies are empirically supported therapeutic methods, tested by using the gold standard of evaluation: the randomized controlled trial (RCT).

We know these methods work, and in some cases, we also know why they work, in ways that make sense in light of evolutionary theory. Therapies that teach people to respond more flexibly in the presence of emotions increase healthy variation that can help them rise to the challenge of diverse problems such as chronic pain (e.g., Wicksell et al. 2009), substance use (e.g., Witkiewitz & Bowen 2010), tinnitus (e.g., Westin et al. 2011), worksite stress (Flaxman & Bond 2010), or suicidal behavior (Berking et al. 2009). Therapies that teach people simply to notice their thoughts without automatically having to obey them also induce healthy flexibility that can help people solve panic disorders (Arch et al. 2012a; 2012b), stop smoking (Gifford et al. 2011), stay out of the hospital when suffering psychotic hallucinations (Bach et al. 2012), deal with diabetes (Gregg et al. 2007), or lose weight (Lillis et al. 2009). Focusing on chosen values as the selection criteria for action can empower people to confront their anxieties (Roemer et al. 2008), face the challenges of chronic illness (Lundgren et al. 2008), or live productive lives in the face of chronic pain (Vowles & McCracken 2008). Increasing retention of new behavior by practicing skills is as applicable to experts in almost any field (Ericsson & Ward 2007) as it is to personality-disordered clients trying to establish a new way of relating to their own distress (Lindenboim et al. 2007).

A recent example of how these developments have affected evidence-based psychotherapy is provided by Arch et al. (2012a), who randomly assigned 128 patients suffering from a variety of anxiety disorders either to exposure and gold-standard cognitive change methods (i.e., CBT) or to exposure and acceptance and mindfulness methods (i.e., ACT). Following 12 weekly 1-hour sessions, patients in both conditions showed very strong and equivalent improvements. Blind clinical interviews showed nearly a 50% reduction in clinical severity post-treatment. From week 13 to the end of a 1-year follow-up, however, the ACT group experienced about 25% additional improvement, whereas the other group maintained their original gains but did not continue to improve. In both groups, improvements were best accounted for by greater psychological flexibility toward difficult thoughts (Arch et al. 2012b), but ACT improved more on general and thought-specific measures of psychological flexibility (Arch et al. 2012a; 2012b). Moderation analyses showed that ACT was more helpful with patients who were also suffering a mood disorder (Wolitzky-Taylor et al. 2012), suggesting that targeting flexibility is especially useful when dealing with problems that are more complex.

The best way to appreciate the generality of these therapeutic methods across so many domains is from an evolutionary perspective: They are broadly applicable because they help manage variation and selection. Genetic evolution and the immune system are understood in rich mechanistic detail. Learning and symbolic thought are much more poorly understood, in part because they have only recently been envisioned as evolutionary processes comparable to genetic evolution and the immune system. The fact that elements of ACT and other acceptance and mindfulness–based methods are often found in spiritual and religious practices suggests that some of these practices evolved by cultural evolution as strategies that help people transcend immediate consequences in order to achieve longer term success.

Once we appreciate that all evolutionary processes result in both dysfunctional and functional outcomes, and that even functional outcomes from an evolutionary perspective can be dysfunctional from the perspective of long-term human welfare, the need to manage the variation-and-selection processes taking place all around us to prevent the development of human problems becomes manifest. The field of prevention science is dedicated to finding science-based solutions to a diversity of real-world problems, such as how to prevent children from playing in streets, how to prevent classroom environments from becoming disruptive, how to prevent self-destructive behaviors in adolescents, how to prevent crime, depression, academic failure, and drug abuse, and how to reduce the prevalence of smoking. In short, prevention scientists have developed the same ability to manage behavioral and cultural change in everyday settings that clinical scientists are generating in therapeutic settings – and they can prove it. The Institute of Medicine's report on prevention (National Research Council & Institute of Medicine 2009b) documents numerous effective preventive interventions for all phases of human development, from the prenatal period through adolescence. Figure 1 is from that report. The figure indicates interventions that have been shown through rigorous experiments to have effects many years after implementation. This includes family-focused and school interventions, plus community and policy interventions affecting entire populations.

Embry and Biglan (2008) compiled a list of more than 50 evidence-based *kernels* (see Table 1 for a sample), which are defined as "a behavior-influence procedure shown through experimental analysis to affect a specific behavior and that is indivisible in the sense that removing any of its components would render it inert" (Embry 2004). Some interventions involve change at the individual level, using principles similar to behavioral, cognitive, and mindfulness-based therapies. Others involve change at the level of small groups and large populations, as described in sections 3.2 and 3.3 below. Lists of empirically validated methods (including some of the methods we describe in this paper) are maintained by the Substance Abuse and Mental Health Services Administration (the National Registry of Evidence-Based Programs and Practices; http://nrepp.samhsa.gov); the American Psychological Association (www.div12.org/PsychologicalTreatments/treatments.html); the What

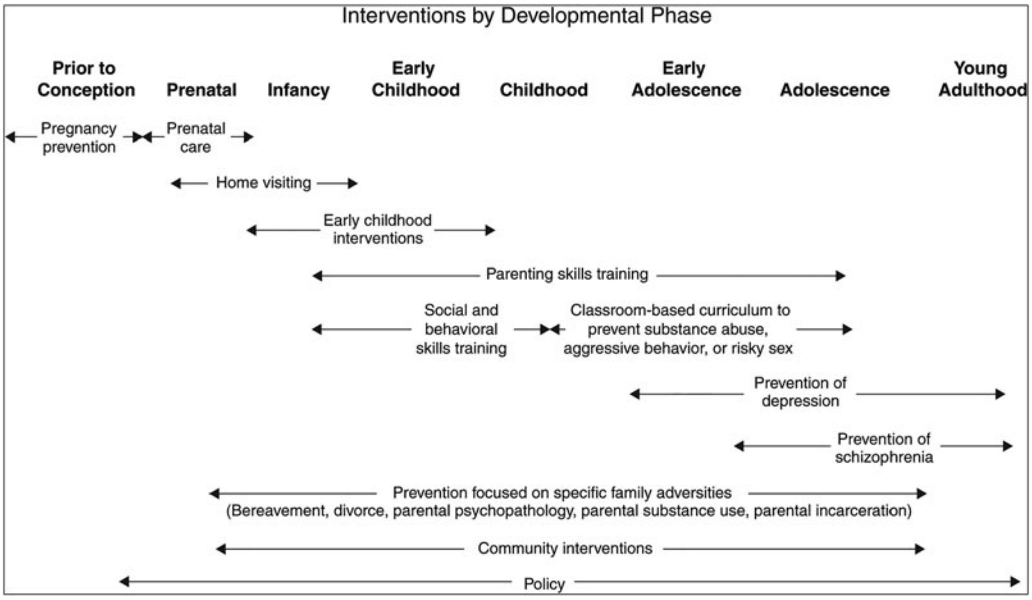

Figure 1. Interventions by developmental phase.

Table 1. *Examples of reinforcement, relational frame, physiological, and relational frame kernels for selected, indicated, and universal prevention.*

Kernel	Selected Prevention	Indicated Prevention	Universal Prevention
Prize Bowl/Mystery Motivator: Example Reinforcement Kernel Rewards of varying value are drawn contingent on targeted behaviors	Reduce alcohol, tobacco, or drug use (Petry et al. 2004; 2005; Stitzer & Petry 2006) (Petry et al. 2005; Petry et al. 2004; Stitzer & Petry, 2006) [2–4]Improve engagement in treatment goals (Petry et al. 1998; 2000)	Reduce problem behavior in high-risk children or youth (Maus 2007; Moore et al. 1994; Valum 1995)	Improve engaged learning and reduce disruptions of whole classes (Bennett 2007; DeMartini-Scully et al. 2000; Madaus et al. 2003)
Goal/Node Mapping: Example Relational Frame Kernel People receive help to analyze a problem and identify steps they can take to resolve it	Reduce relapse or recidivism rates (Collier et al. 2001; Czuchry & Dansereau 1999) Improve recovery (Pitre et al. 1998)	Prevent ATOD use rates (Collier et al. 2001; Czuchry et al. 1999; Newbern et al. 2005; Pitre et al. 1998) Improve attainment of therapeutic goals (Newbern et al. 1999)	Increase academic success or cognitive processes (Blankenship & Dansereau 2000; Czuchry & Dansereau 1998; Nesbit & Adesope 2006; O'Donnell et al. 2002)
Omega-3 fatty acid supplementation: Example Physiological Kernel	Treat depression, borderline, and/or bipolar disorder (Freeman et al. 2006) Reduce autism symptoms (Amminger et al. 2007; Richardson 2006)	Prevent emergence of psychotic episodes in prodromal adolescents (Amminger et al. 2010)	Improve children's cognitive performance and prevent behavioral disorders (Dunstan et al. 2004; 2007; Helland et al. 2003; Hibbeln et al. 2007)
Public posting: Example of Antecedent Kernel A record or chart of a desirable behavior is publicly displayed to provide recognition to either increase or decrease behaviors, such as signs showing speed of cars on a road or the number of people giving to charity	Reduce community illegal behaviors (Biglan et al. 1995; 1996; Embry & Biglan 2009)	Improve problematic behavior in therapeutic settings (Bacon-Prue et al. 1980; Lyman 1984)	Reduce impulsive or risky behaviors in general population (Houten & Marini 1980; Kehle et al. 2000) Improve academics (Gross & Shapiro 1981; Van Houten et al. 1974; 1975) Promote participation or community goods (Jackson & Mathews 1995; Stokes et al. 1978)

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Works Clearinghouse (http://ies.ed.gov/ncee/wwc/); and the Promise Neighborhoods Research Consortium (http://promiseneighborhoods.org).

As we stated at the beginning of this article, a science of positive intentional change is surprisingly close, once successful research programs in the applied behavioral sciences are related to core evolutionary theory. In this way, applied disciplines largely unknown to evolutionists can expand core evolutionary theory, and core evolutionary theory can provide a general theoretical foundation for the applied disciplines.

The principles that we have outlined for individuals are equally relevant to groups of all sizes. Groups can benefit by increasing their behavioral flexibility and reflecting on their values in selecting their practices no less than individuals can. However, an additional set of considerations are required for groups to function as "corporate units" in this sense.

3.2. Change at the level of small groups

A science of intentional change at the level of groups draws on a set of evolutionary principles that complements the principles reviewed in the previous section. Just as the principle of selection by consequences works at the level of individual behavioral and genetic selection, it is fruitful to analyze the selection of group practices by the consequences to the group (Biglan & Glenn 2013).

Some branches of the human-related sciences assume that individuals pursuing their self-interest automatically self-organize into well-functioning groups. According to the most recent edition of the *Palgrave Dictionary of Economics,* for example, "laissez faire leads to the common good [is] the first fundamental theorem of welfare economics" (Feldman 2008).

Evolutionary theory tells a different story. Natural selection is based on relative fitness; and the traits that maximize the fitness of individuals, relative to members of their own group, are typically different than the traits that maximize the fitness of the group as a whole. The conflict between individual self-interest and behaving "for the good of the group" has occupied center stage in evolutionary biology since the 1960s (Williams 1966). It is recognized by all theoretical frameworks for studying the evolution of social behavior, including multilevel selection theory, inclusive fitness theory, evolutionary game theory, and selfish gene theory. These frameworks have been argued against one another in the past; but in their most general forms, they become equivalent methods for accounting for evolutionary change in multigroup populations (Okasha 2006; Sober & Wilson 1998; Wilson 2012; Wilson & Wilson 2007).

The evolutionary dynamics of cooperation in all social species provides one body of information that can be brought to bear on real-world human groups. A second body of information is our own particular evolutionary history, resulting in our unique ability to cooperate in groups that need not be genetically related, to think symbolically, and so on, as recounted in previous sections of this article. These two bodies of information provide a framework for integrating human-related academic disciplines such as sociology, social psychology, biological and cultural anthropology, history, religious studies, economics, and political science. The field of social psychology, for example, has a long history of emphasizing norms, group identity, and other aspects of group psychology that can be readily interpreted from an evolutionary perspective (Simpson & Kenrick 1997). The unified academic study of human sociality can then help to improve the efficacy of real-world groups.

The work of Elinor Ostrom and colleagues (1990; 2005; 2010) on groups that attempt to manage common-pool resources provides an outstanding example. Prior to Ostrom's work, the received wisdom of economics was that common-pool resources inevitably result in the "tragedy of the commons," a problem of overuse to be solved only by privatization or top-down regulation. Ostrom shared the 2009 Nobel in economics for showing that *groups of people are capable of managing their common resources on their own, but only when certain conditions are met*. She did this by assembling a database of groups around the world that were attempting to manage common-pool resources. Empirically, she was able to identify eight design principles that enable groups to manage their common-pool resources successfully (Ostrom 1990):

1. *Group identity*. Members of the most successful groups have a strong sense of group identity and know the rights and obligations of membership, along with the boundaries of the resource they are managing.

2. *Proportional costs and benefits*. Having some members do all the work and others receive the benefits cannot continue over a long term. In the most successful groups, the expectation is that everyone does his or her fair share and those who go beyond the call of duty receive appropriate recognition. When leaders receive special privileges, it is because they have special responsibilities for which they are accountable.

3. *Consensus decision making*. People hate being bossed around but will work hard to implement a consensus decision – to do what *we* want, not what *they* want. In addition, the best decisions often require knowledge of local circumstances that *we* have and *they* lack, making consensus decision making doubly important.

4. *Monitoring*. Even when most members of a group mean well, the temptation to receive more than one's share of the benefits and to contribute less than one's share of the costs always exists. In addition, at least some members might try to game the system actively. If lapses and transgressions are undetectable, the group enterprise is unlikely to succeed.

5. *Graduated sanctions*. Friendly, gentle reminders are usually sufficient to keep people in solid citizen mode, but there must also be the capacity to apply stronger sanctions, such as punishment or exclusion, if transgressions continue.

6. *Fast and fair conflict resolution*. When conflicts arise, they must be resolved quickly and in a manner that the parties consider fair. This typically involves a hearing in which respected members of the group, who can be expected to be impartial, make an equitable decision.

7. *Local autonomy*. When a group is nested within a larger society, such as a farmer's association dealing with the state government, the group must have enough authority to create its own social organization and make its own decisions, as outlined in 1–6.

8. *Polycentric governance*. When groups are nested within a larger society, relationships with other groups and higher-level entities (such as state and federal regulatory agencies) must reflect the same principles outlined above for single groups, a point we will expand on in section 3.3.

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These core design principles, which were originally informed by political science and empirically derived from the performance of contemporary groups, are consistent with the basic evolutionary dynamics of cooperation in all species and the specific factors that caused humans to become such a highly cooperative species (Wilson et al. 2013; see also Boehm 2011; Gintis 2007; 2009a; Gintis et al. 2005; Henrich et al. 2004). The features provide a surprisingly practical how-to guide for any group attempting to achieve common objectives, not just for groups attempting to manage common-pool resources. For example, Wilson (2011b) and Wilson et al. (2011b) relate the core design principles to groups that attempt to create playgrounds and community spaces.

It is important to stress that human groups do not necessarily adopt the core design principles on their own, as if the features were purely instinctive. The reason that Ostrom could derive the design principles in the first place is because groups varied in their employment of them, both with failures and successes. Anyone familiar with modern-day groups can attest to the frequent absence of one or more of these design principles. Neighborhoods seldom have a strong sense of group identity (a violation of design principle No. 1). Groups frequently consist of a few beleaguered volunteers who do most of the work (a violation of design principle No. 2). Discipline in schools is frequently neither fast nor based on a procedure that the students perceive as fair (a violation of design principle No. 6). Why are these design principles not more purely instinctive? We could ask the same question of other basic biological adaptations: How can the cultural practice of bottle-feeding infants become so widely established, for example, when lactation has been the signature mammalian adaptation for nearly 200 million years? Part of the answer is that for virtually all of that time, female mammals had no alternative to breastfeeding and therefore no reason to evolve a preference for it compared with an alternative. Similarly, throughout their evolutionary history, humans had no alternative to living in small social groups and therefore did not necessarily evolve the instincts for creating them when alternatives became available.

It is also important to distinguish between the core design principles and their implementation in any particular group. In genetic evolution, a highly designed adaptation such as a wing can be implemented in different ways, such as an insect's, a bird's, or a bat's. The one-to-many relationship between a design principle and its implementations can be demonstrated in the laboratory. In one classic experiment, the same phenotypic trait of wing vein length was selected for in a number of isolated laboratory populations of drosophila (Cohan 1984). There was a phenotypic response to selection in each population, but the specific genes that evolved differed among the populations. The one-to-many relationship also exists for antibody formation: People evolve different antibodies in response to the same disease because more than one antibody can successfully bind to a given antigen; which one becomes amplified is largely a matter of chance.

The same one-to-many relationship exists for the cultural evolution of symbotypes. Ostrom's database of attempts to manage common-pool resources contains groups that were faced with an identical problem—attempts to manage irrigation systems by different Nepalese farmer associations, for example (Ostrom 1990). The groups arrived at different implementations of the various design principles (e.g., of how to monitor, design principle No. 4), just as the different populations of drosophila evolved different genes for wing vein length. The groups adapted to their particular environments through an open-ended process of cultural evolution, not by the expression of genetically evolved modules triggered by the environment. The need for local groups to discover the implementations that work best for them is one reason cookie-cutter policy solutions do not work and groups need local autonomy (design principle No. 7).

The core design principles that enable groups to function as adaptive units are so general that they have been independently derived on other "islands" of the applied behavioral science "archipelago," without any awareness of Ostrom or core evolutionary theory. We will focus on the field of education, where a number of programs have converged on the core design principles and appear to work exceptionally well, compared with the conventional American classroom environment.

An alternative school called the Sudbury Valley School (preK–12; www.sudval.org) embodies most of Ostrom's design principles and functions exceptionally well. The governance of the school is democratic, with students taking part in all of the major decisions, including the hiring and firing of faculty. Norms of good behavior are agreed on by consensus, monitoring is efficient, and conflicts are resolved by a judicial committee on which all students and staff members are expected to take turns serving. Within this strong democratic and normative environment, students have complete freedom to learn what they want, without any formal courses or examinations. The adult staff facilitates the students' self-motivated learning and provides explicit instruction when asked.

Peter Gray, who wrote the first introductory psychology textbook centered on evolution and whose son attended the Sudbury Valley School, has interpreted its practices from an evolutionary perspective and evaluated its performance by tracking its alumni (Gray & Chanoff 1986; Gray & Feldman 2004). Gray (2009; 2013) notes that in hunter-gatherer societies and many traditional cultures, learning and teaching take place largely without explicit instruction. Instead, children spend most of their time in mixed-age groups. The older children are strongly motivated to become adult, and the younger children are strongly motivated to become like the older children. Learning the skills and roles of the society takes place in the context of self-motivated practice and play. It is an open question whether the skills of modern society can be learned in this fashion. Reading, writing, and mathematics were invented only a few thousand years ago and might not be learnable with the same ease as hunting, gathering, and warfare (Geary 2004; 2011). On the other hand, Gray argues that all cultures have bodies of knowledge comparable to reading, writing, and mathematics. Is there really such a difference between an American boy learning his multiplication tables and an Australian aborigine boy learning his songlines (Chatwin 1988)? When evaluated in terms of the success of its alumni, the Sudbury Valley School compares very favorably with conventional schools, at a fraction of the cost of a public school education and even less compared with an elite private school education.

Conventional schools can also implement the design principles more than they customarily do. A grade-school teacher invented a set of practices called "The Good Behavior Game (GBG) (www.GoodBehaviorGame.org)," which prevention scientists have refined and assessed over a period of decades (reviewed by Embry 2002). The game, as played in several thousand classrooms today in the United States and Canada under is modern name of PAX GBG, has most, if not all, of the core design principles identified by Ostrom for common-pool resource groups. The GBG begins by establishing norms of good behavior by consensus. Even first-graders are able to list the appropriate dos and don'ts: The important fact is that the lists are *theirs* and not lists arbitrarily imposed on the children by the teacher and school. Once the norms of good behavior have been established and suitably displayed in the classroom, the class breaks up into groups that compete to be good while doing their schoolwork. Groups that manage to avoid a certain number of misbehaviors receive a small reward, such as picking from a prize bowl of activities such as singing a song or dancing for a minute. At first, the children play the game for brief periods, with immediate rewards. Gradually the game lengthens and occurs without any previous announcement. The rewards gradually are received later – the end of the day or week – until the norms of good behavior become the culture of the classroom.

Competing as groups is highly motivating and causes peer pressure within each group to reward good rather than deviant behavior. Potentially destructive aspects of between-group competition are managed by periodically shuffling the composition of the groups. These and other elements of the GBG are now conceptualized as "kernels," as we described earlier (Embry 2002; Embry & Biglan 2008).

GBG have a transformative effect on classroom behavior over the short term, as Figure 2 shows for 186 classrooms in eight diverse Title I school districts in California, Georgia, Illinois, Michigan, Ohio, and Texas using real-world implementation of the widely used commercially available version, PAX Good Behavior Game over the span of 3 to 4 months. Each district had multiply trained implementation mentors who helped collect both observational data on unwanted, contextual behaviors (e.g., disturbing, disruptive, destructive, inattentive, or unengaged) at group level, coding every minute interval for 15 minute samples taken on multiple occasions. These unwanted behaviors happen at a far higher frequency than most readers would imagine, but which teachers and students commonly experience. Before any program or training, baseline observations across the United States tend to average 125 to 150 per 15 minutes. The mentors and others were and are trained to do these observations, using tools and practices commonly applied to behavioral interventions in schools, for which there are even apps for web-enabled tablets and phones. The average baseline frequency for the 186 classrooms was 135 per 15 minutes, which then fell to an average of 30 per 15 minutes have 30 to 45 days of exposure and practice the PAX Good Behavior Game. In epidemiological studies, high exposure to problematic student behaviors predicts increased frequency of lifetime mental, emotional, and behavioral disorders (Kellam et al. 1991).

While these rapid reductions in unwanted behaviors are impressive to bedraggled teachers and principals, this experimentally induced change in self-regulation by youngsters in varied peer-group contexts for even just one year can have long-term effects that extend into adulthood. In longitudinal studies that began in the 1980s in the Baltimore City School District, the GBG was implemented on multiple occasions (Dolan et al. 1993; Ialongo et al. 1999), in the first grade, or in first and second grades, for some classrooms but not others, in a randomized controlled, comparative effectiveness design. No intervention took place after the second grade. By the end of the first or second grade, children showed fewer behavioral problems, including bullying and improved their reading scores. By the sixth grade, students from the GBG classrooms were less likely to be diagnosed with conduct disorder, to have been suspended from school, or to be judged in need of mental health services; parents were also more reinforcing and less rejecting of their children. During grades six through eight, the GBG students were less likely to use tobacco or hard drugs. In high school, they scored higher on standardized achievement tests,

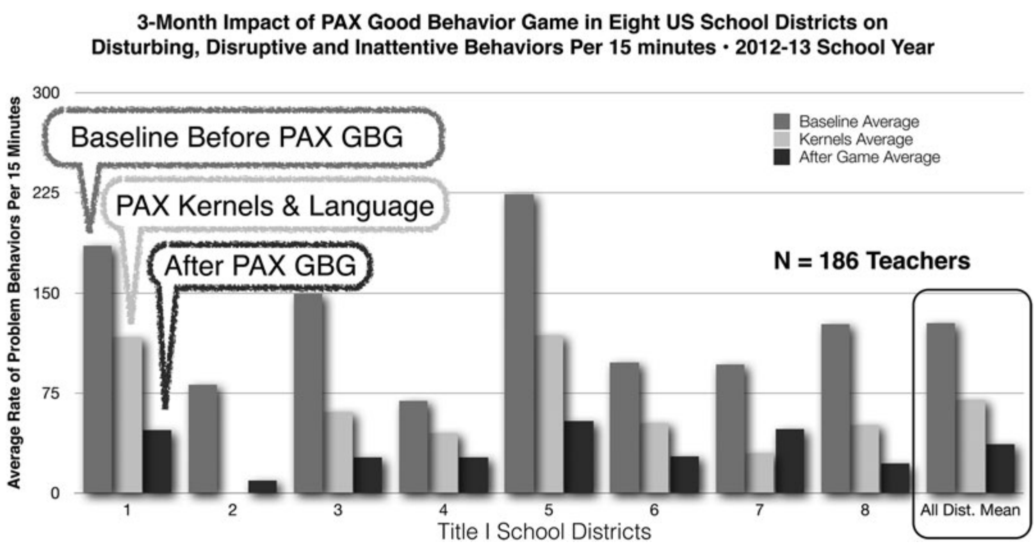

Figure 2. Good Behavior Game outcomes for 43 classrooms.

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had a greater chance of graduating and attending college, and had a reduced need for special education services. In college, they had a reduced risk for suicidal ideation, lower rates of antisocial personality disorder, and lower rates of violent and criminal behavior. The game was especially effective at achieving these outcomes for boys (Bradshaw et al. 2009; Kellam et al. 2008). The experience with the game also increased the age of first vaginal intercourse as well as reduced risky sexual behavior (Kellam et al. 2012). Most recently, the early exposure to the Good Behavior Game trigger protective expression of Brain Derived Neurotropic Factor gene SNPs associated with reduced lifetime risk of these problems at age 19 to 21 (Musci et al. 2013).

These lifelong positive outcomes illustrate the cumulative effect that cooperative behavior can have over the course of child development (Belsky 2010; Del Giudice et al. 2011; Ellis & Bjorklund 2005; Ellis et al. 2012; Moffitt et al. 2011). The benefits of cooperation are like money in the bank earning compound interest. Children raised in cooperative social environments have multiple assets, and those raised in uncooperative environments have multiple liabilities. Rather than treating these liabilities as isolated factors, the single most important prevention measure is to create social environments in which cooperation succeeds as an evolutionary strategy (Biglan & Cody 2013; Biglan et al. 2004). This objective can be accomplished surprisingly easily, once the design principles that enable groups to function as cooperative units have been identified, as the GBG attests.

Ostrum's principles, as illustrated by GBG in a classroom are dynamic, working across virtually every culture (Nolan et al. 2014). They are scalable rapidly, which is necessary for intentional change. For example, the Healthy Child Manitoba Office has implemented PAX GBG in most first-grade classrooms in the province, even using a randomized trial with measurable results across the province's diverse population in a semester (http://www.gov.mb.ca/healthychild/pax/). The U.S. Substance Abuse and Mental Health Services Administration likewise has demonstrated that it can be rapidly scaled up across the United States in very diverse school districts (http://paxgoodbehaviorgame.promoteprevent.org).

Interventions that start during the adolescent stage of the life cycle are inherently more challenging than early childhood interventions, because the life challenges, personal habits, and social networks of at-risk adolescents are often firmly entrenched. Interventions that involve working with at-risk adolescents in groups often backfire because the positive reinforcement of deviant behavior within the peer group outweighs the coaching that the adults are trying to provide. This well-documented phenomenon, called "deviance training" (Dishion et al. 1996), illustrates how well-meaning efforts to manage behavioral change that seem reasonable on the surface can nevertheless fail for reasons that can be easily understood from an evolutionary perspective.

The difficulty of working with adolescent peer groups extends to classroom interventions. The Promise Academy, a school associated with the highly publicized Harlem Children's Zone, started in 2004 with a first-grade and a sixth-grade class (Tough 2008). Intensive efforts to improve academic performance, based on the same educational principles in both grades, succeeded for the first-graders but failed for the sixth-graders. The Promise Academy has since improved its success with the older students, but only with an intensive effort that includes an extended day, an extended school year, meal and health-care programs, and more (Whitehurst & Croft 2010). Other successful schools for at-risk teenagers are similarly intensive (e.g., Angrist et al. 2010; Henig 2008).

These discouraging results can be interpreted in two ways. First, it is possible that at-risk adolescents have become difficult to change as *individuals*, because of developmental mechanisms that are less flexible later in life than in early childhood. For example, consider the cost and intensity of adolescent treatment strategies compared with early prevention strategies such as the Good Behavior Game (Drake et al. 2009). Second, adolescents might have become more difficult to change as *groups*, because peer groups play a larger role in their lives than they do in young children's lives. The latter interpretation implies that at-risk adolescents might be capable of transformational change given an appropriately designed social environment that the adolescent peer group accepts.

Strategies that have paid careful attention to the science of behavioral change show remarkable promise. The Morningside Academy in Seattle uses many of the procedures from the Good Behavior Game and related behavior analysis studies for students in grades K–10, with exceptional success (Johnson 1997). The Juniper Gardens projects in Kansas City, Kansas, show robust longitudinal academic results using peer-to-peer tutoring within classrooms (Greenwood 1991a; 1991b), which also embraces the core principles of Ostrom's key findings. A natural randomized control study of London high schools conducted by Rutter and colleagues (1979) reveals that improvements in academic success, behavior, delinquency, and attendance came about through strategies that hauntingly echo Ostrom's observations. Also, the Good Behavior Game works in 12th-grade classrooms (Kleinman & Saigh 2011).

A new program for at-risk 9th- and 10th-graders called the Regents Academy, which is the first to be designed explicitly from an evolutionary perspective, achieved impressive results during its first year (Wilson et al. 2011a). The evolutionary principles used to design the Regents Academy include the core design principles, the need for learning to occur in a safe and secure social environment, and the need for long-term learning goals to be rewarding also over the short term. Not only did the Regents Academy students greatly outperform their comparison group in a randomized controlled design, they performed on a par with the average high school student on the state-mandated exams. At least according to this metric, a single year erased years of academic deficits. The Regents Academy operates during the normal school day and year; similar programs are feasible for most public school districts.

This kind of improvement at the adolescent stage of the life cycle might seem too good to be true, but no more so than the effective therapeutic interventions for adults at the individual level reviewed in section 3.1. Once we appreciate that people of all ages are adapting to their immediate environments, it becomes clear that the wrong environmental intervention will make change appear difficult or impossible, whereas the right one will make change appear effortless. Contemporary evolutionary science can help us find the right environmental interventions better than we could before.

The core design principles that Ostrom derived for common-pool resource groups can be generalized from an evolutionary perspective and are equally relevant to other kinds of groups (Wilson et al. 2013). We have focused on classroom groups but could have focused on any other kind of group (e.g., businesses, neighborhoods, voluntary associations). The core design principles are scale-independent and therefore apply similarly to large groups such as business corporations and nations; however, functional organization at the level of large groups requires an additional set of considerations, as we will outline in the next section.

Our discussion of small groups also highlights the value of selecting outcomes at the group level – the cultural equivalent of group selection in genetic evolution. For example, in the Good Behavior Game, a group's reward is contingent on the interlocking behavior of the group's members. In Ostrom's cases, the set of principles (her design features) that the group follows led to an outcome that rewarded group members for all the things they did to produce that outcome. At the group level, an outcome such as a bigger harvest maintains the interlocking behavior of the group members and (if following design principle No. 2) leads to rewards for all group members. This is what Glenn (2004) has called a "meta-contingency" – where a group action is selected by a consequence. The principle encourages us to look for additional situations where we can enhance the evolution of cooperative behavior by making outcomes contingent on the cooperative production of groups.

3.3. Change at the level of large populations

Changing behavioral and cultural practices at a large spatial and temporal scale is inherently more challenging than for individuals and small groups – but still possible with a sufficiently clear vision of what needs to be done. An important point to keep in mind is that our genetically evolved adaptations for cooperation, including the cultural transmission of learned behavior, evolved in the context of small face-to-face groups and might not necessarily work well in the context of larger groups. A village or township might seem to constitute itself naturally, as the great social theorist Alexis de Tocqueville observed (1835/1990), but an old nation such as France or the new American democratic experiment is another matter. For society to function at these larger scales, new products of cultural evolution are needed to interface with old products of genetic evolution (Johnson et al. 2013; Mullins et al. 2013; Richerson & Boyd 2005; Stoelhorst & Richerson 2013; Witt & Schwesinger 2013).

The growing scale of human society over the course of human history is increasingly being studied from a multilevel biocultural evolutionary perspective. According to Turchin (2003; 2005), empires tend to originate in geographical regions chronically at war, which acts as a crucible for the cultural evolution of exceptionally cooperative societies. The most cooperative expand into empires, but then cultural evolution *within* the empires favors practices that eventually lead to their collapse. New empires almost invariably form at the boundaries of old empires, whose centers become "black holes" for cooperation at a large scale (see also Putnam 1992).

In this halting fashion, with much carnage along the way, modern human society manages to function at a remarkably large scale. However, there is enormous room for improvement, especially with respect to global problems such as climate change and the worldwide economy. There will be no between-planet selection, so addressing these problems will require another kind of selection – the intentional selection of policies with large-scale and long-term human welfare in mind. Devising such enlightened policies will require a sophisticated knowledge of evolution. The challenges will be daunting, but at least in principle, the right kind of environmental intervention could cause the difficult to become easy, as is already beginning at the level of individuals and small groups.

We will describe two interventions from the field of prevention science that successfully changed cultural practices at the level of counties, states, and nations. The first intervention reduced the very specific practice of convenience store clerks in Wyoming and Wisconsin illegally selling cigarettes to minors. The second intervention employs a population approach to improving parenting practices, which has been assessed in RCTs at the county level and is in the process of being implemented around the world. These examples fall short of addressing the gravest problems afflicting our planet, but they still show how evolutionary science can be used to accomplish intentional positive change above the level of individuals and small groups.

The United States federal government monitors rates of illegal tobacco sales to minors by employing minors to enter convenience stores and attempt to buy cigarettes. States that exceed a certain level of illegal sales stand to lose millions of dollars of federal block grants. Wyoming and Wisconsin were in this situation when they engaged the services of Embry to find a solution. Biglan had already designed and validated an intervention at the level of whole towns in Oregon (Biglan et al. 1995; 1996), which Embry expanded to the statewide scale. The intervention involved the following components:

1. *Establishing a meaningful consensus that selling tobacco to minors is wrong*. Consensus in small groups tends to establish norms easily, but more work is required at the level of a whole state. Embry and Biglan (2009) accomplished their objective with a billboard marketing campaign, endorsements by well-known and respected individuals, and by communicating with convenience store owners, who in turn communicated with their clerks. Signs also went up in convenience stores as a visible reminder of the norm.

2. *A "reward and reminder" procedure for reinforcing clerks' behavior*. Embry and Biglan employed their own team of minors to enter convenience stores and attempt to buy cigarettes. Clerks who upheld the law received positive reinforcement with praise, coupons donated by local businesses, and even articles in the local press. Clerks who failed to check for ID received gentle reminders that they had violated the law. The principle of abundant praise coupled with mild punishment that escalates only when necessary tends to arise spontaneously in small groups but requires more work to establish at the level of a whole state.

3. *A managed variation-and-selection procedure to discover best practices*. A competition was held among the convenience store clerks for the best way to respond to a minor trying to buy tobacco. The winning entries were

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printed on cards that clerks could simply hand to the customers. One card read,

> I don't think so. Folks like me make about $4.70 an hour. If I sold tobacco to you, which is illegal, I could get fined $500. I'd have to work 107 hours to pay for that. That's about 2½ weeks full-time. How many shifts will you work to help me?

Once again, best practices tend to be identified and copied spontaneously in small groups, but more work is required to identify and copy them on a larger scale.

In short, the mechanisms that cause small groups to "naturally constitute themselves," as Tocqueville (1835/1990) put it, do not necessarily work on a larger scale, *but they can be made to work* with a sufficiently clear vision of what to do. The intervention succeeded at reducing cigarette sales to minors at a statewide scale, as Figure 3 shows. Moreover, this resulted in a lower incidence of smoking by minors, according to independently collected survey data.

Tallying the financial costs and benefits, the intervention was highly cost effective for the states, compared with the potential federal penalty of millions of dollars in lost block grants. The convenience store owners lost millions of dollars of revenue, but they willingly did so to uphold a norm established by consensus and to maintain their reputations as solid citizens. The convenience store clerks received short-term rewards for good behavior and benefitted over the long term by not having to deal as often with a tense situation. Of course, the main benefit was to reduce the incidence of cigarette smoking, saving lives over the long term; but the long-term benefits could not be achieved without a system for reinforcing the appropriate behaviors over the short term. This general principle applies as forcefully to global problems such as climate change and the worldwide economy as to a statewide problem such as illegally selling cigarettes to minors.

In the second example, prevention scientists in Australia (Sanders et al. 2002) developed a population-level approach to improving parenting practices called the Triple P – Positive Parenting Program (See www.triplep.net). Child abuse is a severe societal problem. Five children die each day in the United States due to child abuse. Despite growing efforts to deal with the problem from a variety of perspectives, the rate per day of deaths from child maltreatment in America has increased 60% during the past 12 years (www.childhelp.org/pages/statistics, accessed June 8, 2013). Extreme child abuse is the tip of an iceberg of parenting practices that harm not just the

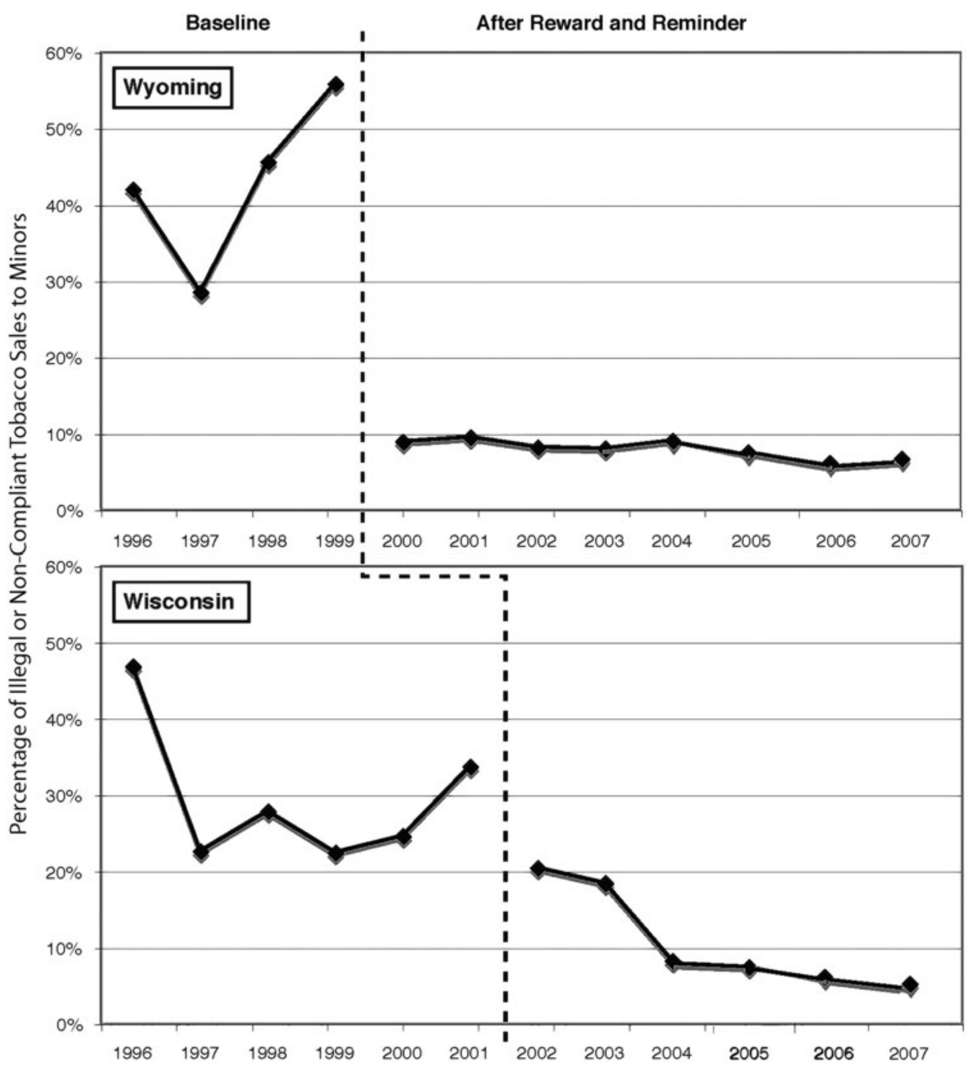

Figure 3. Wyoming's and Wisconsin's Reward & Reminder outcomes.

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short-term but the long-term welfare of children, resulting in depression, academic failure, teenage pregnancy, obesity, substance abuse, and crime – generically called Adverse Childhood Experiences, made famous by the studies of middle-class persons enrolled in Kaiser Permanente (Anda et al. 2008; 2010). If we can solve some of these problems by improving parenting practices, we can substantially improve the quality of human life on our planet.

How can we explain the paradox of parents who harm their children? Conventional evolutionary theory provides part of the answer by showing that the interests of parents only partially overlap with the interests of their children. Humans evolved to maximize their lifetime reproductive success, which can involve parents withholding support from particular children (Trivers 1972). Men are especially likely to invest in mating effort rather than parental effort. Relations between stepparents and stepchildren are likely to be especially problematic, because there is no genetic interest at all (Daly & Wilson 1988; 2001; but see Buller 2005).

These insights are valid as far as they go, but they also provide an outstanding example of how conventional evolutionary theory has failed to include learning and symbolic systems as evolutionary processes in their own right. More than 40 years of research from within the behavioral tradition shows how high levels of coercive interactions can be selected for within families in a tragic coevolutionary race to the bottom (Forgatch et al. 2008; Patterson 1982; Reid et al. 2002). Each family member learns that if others are behaving in an unpleasant manner (e.g., criticizing, teasing, attacking), then escalating his or her own aversive behavior will frequently cause the others to stop momentarily. The process has been labeled "negative reinforcement" because the reinforcer is the removal or cessation of an aversive event. A parent's abusive behavior is shaped by the effect of getting the child to stop doing things that annoy the parent or to do things that the parent demands. A child's resistance is shaped by the effect of reducing the parent's demeaning or aversive behavior. In short, both the parent and the child behave adaptively in an extremely local sense, even though the results are disastrous for both over the long term. Left unmanaged, evolution often takes us where we do not want to go. A similar coercive process has been shown to underpin the development and maintenance of depressive behavior in families (Biglan et al. 1988), for example.

More than 50 experimental evaluations demonstrate that parents locked in a negative coevolutionary spiral with their children can learn to adopt a positive coevolutionary spiral that involves providing high levels of positive reinforcement for cooperative behavior and mild, consistent negative consequences for uncooperative behavior (e.g., de Graaf et al. 2008; Nowak & Heinrichs 2008; Patterson et al. 2004). The techniques of this "symbotype replacement therapy" can work for any family, even those with stepparents and few material resources. Most successful interventions work for single families or small groups. The novelty of Triple P is that its multilevel approach can change parenting in large populations. Level 1 involves using mass media to reach parents with information and advice about effective parenting. Level 2 provides advice to parents from child care providers and human service workers who frequently contact the parents, in the form of brief individual consultations or 90-minute group seminars. Level 3 provides more-intensive training in skills for dealing with a circumscribed set of child problems. Level 4 provides a series of sessions designed to help parents develop skills for dealing with a wider range of issues. Finally, Level 5 provides help with additional issues that affect parenting, such as parental depression and marital discord.

Prinz, Sanders, and colleagues (2009) tested Triple P in 18 South Carolina counties and showed for the first time that it is possible to prevent child abuse in entire populations. They randomized nine counties to receive the intervention and nine to receive no intervention. They trained 649 service providers in the intervention counties to work with parents.

Two years after the start of the study, the counties that did not receive the program showed large increases in substantiated child abuse, out-of-home placements due to child abuse problems, and increases in hospital-reported child injuries. These same increases showed up in the 28 South Carolina counties that did not participate in the study. However, the counties that got Triple P performed significantly better on all three measures: Fewer children were abused, as indicated by both substantiated maltreatment and hospital reports of injuries due to abuse, and fewer children went into foster care. Prinz et al. (2009) point out that for a community with 100,000 children, the differences translate into 688 fewer cases of child abuse, 240 fewer out-of-home placements, and 60 fewer children needing hospitalization. Using very conservative estimates of cost-effectiveness, the dollars saved by implementing Triple P greatly outweigh its implementation cost. Triple P is now being implemented in more than 20 nations worldwide, using a dissemination strategy as novel as its implementation strategy. It rigorously evaluates its own practices and oversees the training of those who implement the program in any particular locality. It provides a model of intentional science-based change at a worldwide scale.

In addition to the two examples described in detail in this section, numerous other interventions have achieved effects in whole populations. Table 2 lists seven community-wide interventions that have been evaluated in randomized trials and shown to affect the incidence or prevalence of one or more youth problems, including tobacco, alcohol, or other drug use and delinquency. Table 3 lists policies targeting alcohol and tobacco use that have been shown to affect population rates of consumption or problems related to consumption. One example is increased taxation on alcohol, a policy that has been shown to reduce alcohol consumption, alcohol-related morbidity and mortality, traffic accident deaths, sexually transmitted disease, violence, and crime. The Promise Neighborhoods Research Consortium website lists and describes many other well-evaluated policies (http://promiseneighborhoods.org/policies/).

4. General discussion

This article has two main purposes. The first is to sketch a basic science of intentional change centered on evolution. The second is to highlight effective examples of intentional change from the applied behavioral sciences, which demonstrate that we are closer to achieving a science of intentional change than one might think.

Table 2. *Community interventions affecting entire populations.*

Community Interventions Evaluated in Randomized Trials			
Project (and Target)	Intervention	Outcomes	References
Project Northland (adolescent alcohol use)	Community organizing, youth action teams, print media regarding norms about underage drinking, parent education and involvement, classroom-based social-behavioral curricula	Reduced adolescent alcohol use and improved attitudes and normative beliefs about its use	Perry et al. 1996; 2000; 2002
Communities Mobilizing for Change on Alcohol (CMCA) (adolescent alcohol use)	Community policy and norm changes through the actions of community leadership teams	Lower levels of alcohol sales to underage youth; fewer purchase attempts by 18- to 20-year-olds; lower rates of alcohol consumption among young adults; fewer arrests for DUI	Wagenaar et al. 2000
Project SixTeen (adolescent tobacco use)	Classroom-based prevention curricula; media advocacy, youth anti-tobacco activities; family communication about tobacco use; rewards to clerks for not selling to youth	Reduced prevalence of youth smoking	Biglan et al. 2000
Midwestern Prevention Project (adolescent tobacco, alcohol, and other drug use)	Classroom curriculum; parent training; education of community leaders; media campaign focusing on prevention policies and practices	Reductions in tobacco, alcohol, and marijuana use	Pentz et al. 1989a; 1989b; 1989c
Communities That Care (multiple youth problems: substance use, school dropout, violence, pregnancy)	Creation of coalitions of community leaders trained in assessing risk and protective factors; implementation of relevant, empirically supported programs	Reduction in targeted risk factors and initiation of delinquency	Hawkins et al. 2008
Aban Aya Youth Project (multiple youth problems: violence, substance abuse, unsafe sex among early-adolescent African Americans)	Social skills curricula, focused social competence or social competency curricula, plus inservice training of teachers and staff; local task force to develop policies, run schoolwide fairs, seek funds for the school, and lead field trips for parents and children; parent training workshops	Reductions in violent behavior, provoking behavior, school delinquency, drug use, and recent sexual intercourse	Flay et al. 2004
PROSPER (multiple youth problems)	Implementation of a selected parenting program (Strengthening Families) and one of two school-based drug abuse prevention curricula (Life Skills Training or Project ALERT)	Reductions in cigarette, alcohol, marijuana, and inhalant use	Spoth et al. 2007a; 2007b

Accomplishing the first goal requires resolving the paradox of elaborate genetic innateness and elaborate open-ended flexibility. For decades, evolution has been marginalized in the human behavioral sciences as a process that can explain the rest of life, our physical bodies, and a few basic urges, but has little to say about our rich behavioral and cultural diversity. Evolutionists, in turn, have concentrated almost entirely on genetic evolution, which includes the concept of phenotypic plasticity, but which did not highlight learning and symbolic thought as evolutionary processes until very recently (Jablonka & Lamb 2006).

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Table 3. *Policies affecting entire populations*

Alcohol Use Policies Evaluated in Randomized Trials		
Policy	Outcomes	References
Increasing the tax on alcoholic beverages	Reduction in alcohol consumption; alcohol-related morbidity and mortality; traffic crash deaths; sexually transmitted disease; violence; and crime	Campbell et al. 2009 Wagenaar et al. 2009; 2010
Limiting the density of alcohol outlets	Large and significant reductions in alcohol consumption and interpersonal violence	Campbell et al. 2009
Reducing the hours of alcohol sales	Reductions in alcohol consumption and related harm (e.g., violence)	Stockwell & Chikritzhs 2009 Popova et al. 2009

Tobacco Use Policies Evaluated in Randomized Trials		
Strategy	Outcomes	References
Increasing the tax on tobacco products	Reduction in youth initiation of smoking and adult rates of consumption	Chaloupka & Grossman 1996 Chaloupka & Pacula 1998 Lewit et al. 1997
Restricting smoking indoors	Reduction in smoking rates	Levy et al. 2004
Increasing access to smoking cessation treatment and telephone support lines	Increased quit rates	Levy et al. 2004

The 1980s and 1990s witnessed a surge of interest in evolution in relation to human affairs. Terms such as *evolutionary psychology* and *evolutionary anthropology* signified that entire disciplines were being rethought from a modern evolutionary perspective. Much progress was made, but a particular configuration of ideas that became associated with evolutionary psychology (EP) set itself apart from the so-called standard social science model (SSSM), which includes the very disciplines that have been successful in developing the beginnings of a science of intentional behavior change. The polarized distinction between EP and the SSSM made elaborate genetic innateness seem even more difficult than before to reconcile with an elaborate capacity for open-ended change.

Every discipline has experiences and narratives about it that are difficult to overcome and therefore limit the potential for future scientific change. In this context, the ACT principles of stepping back from our usual narratives, increasing psychological flexibility, and mindfully working toward important life goals are as relevant to advancing scientific progress as to making healthy individual changes. Scientists and scholars of all stripes must distance themselves from the repertoire-narrowing narratives of their particular disciplines, become open to the possibility of new interconnections and cooperative relations, and work toward a unified science of intentional change (Johnson 2010).

A step in this direction is to achieve a consensus that the paradox of elaborate genetic innateness and an elaborate capacity for open-ended change can be reconciled through the concept of Darwin machines. Variation, selection, and heredity comprise an open-ended process capable of adapting organisms to their current environments according to the selection criteria. An evolutionary process built by genetic evolution must be elaborately innate for variation and selection to take place in a way that leads to genetically adaptive outcomes, on average. The immune system is an outstanding example of a Darwin machine that is *both* elaborately flexible and elaborately innate, providing a guide for how to study the human capacity for behavioral and cultural change.

An important implication of Darwin machines is that a capacity for change requires certain forms of stability and homeostasis. For all inheritance systems, a complex system of interlocking processes is required to create variation, select according to certain criteria, and faithfully replicate the traits that have been selected. If this system breaks down, then so does the evolutionary process. The Regents Academy described in section 3.2 provides an example. Despite its success during the first year, staff turnover threatened its continuity. New staff had to be oriented to the program, requiring procedures that were different from the program itself. Positive intentional change cannot occur unless the "machine" part of the Darwin machine is faithfully maintained.

A second step toward a unified science of intentional change is to realize how much each current discipline has to contribute to the unification. Evolutionists do not have an already perfected framework to offer other disciplines. They have concentrated almost entirely on genetic evolution and paid scant attention to evolutionary processes that rely on other mechanisms of inheritance. The dominant heuristic in narrow-school EP, when trying to explain a particular trait, is to assume that it is genetically determined, ask how it evolved by genetic evolution in

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the distant past, and then ask how it functions in the current environment. For traits associated with parental neglect, the heuristic has led to valid insights concerning the importance of such things as genetic relatedness or availability of resources. Yet it missed the fast-paced process of selection by consequences, resulting in behavioral strategies in parents and offspring that are adaptive in the context of the immediate family environment but profoundly maladaptive over the long term. These are the practices that are most amenable to change after identifying and understanding the contingencies (Biglan 2003). Evolutionists therefore have much to learn from branches of the human behavioral sciences where learning as a variation-and-selection process has occupied center stage for decades.

The concept of human symbolic thought as a Darwin machine is especially new for nearly all disciplines. Only a handful of evolutionists seriously theorize about culture as an evolutionary process and the role of symbolic thought in human cultural evolution. Within the human behavioral sciences and humanities, the disciplines that most appreciate social constructivism also tend to be most avoidant of evolution; yet, turned another way, social constructionists are making needed points about the importance of symbolic evolution.

The fact that symbolic systems, like genotypes and antibodies, exist in nearly infinite variety and that a symbotype-phenotype relationship exists that is similar to the genotype-phenotype relationship is profound in its implications for a science of intentional change. It would be hard to overestimate the degree to which our symbotypes organize our perception and behavior. Tooby and Cosmides (1992) hint at this when they write, "Conceptual systems, models, and theories function as organs of perception…as Einstein remarked, 'it is the theory which decides what we can observe.'" They made this observation to emphasize the transformative nature of their vision of EP – yet that vision marginalizes the concept of cultural constructions as organs of perception! It was Durkheim, not Tooby and Cosmides, who wrote, "In all its aspects and at every moment in history, social life is only possible thanks to a vast symbolism" (1915, p. 264).

A believer in Jesus sees the world differently than a follower of Ayn Rand does, and *seeing* differently results in *acting* differently. This is true not only for religions and political ideologies but also for scientific theories, as Tooby and Cosmides correctly note. Consider the possibility that severe personal and societal dysfunctions, which have defied solutions for decades, can sometimes be relieved by interventions that require just a handful of hours (e.g., Bach et al. 2012; 2013, for struggles with hallucinations or delusions; or Walton & Cohen 2011 for feelings of belonging in minority college students). Against the background of an evolutionary theory confined to genetic evolution, this claim seems too good to be true. Against the background of an evolutionary approach that actively manages a symbotype-phenotype relationship, the possibility begins to make more sense. If we expect artificial selection, genetic engineering, and gene therapy to provide new solutions, then why not expect the same from their counterparts in learning and symbolic systems? In this fashion, expanding core evolutionary theory beyond genetic evolution results in new possibilities for action that were previously invisible. Indeed, as the behavioral and symbolic impact on epigenetic processes becomes better understood, this expansion promises to alter our perspective on the role of genetic evolution itself.

This new sense of theoretical possibility is interesting as far as it goes, but becomes far more interesting when substantiated by examples from the applied behavioral sciences. The first author of this paper (DSW) had never heard of the field of prevention science until the third author (AB) contacted him in 2007 (recounted in Wilson 2011c). DSW was amazed to discover examples of intentional cultural change, validated by the most rigorous experimental methods. He came to regard prevention science as "applied cultural evolution" and started to ask his colleagues in evolution, psychology, and other basic scientific disciplines whether they had ever heard of the field of prevention science. Very few had. It was like a far-off island in an archipelago of disciplines with little communication among islands. Prevention science was even little known among other applied scientific disciplines.

Just as evolutionary biologists are accustomed to studying all traits in all species, a science of intentional change centered on evolution can be applied to any real-world behavioral or cultural issue. Current theories and perspectives that inform public policies are an archipelago in their own right. Each "island" (e.g., rational choice theory in economics) is a symbolic system that organizes perception, making some actions appear reasonable, some appear inadvisable, and others invisible altogether. The policies are the phenotypes that emerge from the symbotypes. The policies are winnowed by selection to a degree – it is not as if we are doing *everything* wrong – but there is tremendous room for improvement by using an expanded evolutionary theory to organize our perception and the most rigorous experimental methods to evaluate the consequences of our actions.

In our efforts to establish a unified basic science of intentional change, we are confronted again and again with the same question from colleagues who are open-minded about evolution but have not seriously considered it in relation to their discipline: "What is the added value of a more comprehensive evolutionary perspective that I and my colleagues have not already achieved without such a perspective?" We acknowledge that interpreting past research from an evolutionary perspective cannot entirely answer this question and that the best answer will come from future research and policy formulation. The Regents Academy for at-risk high school students (Wilson et al. 2011a; 2011b), which was explicitly designed from an evolutionary perspective, is an encouraging sign. It represents an integration of disciplines such as political science, education, and clinical psychology that had not taken place in the past but came together easily from an evolutionary perspective. See Wilson and Gowdy (2013) for a more detailed answer to the "added value" question, which respectfully considers four reasons why an evolutionary perspective might not add value and concludes that those four reasons fail for any sizeable human-related subject area.

A science of intentional change need not compromise norms of respect for the rights of individuals. Indeed, the importance of consensus decision making for groups to function as cooperative units accentuates the need for democratic processes to formulate benign social policies. All of the interventions we have described were implemented because they targeted outcomes that were concerns of individuals or were well-established threats to public health (e.g., youth tobacco use, child abuse). In no case was coercion used. Rather, the interventions created conditions that favored the selection of behaviors or cultural practices that were desired by individuals and communities. If improving the human condition is our goal, there is no alternative to becoming wise managers of evolutionary processes.

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Open Peer Commentary

Could Bertrand Russell's barber have bitten his own teeth? A problem of logic and definitions

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Abstract: Guiding the positive evolution of behavior is an admirable goal. Wilson et al.'s arguments are based largely on studies of problem correction. The methodology is sound, but not the *post hoc ergo procter hoc* extrapolation. What is required is evidence that it can proactively generate positive change. The evolution of human behavior to date has been affected by many factors that include unmalleable and unpredicted environmental changes.

Trying to define yourself is like trying to bite your own teeth.
— *Alan Watts (1961)*

Philosophy classes often start by considering Bertrand Russell's "Barber's paradox" – if an island has a male barber and all and only those men who do not shave themselves are shaved by him, does he shave himself? Logically, if the barber does not shave himself, then he must shave himself; but if he does, he cannot. The only solution to this quandary is to accept that, as defined, no such island could exist.

The authors' positive, provocative, and controversial paper posits a world much like that of Russell's hypothetical Barber. It follows in the footsteps of J. B. Watson's early claims for the world-changing potential of behaviourism (Watson 1924) and B. F. Skinner's 1948 novel *Walden Two*. As in these earlier works, Wilson et al. are trying to anticipate and explain a world they believe can be completely predicted, controlled, and shaped for the common good. It forms part of a growing interest in how we humans might have influenced and may be able to influence our own evolution (Cochran & Harpending 2009; Wrangham 2009).

The target article promises a satisfying bite at these issues, but perhaps the authors have tried to bite off something no one can chew.

I agree that a pragmatic methodology for change requires the integration of current knowledge across a number of overlapping domains. I also agree that the most intuitive and best empirically supported framework for such a transdisciplinary perspective needs to integrate behavioural analysis with social, cognitive, and evolutionary psychology and psychobiology. Where I take issue is with the authors' assumptions on a number of more specific points and the resultant conclusions that can be drawn about our ability to be the "wise managers of evolutionary processes."

They appear to suggest:

1. That the revision to evolutionary psychology and its integration with other branches of current science possible through their proposed synthesis would approach a definitive articulation of the understanding required;
2. That knowledge in these areas is effectively as good as it is going to get and is more or less complete except for its integration;
3. That successful management of the process of evolutionary change could be actively, effectively, and prospectively directed using this approach.

Many of the examples used here concern redress, not progress. For example, how to increase play behaviour where it is poor, or alter alcohol and tobacco sales when they produce health or economic problems. The results in the studies cited are impressive, and it is a useful exercise to open this material to critical scrutiny from a wider scientific audience. I came away from reading it not convinced that I had read about a methodology for proactive positive change, however, but rather about one that can be used in addressing concerns.

A logical *non sequitur* in this argument lies in assuming some understanding of a desired progression and endpoint. Human history is liberally strewn with well-intentioned failed attempts to wield such control.

The focus is largely on effecting a process of change in the individual rather than a reflexive process of change in all relevant aspects across a social–evolutionary context (including those trying to consciously introduce and direct such change).

A feature of comprehensive behavioural accounts is that they should be reflexive. This is a well-recognised issue with unidirectional analyses of behaviour (Bandura 1978; Hineline 1980).

Evidence-based practice has become a key concept for clinicians (Satterfield et al. 2009), and the development of comparative models by PCORI (the Patient Centered Outcome Research Institute; Gabriel & Normand 2012) and of RDoC (Research Diagnostic Criteria) by the National Institute of Mental Health (see Aitken 2013) will develop this further. This methodology has been largely concerned with addressing problems or with their primary prevention. Even large-scale datasets using this approach have often been surprisingly poor at prediction across populations (Brindle et al. 2003). This may be partly due to a tendency to assume that mathematical/statistical and behavioural equivalence are synonymous (Saunders & Green 1992), and partly to assuming that the same explanatory model will hold irrespective of population differences.

Much is made in the paper of being able to use "evidence-based kernels" of knowledge to drive the process of change. This sounds sensible where such a knowledge base exists. The examples referred to are useful but largely concern either prevention (stopping a problem from developing) or treatment (dealing with a problem) and not with moulding the process of evolving more successful behaviour, which I take to be the authors' intent.

Development can be channelled but is often serendipitous. Its influences cannot be readily predicted; it can, however, be affected by changes in environmental affordances. Many such factors are outside previous knowledge or control and can only be adapted to *post hoc.*

Perhaps a good example of change outside the scope of this model is the impact exerted by changing climatic conditions on human behaviour (see, e.g., Hsiang et al. 2013). Increasing global temperature and rainfall are precursors to higher levels of inter-group violence. A proximal focus on conflict de-escalation to target the human response might help to address these issues. We are currently unable to positively modify climate to any significant degree. It is probable that only approaches based on things such as reducing carbon dioxide, deforestation, levels of animal farming, and fossil fuel use (assuming these were possible and the science behind their roles to be accurate) will alter these more distal factors. In our prehistory, glaciation obviously shaped evolution through factors our ancestors would have been unable to appreciate or modify.

We have the methods to engage in changing behaviour and to tell when we have succeeded. I think we are still some way off from an intentional science that can mould evolutionary change, and like Sir Karl Popper (Senn 1991), I am not sure if or how we could tell we had ultimately succeeded.

What men have seen they know,
But what shall come hereafter,
No man before the event can see,
Nor what end waits for him.
—*Sophocles (Grene & Lattimore 1957)*

Developing of the future: Scaffolded Darwinism in societal evolution

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Abstract: We sympathize with the project of a synthetic approach for devising a "theory of intentional change" and agree that Darwinism should be central in such a theory. But Darwinism is not the only process of evolution that needs to be included. Evolutionary biology itself has taken such a turn recently, with the emergence of developmental evolutionary approaches.

We strongly sympathize with the aim of a synthetic construction of a "theory of intentional change." We think, however, that to break the current stagnation in evolutionary social science we need to follow more in the tracks of recent moves toward a causal–mechanistic understanding of evolution in biology (Laubichler & Maienschein 2013) than in the tracks of neo-Darwinism. Darwinism – which is what Wilson et al. really mean by "evolution" – is necessary but not sufficient here; we also need to mind the multilevel organization that evolution produces and that scaffolds Darwinian dynamics.

A fundamental role of Darwinism for adaptation in a generalized sense has been argued convincingly by evolutionary epistemologists following Campbell (1965; 1974). The idea is that if we disaggregate macroscopic adaptive systems, we will sooner or later find a level or stage on which intrinsic adaptive behavior no longer can be argued to exist. So if we would like to explain adaptation (including foresight) in a way that is consistent with naturalism, we must understand how systems with entirely "blind" components can come to exhibit or embody foresight. The only process known to be capable of such a feat is what Campbell refers to as Blind-Variation-Selective-Retention (BVSR). Indeed, in all cases of adaptation found so far, explanations appear to have gone through the same stages: providence (by a designer), instruction (such as coin in wax), and finally BVSR (Cziko 1995; 2000). This holds for organic evolution, the adaptive immune system, neural systems, and – to a much more limited extent – social systems. However, as we will argue, there appears to be also a fourth stage that modifies that third selectionist stage.

The appeal of Darwinism has been strong also in social science, where examples of selection and retention in populations of variants are easy to find. We have Darwinian evolutionary economics following Nelson and Winter (1982) and Dosi (1982), the "memetics" movement following Dawkins (1976), the related replicator–interactor ontology for universal Darwinism introduced by Hull (1988), and the so-called dual-inheritance tradition in anthropology following Boyd and Richerson (1985) and Cavalli-Sforza and Feldman (1981). Boyd and Richerson (2005) describe their approach as a mix between rational choice theory and population genetics, and that is not far from being generally true for current evolutionary approaches to social systems – including that proposed by Wilson et al.

Population genetics focuses on the fate of variants in populations subject to selection pressures that are independent of time, frequency, and not least of all, the evolutionary process itself; it treats development as a black box (Amundson 2008) and assumes that the system is near-decomposable (Simon 1996). This may sometimes work as a basis for models of gradual innovation of technology and behavior, which is in practice also how such models have been used. But societal systems are characterized by incessant *radical* innovation – which is the emergence of *qualitative* novelty – and they are not generally possible to separate from the rest of the system in a Simonean fashion. This causes problems for formal modeling; not only the state but also the *ontology* of the system changes on similar time scales (Lane & Maxfield 2005). BVSR is embedded in the very structures that it produces – it reappears on emergent levels of organization, and it even reinvents new versions of itself (e.g., clonal and neuronal group selection; see above and Andersson 2008; 2011).

Without radical innovation one is confined to special cases of gradual adjustment of systems to meet predefined functional specifications – similar to what is the case in genetics algorithms (Holland 1992). The examples chosen by Wilson et al. indeed represent a sort of social genetic algorithms, which is fine; but the question is how far this goes toward a science of intentional change.

The fourth explanatory stage alluded to above would then be the realization that BVSR must act through systems whose path-dependent organization and dynamics introduce *other* principles of evolution alongside them, and from which BVSR cannot be disentangled. BVSR is necessary *but not sufficient*. Along those lines, evolutionary biology has undergone a revolutionary change since the time when it was injected into the above disciplines in social science. *Development* (in a broad sense) has become an integral part of evolutionary theory, and it is no longer possible to ignore the constraining and channeling effects of the structures that emerge in evolution; for example, evolutionary developmental biology (e.g., Arthur 2011), niche construction theory (Odling-Smee et al. 2003), generative entrenchment (Wimsatt & Griesemer 2007), and developmental systems theory (Oyama et al. 2001).

Although Wilson et al. repeatedly refer to development, it is not an integral part of their approach. In other words, they do not draw the consequences of minding development, and even less of the notion that BVSR is scaffolded by the structures that are generated in evolution. They see evolution as reducible to BVSR on a single level with only minor adjustments.

So what if we by "intentional change" mean large-scale societal problems that are deeply embedded? What if we, for example, want to understand how to replace unsustainable technologies rather than how to reduce underage smoking? Wilson et al. motivate their work in an admirable way in that direction, but their examples are of a simple social character that we think represents special cases rather than stepping stones on the way to those vexing "wicked problems" (e.g., Rittel & Webber 1973) that we face in modern society. We think that when it comes to unifying social and natural sciences – including Darwinism – new developmental theories in evolutionary biology fall much better into place as a source of inspiration (see Andersson et al. 2014).

The bedfellows of such a synthesis include developmental evolutionary rather than neo-Darwinian evolutionary biology, systems-level rather than reductionist theories in the social sciences, and developmental rather than behavioral psychology. Although one does not strictly preclude the other, these divisions (which cut just as much within as between disciplines) signify quite profoundly different conceptions about what a science ought to be like. What is needed to cut across those divides is a deeper methodological discussion.

Unintentional behaviour change

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Abstract: We argue that the authors ignore a broad range of possible means of changing behaviour: unintentional change. Most of the behaviours that people seek to change – either in themselves or that are the subject of public health campaigns–are habitual, and hence not necessarily responsive to intentions. An evolutionary approach should take into account all kinds of evolved behavioural responses.

We applaud Wilson et al. for bringing the issue of behaviour change to the attention of *BBS*'s readers. Behaviour change efforts are generally improved by use of theory (Bartholomew & Mullen 2011; Glanz & Bishop 2010), and we agree with the authors that evolutionary theory is the proper domain for the theorizing of behaviour. As evolutionary theorists working in the applied domain of public health, we have spent many years seeking to develop a more fundamentally grounded approach to changing behaviour than those currently advocated by health psychologists, behavioural economists, and consumer marketers, for example (Aunger & Curtis 2014).

These efforts have led us in a different direction to that of Wilson and colleagues. Instead of restricting our attention to only one mechanism of behaviour change – intentional (especially "mindful") change – they have led us to what can be called "unintentional" approaches. These include direct appeals to emotional responses (which predominate in marketing), as well as environmental manipulations that may not be recognized at the conscious level (e.g., putting pavements for walking in public areas). There are therefore other routes to changing the behaviours of interest to public health (and social welfare) than appeals to conscious cognition.

Examining the evolutionary history of adaptations to produce behaviour shows that there are three general mechanisms by which human brains produce behaviour: cue-driven reflexive behaviours, produced using mechanisms that first arose with early vertebrates; the mammalian suite of motivated behaviours that include those driven by the emotions; and the most recently evolved control system, executive control, which allows humans to plan their responses (Aunger & Curtis, in press; Bressler & Menon 2010; Menon 2011; Rolls 2005). The existence of these alternative mechanisms for behaviour production suggests that improvement of the health and welfare of a target population need not always appeal to intentional control over behaviour. We can also manipulate the environment in ways that produce reflexive or motivated responses, leading to improvements in health (Lally et al. 2007).

Indeed, many of the behaviours people would like to change for themselves, or that are important underlying causes of public health problems, are likely to rely on the reactive control system – in particular, the learned reflexes called habits. Behaviours often performed habitually include the use of psychoactive compounds such as cigarettes and alcohol (Everitt & Robbins 2005; Orbell & Verplanken 2010), eating and exercise (Aarts et al. 1997; de Bruijn & Rhodes 2011), and hygiene practices (Curtis et al. 2009; Judah et al. 2012). Habitual behaviours tend to be performed automatically in response to environmental cues and are relatively insensitive to changes in rewards (Graybiel 2008; Wood & Neal 2007; Yin & Knowlton 2006), so that changing such behaviours through appeals to high-level cognition can be ineffective (Webb et al. 2009). Rather, we need to provide the products and cues that lead to the formation of healthier habits – for example, fruit displayed at school lunch counters (French & Stables 2003) or the introduction of speed bumps to reduce driving fatalities (Afukaar 2003).

A second category of behaviour is under motivated or emotional control. Our evolutionary theoretic approach posits there are 14 human motives – particular adaptations serving particular needs in the human niche (Aunger & Curtis 2013). For example, nurture serves the need to rear altricial children, disgust helps keep parasites outside the body (Curtis 2013), affiliation promotes efforts to belong to social groups, and love drives behaviour that serves the need to pair-bond (Aunger & Curtis 2013). These habitual and motivated drivers of behaviour are often more fundamental and powerful than the intentional or willful control of behaviour (Baumeister & Tierney 2012; Bechara 2005; Loewenstein et al. 2007), which suggests they should be incorporated in any comprehensive approach to behaviour change.

Our behaviour change model, which we call the Evo-Eco approach, uses evolutionary theory to identify the key psychological, environmental, and situational causes of any particular behaviour and then provides a process to help develop interventions for large-scale behaviour change promotions. An example is our recent hand-washing campaign in rural India. Formative research identified disgust, affiliation (to group norms), and nurture as key motives for hand washing. We used these insights to design a multifaceted campaign that strongly associated these powerful emotions to hand washing with soap.[1] We also manipulated the social and physical environment to make it seem that everyone was doing hand washing (e.g., households that pledged to become hand washers had their names displayed in a prominent location). Finally, we used eye-spots in bathrooms to help cue hand-washing habits. A randomized controlled trial showed that directly observed hand washing with soap at key moments had gone from 2% to nearly 30% of the population, and it remained at that level six months after the intervention (Biran et al. 2014). By contrast, a similar trial of an educational (intentional) behaviour change campaign in a similar area of rural India showed no significant changes in hand-washing behaviour (Biran et al. 2008).

In sum, we fully endorse the efforts of Wilson and colleagues to bring evolutionary theory to efforts to change socially important behaviours, but suggest that a thoroughgoing evolutionary approach implies that there are many more – and more powerful – levers that can be employed to successfully change behaviour than just conscious and mindful intentions.

NOTE

1. See a video used in the campaign at http://www.youtube.com/watch?v=tLoNTe9ifCA.

For public policies, our evolved psychology is the problem and the solution

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Abstract: For the authors, evolutionary approaches should rely less on evolutionary psychology, which studies innate fixed capacities, and more

on cultural selection, which emphasizes cultural learning and symbolic innovation. However, successful policies do not seem to culturally reengineer people. Rather, they work by tapping into old human instincts (fairness preference, reputation management, resource seeking) to motivate individuals to change their behaviors.

For the authors, the main lesson from evolutionary biology is that all species, and in particular the human species, have evolved mechanisms of phenotypic plasticity that enable them to respond adaptively to their environments. This idea allows the authors to be very optimistic about "intentional change": Thanks to our symbolic and learning capacity, people can be reprogrammed and old problems will be solved with the right cultural tools.

However, this faith in cultural selection might be misplaced. Is cultural selection really responsible for innovative policies? Consider, for instance, people's ability to solve common pool resource (CPR) problems. Wilson et al. attribute people's successes to their cultural ability to discover new ways to cooperate and to successfully transmit these solutions to others. But this overlooks the fact that, in Ostrom's survey, many societies fail miserably and are unable to produce working institutions. In these cases, cultural evolution does not seem to be "selection by consequences": The same humans, with the same abilities, faced with the same problems, are unable to find a working solution to their CPR.

Why is this so? Ostrom is very clear here: the conditions for solving the CPR are not met. The CPR either has shallow boundaries, or it involves too many people, with too different backgrounds, and so on (Ostrom 1990). In this perspective, psychology, rather than culture, seems to be the crucial factor: People find a solution only in very specific conditions, where the problems (tracking resources, detecting cheating, identifying members, etc.) fit their psychological abilities.

What about the solution now? Does it display the kind of plasticity that Wilson et al. attribute to humans? Not that much. For instance, we could imagine that culture might have reshaped humans so that they become more altruistic and more group-oriented when they need to solve a CPR problem (a solution much favored by group selection theorists; Boyd et al. 2003; Gintis et al. 2003). But nothing of this sort is visible in the field. On the contrary, in a CPR, just like in any other social interaction, people cooperate only insofar as the interaction benefits each person equally (Baumard et al. 2013; Trivers 1971). People restrict the benefit of cooperation to the contributors of the interactions (Ostrom's rule 1), they proportionate costs and benefits so that people equally benefit from the cooperation (rule 2), they proportionate sanctions so that even cheaters are treated fairly (rule 5), they make decisions based on consensus so that the rule is equally respectful of individuals' interests (rule 3), and so on.

It has often been claimed that cultural evolution can make people more cooperative and transform them into "strong cooperators" who altruistically cooperate and punish cheaters. What Ostrom's work shows is quite the opposite. People abide to the norm because their behavior is monitored, and they punish others because they are rewarded to do so (Baumard 2010; Guala 2012). Hence, *institutions do not transform people*, they rather reorganize social interactions so that the same old psychology can produce something new. Consider, for instance, the way CPR institutions supply the cost of monitoring:

> The cost of monitoring is low in most CPRs as a result of the rule in use. Irrigation rotating systems, for instance, usually place the two actors most concerned with cheating in direct contact with one another. The irrigator who nears the end of a rotation turn would like to extend the time of his turn (and thus the amount of water obtained). The next irrigator in the rotation system waits nearby for him, and would even like to start early. The presence of the first irrigator deters the second from an early start, the presence of the second irrigator deters the first from a late ending. Neither has to invest in additional resources monitoring activities. *Monitoring is a by-product of their own strong motivations to use their water turns to the fullest extent.* (Ostrom 1990, p. 95, emphasis mine)

In others words, CPRs work only when they are compatible with humans' evolved psychology (e.g., when the interaction is perceived as fair by individuals). When these psychological constraints are not respected (which, again, happens quite often in Ostrom's database), the CPRs are simply not produced.

In their paper, Wilson et al. celebrate Ostrom's rules as evidence of the formidable plasticity of humans, but they fail to notice that these rules work only because they fit the not-so-plastic human psychology. The same conclusion holds for therapies that work at the individual level first. Simply noting that people can "reconceptualize" their problems does not explain why some therapies work and why some totally fail. Why is it that Alcoholics Anonymous has been so successful? Like other (less successful) therapies, it insists on the danger of alcoholism and tries to reconceptualize people's views on alcoholism. But on top of that, it taps into very intuitive aspects of human psychology, such as morality, reputation, or social motivation. Four of the famous 12 steps are about how alcoholism makes people harm others (e.g., step 8, "Made a list of all persons we had harmed, and became willing to make amends to them all"). More generally, by joining an AA group, people bind themselves to others; by feeling accountable to this social group they put themselves in a situation where drinking would amount to losing face.

Turning to large populations, we can make the same observation. How does the intervention against selling tobacco to minors work? Is it by changing people or simply warning them of the dangers of smoking? Not really. It works by tapping into some powerful instinct such as fairness ("How many shifts will you work to help me [if I get caught because you wanted to buy tobacco]?"), reputation management (praise in local newspaper), or resource acquisition (coupons). That is, it works precisely by tapping into the fixed genetic dispositions that the authors view as hindering any progress in social change. Indeed, as more and more behavioral studies show, our evolved psychology is not only a constraint that policy designers need to take into account, it is also a powerful lever to solve social problems (for reviews, see Baumard, in preparation; Griskevicius et al. 2012; Thaler & Sunstein 2008). Hence, for public policies, our evolved psychology is both the problem and the solution.

Large-scale societal changes and intentionality – an uneasy marriage

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Abstract: Our commentary focuses on juxtaposing the proposed *science of intentional change* with facts and concepts pertaining to the level of *large populations* or changes on *a worldwide scale*. Although we find a unified evolutionary theory promising, we think that long-term and large-scale, scientifically guided – that is, intentional – social change is not only impossible, but also undesirable.

Wilson et al. propose a synthetic theory that articulates a unified evolution-based framework accounting for individual, group, and societal levels of phenomena of change. The theory seeks to fuse traditionally isolated levels and styles of analysis, such as psychology, social psychology, and sociology, under a broadly conceived evolutionary umbrella in order to enable human communities "to become wise managers of evolutionary processes" (sect. 1, para. 3). The authors not only offer a set of evolutionary concepts, but they argue for the intentional change of the relevant processes serving to benefit the wider community, as well. In our estimate, extending an evolutionary model is a fertile idea. At the same time, it is clear that the authors aim at nothing less than scientifically guided social change. This we find problematic.

Our commentary focuses on facing the proposed *science of intentional change* with facts and concepts pertaining to the level of *large populations* or changes on *a worldwide scale*.

The authors claim that the scope of their proposal can be extended to "changing behavioral and cultural practices at a large spatial and temporal scale" (sect. 3.3, para. 1), and they mention "global problems such as climate change and the worldwide economy" (sect. 3.3, para. 3) as examples. In our view, they exemplify their thesis more by *middle*-scale than by large-scale changes in space and time. Changing routines of selling tobacco to minors in two states of the United States and improving parenting practices in 18 South Carolina counties are important, major public-policy programs. Obviously, they are good examples of social constructivism, but resorting to evolutionary theory seems redundant here in both descriptive and analytic senses. In addition, a significant issue, which we do not have space to elaborate here, is that the examples' key characteristic is that given the aims, a consensus is readily attained.

In our view, truly profound and important social changes require a greater spatial and temporal scale. There is general agreement among historians that the attainment of Western-type social organization took roughly three centuries. Various authors seem to share this view: Weber (1930) eloquently argued on how the Protestant world view and the corresponding value system instigated the coming era of capitalist society, with its peculiar work ethic, puritanism in consumption, and emerging bureaucracy as the manner of organization; Elias (2000) provided a detailed analysis of how the courtly manners of everyday life, with its control of emotions, permeated the lower strata of society and with appropriate modifications become the European habitus, the normative manner of everyday life and emotionality for civilized Europe; Foucault (1970; 1977) investigated the gradual changes of structures of the power–knowledge complex, prefiguring the modern way of discipline in school, at work, in the military, and in legal and penal systems and such diverse endeavors as the human sciences, including psychology, economy, and linguistics.

Still other historians such as Jackson Lears strongly believe that "all history is the history of unintended consequences" (in Cohen 2013). Would a science of intentional transformation apply to this process, as well? It seems that stretching social transformation to such an extent would not be all that alien to the authors, as, by way of illustration, they cite issues such as ecology and globalization. Therefore, properly posed, the question is one of enabling intentional transformations via diffusion of cultural innovations over generations. Is this compatible with the authors' preference for an evolutionary approach?

Indeed, there is a chapter in social science devoted to the issues of diffusion of innovations – either the behavioral innovations the target article deals with or technical ones, about which the target article is interestingly quiet – on a really large scale: Continents and centuries are involved (Geroski 2000; Kornai 2010; Modelski & Gardner 2002). For example, diffusion of technological innovations such as hybrid corns, train lines, cars, mobile phones, and Internet hosts all can be described by a general model of logistic function; furthermore, social phenomena such as geographical discoveries, activity of space research, and urban guerrilla activities also share these kind of formal properties (Fokas 2007). Those studies are more descriptive than explanatory, however, and applying evolutionary theory to these changes without hesitation seems a dubious move. This is all the more germane because in European social theory there is a trend of thought preceding Darwin; indeed, one that exerted an influence on him through Malthus, and which works with a concept of development much like Darwin's. This "shows how complex, orderly and, in a precisely defined sense, suitable institutions may develop through interpersonal relations, which owe little to planning, which we do not make up, but derive from the autonomous actions of many people, who were acting unawares" (Hayek 1960, pp. 58–59). As Hayek maintains, the development of this social order would really be "the result of adaptive evolution" (p. 58) but without any intentionality.

This line of reasoning on large-scale historical changes was also formulated by Popper (1957), instigated by a seminar headed by Hayek in which Popper participated, and the arguments of which are perhaps less well known among cognitive scientists than are Popper's seminal ideas on the philosophy of science. Popper fiercely criticized the grand-scale models of historical change, which he called *historicism*, while also arguing for gradual change in improving society, the task he delegated to social engineers. At the same time, he maintained that social institutions are mainly emerging from human activity in a not-intentional manner: "Only a minority of social institutions are consciously designed while the vast majority have just 'grown,' as the undesigned results of human actions" (Popper 1957, p. 54).

We fail to see any possibility of truly long-term social changes guided by science – a grasp of which may well call for the authors' proposed extended evolutionary theory. Further, in our estimate, given our East European experiences, this frankly is rather fortunate. In sum, it seems to us, it is a long but promising journey to fulfill the authors' wish "to become wise managers of evolutionary processes" (sect. 1, para. 3). Till that time we can only hope to be if not wise at least not to be charlatan agents in the overall process of evolutionary bricolage.

Why can't we all just get along? Integration needs more than stories

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Abstract: As astutely noted by the authors of this provocative article, it is time for evolutionary psychology (EP) to be incorporated into clinical and educational interventions. However, two issues from this article are raised in the current commentary: some historical misconceptions of the evolutionary label and a lack of clear and specific guidelines for developing or improving interventions based on EP.

This rich and provocative target article has two major components. One is a critique of "traditional" evolutionary psychology (EP) and a call for incorporating perspectives from behaviorism, cognitive science, and the social sciences and humanities in general. The second is a description of some promising applied experimental interventions to address dysfunctions in important areas of human behavior, such as clinical psychology and education. Although we agree with much that is described and proposed, we discuss two problematic areas: historical and conceptual missteps, and the proposed role of evolution in driving "intentional" interventions to improve the lives of individuals, groups, and societies.

Although the EP approach promulgated by Cosmides, Tooby, Barkow, Buss, and others has grabbed considerable attention, it also was a narrow misappropriation of the evolution label. It basically ignored individual differences (other than sex), nonhuman animals, naturalistic observation, ethology, and neuroscience (e.g., Burghardt 2013; Panksepp & Panksepp 2000). The current article, although criticizing the extreme modular and antibehaviorist inclinations of these early workers, is itself misleading, such as considering B. F. Skinner an evolutionary psychologist. The senior author was a commentator in the *BBS* special issue on the canonical papers of Skinner, which included two that compared natural selection and selection by consequences (Burghardt 1988). Burghardt pointed out that Skinner seemed uninterested in understanding the natural behavior of animals and that his basic comparison was anticipated by Edward L. Thorndike, who explicitly contrasted natural selection and "selection *within the individual* that is the great case of plasticity, and is of tremendous usefulness, in that it definitely enables the animal to modify his acts and so meet new varieties and modifications of environment" (Thorndike 1900, p. 91, emphasis in the original; reprinted in Burghardt 1985).

What is telling here is that Wilson et al. repeatedly invoke trial-and-error learning, what the authors term "open-ended processes of variation and selection" (target article abstract, para. 3), a process much more associated with Thorndike than Skinner, in the development and evaluation of applied interventions. In short, Thorndike and James Mark Baldwin, known for the Baldwin effect, who wanted to apply the evolution of plasticity to human social and cultural phenomena and was a pioneer of interdisciplinary efforts (e.g., Baldwin 1902), are the intellectual forerunners of the approaches noted here. Furthermore, many have noted similarities between biological and cultural evolution, as Konrad Lorenz reviewed in his Nobel Prize address (Lorenz 1974) using the work of Koenig (1970). Certainly much progress has been made, such as in gene-culture co-evolution; and although the target article cannot be expected to be historically comprehensive, it should, given the strong criticisms made of others, not deny credit to important pioneers.

Second, although the clinical and intervention examples presented by Wilson et al. to support the inclusion of evolutionary theory and principles are of excellent and successful programs, it is unclear what is evolutionary about them. More specifically, it is unclear how evolutionary theory either guided their development or anticipated their success, other than their being a product of variation and selection. For example, the Ostrom 8 design features of effective groups are based on a "what works" analysis, and to retrospectively use them as a basis for evolutionary-derived interventions seems to claim only that functional and dysfunctional behavioral systems must be a result of evolutionary processes underlying human nature.

We agree with the authors about the great potential for developing more efficacious prevention and intervention programs by integrating principles of EP into psychological treatments. However, we are disappointed that the authors did not provide more guidance into *how* evolutionary principles can best be incorporated into new or existing intervention and prevention programs. Can the authors provide robust guidelines for evaluating the myriad of current intervention programs, many of which are failures and fads? We need a framework for constructing and evaluating risky, testable, falsifiable predictions for intervention and prevention programs based on the authors' innovative expansion of EP theory.

For instance, numerous educational programs (e.g., Drug Abuse Resistance Education [D.A.R.E.]; Bureau of Justice Assistance 1988) and "therapeutic" interventions (e.g., conversion therapy or reparative therapy; Nicolosi 1991; batterer intervention programs for domestic violence) can be viewed largely as failures, in which the programs either were ineffective or caused harm to participants (e.g., Ennett et al. 1994 [D.A.R.E.]; Jenkins & Johnston 2004 [conversion/reparative therapy]; Stuart et al. 2007 [batterer intervention]). Other psychological interventions are extremely efficacious and have helped to alleviate enormous suffering (e.g., cognitive-behavioral Panic Control Treatment; Barlow et al. 1989). It would be helpful if the authors could present guidelines that could be used to explain how their extension of interdisciplinary evolutionary theory could explain, more universally, why some treatments are helpful and others fail. Would the authors have been able to predict, on the basis of EP theory and principles, which treatments would be efficacious and which would not? Can the authors outline specific principles for making up-front predictions regarding which newly developed psychotherapies will be successful and which will require modification or become failures? As it currently stands, one could construe that the authors are only choosing successful programs and interventions to support the incorporation of evolutionary theory, rather than undertaking the prospective analysis we need to move forward.

Perhaps the greatest need now is to provide guidance, via the provision of specific strategies, to improve existing therapeutic modalities or to develop new prevention and intervention programs, by incorporating an expanded EP theory. For example, there is some evidence to support several treatments for substance use disorders (e.g., Motivational Enhancement Therapy [MET]; Project Match Research Group 1997; Behavioral Couples Therapy; O'Farrell & Fals-Stewart 2006). However, relapse to substance use is an immense problem (Witkiewitz & Marlatt 2004). Can the authors provide guidance to intervention developers on how existing therapies that have some empirical support may be improved on the basis of evolutionary theory? Would expanded evolutionary theory provide guidance on the specific components of existing interventions that could be retained, improved, or removed, thus increasing the overall efficacy of treatment? Tensions between an integrative world view and detailed interventions are inevitable, but they need to be addressed.

Toward an integrated science and sociotecture of intentional change

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Abstract: We heartily agree with the target article and focus on how positive sociocultural change can be accelerated through the systematic use of scenario planning – what we call *sociotecture*. Scenario planning is a design process for the creation and selection of symbotypes that make a positive difference. It cuts through complexity by integrating cognitive and affective processes across multiple scales.

We wholeheartedly agree with the intention of the article by Wilson et al. to create a "science of intentional change" based on a long overdue integration of evolutionary concepts across the natural and social sciences and the humanities. We also applaud the incorporation of Elinor Ostrom's design principles for effective governance of the commons as a key element, emphasizing the importance of cooperative rules, norms, and behaviors for cultural group selection. Here we expand on these ideas by exploring the use of scenario planning as a design tool for creating what we call a *sociotecture* of intentional change integrated with basic science.

After admirably demonstrating the power and generality of evolution to describe and solve complex problems across a range of scales, the authors conclude in the last sentence: "If improving the human condition is our goal, there is no alternative to becoming wise managers of evolutionary processes" (sect. 4, para. 14). In this comment we focus on how we might become not just wise managers but creative design agents. We agree that evolutionary science, broadly conceived to include both genetic and cultural evolution acting on multiple levels of organization, as the authors propose, can help us *understand* how cultures change. But deciding what we want to do is a bit outside this purview. It is a uniquely human ability to bring *foresight* to the evolutionary table. By using the term *sociotecture* as opposed to *science,* we wish to emphasize the application of evolutionary theory toward both understanding and *crafting* ("-tecture") our social future. We can, in fact, envision and design the future we want and then use our understanding of evolutionary processes to help achieve it (Beddoe et al. 2009). Doing this involves the conscious development of technical, institutional, and world view alternatives for selection to act upon, rather than waiting for random mutations. Such an approach can radically speed up the change process, as the rapid rise of *Homo sapiens* attests.

However, like other evolutionary processes, cultural evolution is susceptible to path dependence, multiple equilibria, lock-in, and traps (Arthur 1988; Costanza 1987; Costanza et al. 1993). Many historical civilizations have collapsed due to their inability to escape these processes (Costanza et al. 2007; Diamond 2005; Tainter 1988). For example, the ancient Maya developed elaborate trade networks, elites, and cities that lost resilience to recurring drought cycles and eventually collapsed (Diamond 2005; Heckbert et al., in press).

What the Maya and other collapsed civilizations lacked was the ability to envision radically different world views, institutions, and technologies – new cultural regimes – and the ability to make smooth, intentional transitions in time.

Scenario planning is one method to discuss and develop consensus about what we want. Predicting the future is impossible. But what we can do is lay out a series of plausible scenarios, which help us to better understand future possibilities and the uncertainties surrounding them. Scenario planning differs from forecasting, projecting, and predicting, in that it explores plausible rather than probable futures, and it lays out the choices facing society in whole-systems terms (DTI 2003; Peterson et al. 2003).

Scenario planning both fosters variation in symbotypes and also supports selection of the most desirable pathways for action. The inherent tension between heterogeneity and homogeneity captured in the term "Darwin machine" is, of course, as true for the social transmission of stories as it is for other evolutionary processes. The more different stories (symbotypes) we can generate, the greater likelihood that helpful symbotypes will be available for selection. But too much diversity in our stories reduces the potential for "heredity" – the transmission and sharing of a common vision for the future.

Wilson et al. point out that it is hard "to overestimate the degree to which our symbotypes organize our perception and behavior" (sect. 4, para. 9). We see scenarios as particularly potent symbotypes. By using narrative and metaphor to make sense of complexity, scenarios work both cognitively and affectively. They help direct our attention to the future but, more importantly, they help us comprehend and value different possible outcomes. Scenarios support a kind of collective "selection," a shared story about the future that is more than the sum of individual perceptions. The whole-systems nature of scenario narratives of possible futures (rather than isolated measures of CO_2 or population, for example) perhaps accounts for their greater efficacy in organizing perception and motivating action.

Several scenario-planning exercises have been conducted in recent years at a range of spatial scales and for a range of purposes, including global futures (Costanza 2000; Gallopín 2002; Gallopín et al. 1997; MA 2005; Nakićenović & Swart 2000; Raskin et al. 2002), regional futures (Bohensky et al. 2011; European Environmental Agency 2009), corporate strategy (Shell International 2003; Wack 1985), political transition (Kahane 1992; 2004), and community-based natural resource management (Evans et al. 2006; Wollenberg et al. 2000).

Although multiple futures are possible and plausible, the goal of a *sociotecture* of intentional change would be to aid the design of futures that are both sustainable and desirable, recognizing evolutionary dynamics. The goal of a *science* of intentional change is to bring to bear an integrated understanding of cultural and biological evolution to allow us to accelerate evolution in positive directions.

One compelling example of sociotecture is the transition in South Africa after apartheid. Adam Kahane led a scenario-planning workshop that involved leaders from both the white and black political parties (Kahane 1992; 2004). He convinced them to go beyond recriminations and to create together four possible future scenarios for the country, only one of which – the "flight of the flamingos" – envisioned a shared country with everyone rising together with truth and reconciliation. Its adoption allowed a relatively rapid and smooth transition. Not perfect, but it could have been much slower and more difficult had this important consensus about a vision for the country not been reached. Scenario planning can thus act as a critical catalyst for making change faster and easier.

So, we need not only a *science* of intentional change, but also a *sociotecture* integrated with it to develop and test alternative models and visions of the world we want and to help us get there.

Does evolving the future preclude learning from it?

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Abstract: Despite its considerable length, this article proposes a theory of human behavioral science that eschews half the evidence. There is irony in the title "Evolving the Future" when the featured examples of intentional change represent procedures that build slowly on the past. Has an opportunity been missed, or is an evolutionary perspective simply incompatible with learning from the future?

This article offers an intriguing promise in its title giving reference to the *future* and *intentional change.* A detailed reading reveals a score of 2 out of 4: unidirectional (not bidirectional) reference to the future, and a 1970s recognition of intentional change. This statement is not intended to be harsh, but I believe that addressing these issues, if it is possible, could make or break the chance of a real contribution to behavioral science. This article misses the opportunity to recognize the future as a source, not just a destination, of learning. "Evolving-the-future" and "learning-from-the-future" (Dowrick 2012a) are clearly opposite processes in the fourth dimension, so contrasting them is easier than linking them.

Evolution is a process of learning from or building on the past. So is operant conditioning, which is why Skinner (1981) wrote the article so much cited in Wilson et al.'s article. Skinner devoted his professional life to explaining as much behavior as he could in operant terms. But his after-hours thoughts encompassed much else, including learning from the future (though he did not call it that; B. F. Skinner, personal communications, April 10, 1983 *et seq.*). For example, in his *Notebooks* he wrote of the folly of the common practice to show batters in a slump, videos of striking out (which is feedback; learning from the past). Better, he wrote, "[that the batsman] be shown a short film of himself hitting home runs. A videotape device in the back of the dugout could have short cassettes for each player" (Epstein 1980, p. 6). Although this may look like a different selection of past behavior, more important, it is a representation of valued future behavior.

Wilson et al. make no effort to include this domain of learning in their treatise, although it represents half the discourse on learning theory. Learning from the future creates dramatic changes, in contrast to hard earned successive approximations toward a modest delta. The article does refer to modeling, self-modeling, goal setting, exposure, and other procedures with potential for participants to be drawn by images of the future, more than being driven by ghosts of the past (Dowrick 2012b). However, these possibilities are either overlooked or avoided. Even the behavior-influencing *kernels* of Dennis Embry (2004) and the variations of Steven Hayes's (2004) *mindfulness* therapy, both potentially replete with the full spectrum of future-oriented learning, are tightly linked here to evolutionary theory or experimental analysis of behavior as ways to build, exclusively, on the past. Potential for connecting to learning from the future is hinted at by reference to "therapy [behavior change] that employs symbolic language" ("the symbolic Darwin machine") and by reference to prevention. However, change at the "level of individuals" is limited almost entirely to clinical, developmental, and educational *problems,* whereas theory needs to address improvements and variations in positive change, as well. All 13 examples in Tables 2 and 3 (community interventions) describe outcomes solely in terms of the reduction of (bad) behaviors, not as improvements in terms of any acquisition or evolution toward future valued behavior. Tellingly, there is no reference to Albert Bandura or other descriptions of social cognitive theory significantly related to intentional change (e.g., Bandura 1986; 1997).

Learning from the future is exemplified by cognitive-behavioral *feedforward,* in which a new skill or level of performance is rapidly acquired when it is constructed as an image made from component behaviors already in the repertoire (Dowrick 2012a; 2012b; cf. Dowrick & Hood 1981, p. 397). A related process is *positive self-review,* in which a previously demonstrated skill (e.g., hitting a home run) is mentally apprehended, via video or otherwise, as a valued future behavior without modification or reconstruction. There is evidence pointing to the neurological functions associated with future thinking, as distinct from episodic memories (see Schacter et al. 2008; Suddendorf & Corballis 2007). These processes can be stimulated in many direct and indirect ways.

But perhaps evolutionary theory cannot be linked to such learning – which is substantially absent in pigeons and earthworms (although rats have been found to combine brief sequences from spatial memory in the hippocampus, such that these sequences "predict immediate future behaviour"; Pfeiffer & Foster 2013, p. 74). If it is not possible to make an effective link between the proposed theory and half our database in the knowledge of learning processes, at least that should be acknowledged. But if it is possible, it will take a different mindset: As the authors note in their final discussion, "*seeing* differently [will result] in *acting* differently" (emphasis in the original). More likely, the proposed theory is fundamentally stuck with incremental learning from the past.

A science of intentional change and the prospects for a culture of peace

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Abstract: Have humans evolved as violent and warlike? Studies of peaceful societies, historical trends of warfare and violence, and cooperation say otherwise. Evolution is not destiny; human choices are important interventions in the process. A science of intentional change, using alternative learning techniques that support human interactions based on nonviolence and peaceful coexistence, might help to evolve a culture of peace.

The target article has promising implications for controlling violence in society, and also for developing what has come to be known as a "culture of peace." Many believe humans evolved to be violent and warlike, that these attributes are innate and unchangeable. One might even call this "the received view," historically speaking, and in terms of a commonly held contemporary perspective on our species (Gat 2006; Keeley 1996; Smith 2007). However, the view in question is undermined: first, by anthropologists and others who classify and study a broad spectrum of peaceful societies; second, by social scientists using empirical methods to chart historical trends in relation to war and violence; and third, by social scientists who investigate the formation and role of cooperation among humans. The first group (Bonta 1993; Boulding 2000; Fry 2007) provides evidence that peaceful peoples exist in the past and present; whereas the second (Goldstein 2011; Muchembled 2011; Pinker 2011) documents the decline of violent behaviors and/or the decline (in frequency and destructiveness) of warfare in general; and the third (Knauft 1996; Tomasello 2009) shows that cooperation (in the absence of self-interested payoffs) is an inborn, universal tendency.

This is not the place to evaluate all of these claims. It is sufficient here to note that considerable light has been shed on the nature of aggression and violence. These are widely held to be human universals. Yet every society works out its own ways of dealing with them, some with greater success than others. Violent and bellicose behaviors can be learned, but so, too, can alternative behaviors – such as symbolic aggression displays and nonviolent actions – through social conditioning based on positive reinforcement. As a leading anthropologist observes, "There are few societies in which some form of aggressive behavior, however slight, does not occur…. The variability and absence of stereotypy [in cross-cultural comparisons] suggest that violent behavior is largely learned…. Human beings can learn virtually anything. Among other things, they can learn to be virtually wholly unaggressive" (Montagu 1978, pp. 5–6). If so, then tendencies toward aggressive violence and waging war do not necessarily override other human potentials for cooperative and nonviolent coexistence, and therefore also do not prescribe human destiny. More broadly speaking, evolution itself is not destiny, and human choices (such as adopting new values and practices) are important interventions in the process of our species's development.

The research discussed by Wilson et al. enters the picture at this point. Consider the following questions: Could a culture in which violence and militarism prevail be transformed into one in which these features are less significant, and perhaps eventually into a culture of peace? Could we choose nonviolence and peaceful coexistence between humans (and even between humans and nonhumans, humans and nature) as our primary goals? Certainly these choices are in the interest of adaptation to circumstances, or "long-term human welfare" (sect. 3.3, para. 3). Although the questions posed are daunting, I suggest that a science of intentional change might one day yield affirmative answers. Let us see how.

The key concept in Wilson et al. is that of managing evolutionary processes. Specifically, they speak of "managing evolved mechanisms of phenotypic plasticity" (Abstract). From their many examples, we learn about our own ability – as individuals, groups, and cultures – to take charge of our behavior and developmental direction. Furthermore, learning that the social sciences yield numerous techniques by means of which evolutionary processes can be shaped and directed provides us with a better understanding and appreciation of how we might manage our future as a species. But this theoretical standpoint itself also serves as a heuristic principle that encourages a trend toward the unification of the social sciences in the service of chosen evolutionary ends.

More peaceable forms of human life would result from everyday interactions enhanced by new symbolic representations (or "symbotypes") that expand rather than limit the resources of discourse and imagination by means of which we express ourselves, and with which we confront personal problems and larger scale challenges as individuals, societies, or cultures. The first step would involve gaining awareness about how these processes work (Lakoff & Johnson 2003; Schäffner & Wenden 1995). Standard metaphors that allude to war, violence, and/or threats could then be reframed in terms of images that neither rely upon simplistic and vague allusions nor divide the field of concern into two camps: our group and others, friends and enemies, victors and vanquished. People can learn to create new vocabularies and associations through cognitive alteration techniques, just as they are enabled to change by means of reconceptualization or through exposure to "education or brief training in cognitive reappraisal" or to "a metaphor or exercise that alters the impact of negative thoughts" (sect. 3.1, para. 15).

Visual imagery in advertising, entertainment, and other media that portray or encourage hostile characterizations of others and interactions with them could be replaced by others that convey more constructive messages but still meet the objectives set for themselves by these industries.

Social experiments in living not only illustrate patterns of human evolution that are unfolding; they also determine what may be possible within a given stage, and hence, help reshape our fundamental understanding of evolution itself. Even beyond this, social changes can take on the role of "inheritance systems" (sect. 1, para. 6) that have ongoing effects on the development of new values and practices.

As Wilson et al. forcefully demonstrate, humans are much more malleable than we often give ourselves credit for. Therefore, patterns of behavior (including linguistic behavior) that seem to be intractable can often be changed – and even changed in short order and by surprisingly simple strategies – into more constructive expressions of our evolutionary repertoire. Genetic innateness, they also show, can be an agent of differential development rather than of stasis.

Violent and war-waging behaviors clearly achieve results that are "dysfunctional from the perspective of long-term human welfare" (sect. 3.1, para. 19; Bickerton 2011; Fox 2013; Tyner 2010). If we desire to survive and flourish as a species, then we will need to select for ways of thinking and behaving that favor peaceful outcomes.

Evolving the future of education: Problems in enabling broad social reforms

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Abstract: The apparent success of the Sudbury Valley School, coupled with its lack of impact on the larger culture, is used here to illustrate general constraints on managed change at the large-population level. Government regulations preventing innovation, the difficulty of bucking social norms, and the inadequacy of current indices of success operate against beneficial educational change in the larger culture.

In their target article, Wilson et al. describe human behavioral and cultural changes as evolutionary processes, contend that such changes must be consciously managed to improve human welfare, and describe some already proven means of promoting beneficial change at the level of individuals, small groups, and even large populations. In their discussion of change at the small-group level, they mention my work documenting the effectiveness of the Sudbury Valley School. Here I expand that example to illustrate why successful innovation at the small-group level does not necessarily lead to reform at the larger population level.

First, I must note that Sudbury Valley School is almost the antithesis of what most people think of as school. It is a setting where children and adolescents mix freely with one another, where they are free to play and explore in their own chosen ways all day, where students and staff members together create all school rules democratically, where there is no curriculum except the informal ones that students may create for themselves, and where students are not tested or in other ways evaluated for academic achievements. Yet, follow-up studies show that the graduates have been highly successful in higher education and careers, even though many came to the school due to failure or rejection in local public schools (Gray & Chanoff 1986; Greenberg & Sadofsky 1992; Greenberg et al. 2005). My analyses suggest that the school works well because it provides the conditions that optimize children's instinctive drives and abilities to educate themselves through observing, exploring, questioning, practicing valued skills in play, and sharing thoughts in conversation (Gray 2011b; 2013).

I do not expect to convince readers of these conclusions on the basis of this brief summary, but I ask readers to suppose that these conclusions are true and then to ponder the problem of why the success of Sudbury Valley has had so little impact on the larger culture. Sudbury Valley (founded in 1968) has existed for nearly half a century. It has hundreds of graduates. Its success and that of its graduates have been documented in articles and books. The school operates on a per-student budget less than half that of the local public schools. Yet, the school's example has had essentially no effect on schooling in the larger culture, which continues to move in a direction ever further from that of Sudbury Valley – a direction that deprives children ever more of opportunities to play, explore, and pursue their own interests and that produces ever more unhappiness, anxiety, and depression (Gray 2011a; 2013). Roughly three dozen schools explicitly modeled after Sudbury Valley now exist worldwide (listed at the Sudbury Valley website), but despite their apparent success, enrollments are small. Sudbury Valley still has only about 150 students, and all of the other schools are smaller.

Here, as I see it, are three constraints to the spread of educational innovation to the larger population level. I think these operate against other potentially beneficial social changes, as well.

Government regulations that prevent innovation. There are no publicly funded Sudbury schools, because nowhere do such schools satisfy government criteria for what a school must be to receive funding. Evolution requires variation. To the degree that variation is prevented by law, evolution cannot occur. A common criticism of Sudbury schools is that they are all private schools, which charge tuition, so there is no direct evidence that such schools would work for the general population in public schools. But laws prevent any test of that criticism. The problem of lack of variation is even greater in most European countries, where government regulations apply to tuition-supported schools just as they apply to tax-supported schools. For example, in the Netherlands, parents who have sent their children to a Sudbury school have been tried and convicted for violation of the truancy law (Hoekstra 2013).

The conservative nature of social norms. Wilson et al. use *symbotype* to refer to "a network of symbolic relations that regulates behavior" (sect. 2.4, para. 2). Symbotypes include culturally ingrained beliefs. Everyone in our culture hears regularly about the value of schooling, and concepts of childhood and conventional schooling are almost indelibly entwined in people's minds. The first thing we ask, on meeting a child, is about their grade in school or their favorite school subject. People find it hard to swim against the cultural tide. A recent survey of parents who had chosen a non-normative educational path for their children revealed that the single biggest challenge in pursuing that path was facing the continuous questioning and criticism from others; the second biggest challenge was combating their own, culturally ingrained, automatic associations about what education is supposed to be (Gray & Riley 2013).

The problem of defining success. Many people in the educational establishment would describe present policies of closing "failing" schools and firing "unsuccessful" teachers as a managed evolutionary process. Successful schools and teachers survive, unsuccessful ones are weeded out. But success here is assessed almost solely through scores on standardized tests, so schooling becomes, increasingly, a matter of drill to prepare for tests. Over the same period that this focus on testing has increased, creativity of schoolchildren has declined (Kim 2011) and stress-induced disorders among children have increased (Gray 2011a; 2013). It is difficult to assess school success through follow-up studies of graduates that consider such factors as happiness, social responsibility, and real-world achievement, but that would be a more telling criterion. International comparisons suggest that the more a school system focuses on improving test scores, the worse are the results in terms of creating the innovative self-starters needed in today's economy (Zhao 2012).

These are among the major constraints that have prevented beneficial change in our educational system, but not the only ones. If the word limit permitted it, I would also comment on the problem of vested interests operating against change and the "you can't get there from here" problem that makes gradual evolution from the current system to something akin to Sudbury Valley essentially impossible.

Which evolutionary process, and where do we want to go?

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Abstract: Taking an evolutionary perspective on human nature is highly commendable when the purpose is to improve society. Changing the course of human evolution is more questionable – in the biological sense of the term. The "science of intentional change" should preferably have a terminology that distinguishes between genetic changes and cultural transformation, and it needs a direction.

I applaud Wilson et al. for a great initiative aimed at creating a "science of intentional change." We need to make informed and rational decisions, and in this respect an understanding of human nature, rooted in biology, offers important contributions that have not been fully exploited. I do have some minor comments about their approach.

My primary concern relates to the use of the term *evolution*. In the text, it refers to two very different processes: either biological evolution (implying genetic changes) or cultural/personal "evolution" (phenotypic changes). It is sometimes difficult to guess which of the two the authors refer to. Yet, the main problem is that a science aimed at changing human society could engage either type of process, but the strategies involved would be completely different. Consequently, the two types are best dealt with independently.

As has been amply demonstrated – for example, in the case of dogs – it is possible to change the course of (biological) evolution, even in the span of relatively few generations. Nevertheless, in the case of humans, this seems at the present to be politically and practically an unsavory strategy. Therefore, the focus ought to be on cultural change. There is nothing wrong with using terms such as "cultural evolution." However, in the present setting, I believe the two meanings of the word *evolution* may confuse the reader, and perhaps alienate people who are skeptical to a biological perspective.

The authors make a case for including all types of human change, from genetics to epigenetics, symbolism, learning, and culture, in a single framework sometimes referred to as a Darwin machine. They argue that the distinction between genetic and other types of change is indistinct. For example, genes can be altered after conception (e.g., immunoglobulin genes); acquired traits may be inherited (epigenetics); cultural factors can influence the course of biological evolution; and the "evolution" of cultural traits is, in many ways, analogous to biological evolution. I do not object to any of these accounts, but I still believe that a science aimed at improving society ought to distinguish between alterations in the gene pool and the development of phenotype. The differences are more profound than the similarities. Rather than lumping all the factors that make an impact on human society into one concept (evolution), it seems more salient to clarify the mechanism used by the various factors, and focus on how the different mechanisms allow for the implementation of change. My point is certainly not to downplay the role of the environmentally based mechanisms, as I believe these represent the avenues worth following.

The authors point out that we should try to improve society by taking advantage of the inherent plasticity of the human phenotype. In my view, the main contribution from biology in this respect is insight into human nature. A biological approach helps us understand just how plastic the human brain is, and how to have an impact. I believe a pendulum (or a rubber band) offers a useful analogy as to plasticity (Grinde 2009). There are vague limits as to how far away from the "default setting" of the human genotype one is likely to move a population. It is, for example, possible to expand our capacity for empathy, and subdue the tendency for aggression. In the case of a carefully raised individual, we can go a long way; but for a larger population, it requires a lot of effort to move far away from the default mix of good and bad behavior indicated by the genes. Energy is needed to keep the pendulum in a position away from an area surrounding the point of gravity. An understanding of human nature offers a handle that helps us pull the pendulum to a desired position.

Evolution designed humans for a life in a certain type of environment (and a concomitant behavioral style). Although this environment can only be vaguely outlined, and a broad range of settings will do fine, some of the changes introduced by modern societies cause problems. The diseases of civilization, including common mental disorders, are presumably a consequence of unwholesome changes. The term *mismatch* is used for differences between the archaic human environment and the present conditions (Eaton et al. 1988). I use the term *discords* for the mismatches that can have detrimental effects (Grinde 2004). When instigating changes, one ought to be careful not to introduce factors that, although potentially beneficial for one purpose, are discords in the sense that they also contribute to undesirable effects. Understanding human nature, and the environment that shaped it, helps us avoid this trap.

Another issue is that a science of intentional change ought to discuss why alterations are desired, and in what direction one wishes to move. Evolutionary success for the human species is, for example, unlikely to be advantageous – as our species already had too much of it. The commitment of both my Institute and my own work is to change human society. As to the Norwegian Institute of Public Health, the aim is for better health, mental well-being included; I seek to improve quality of life, taking a biological approach as to what a good life, or happiness, is about (Grinde 2012). The formula introduced by the *Happy Planet Index* (Abdallah et al. 2012) – *Experienced well-being* × *Life expectancy* / *Ecological footprint* – could serve as an aim.

There are many frameworks, and concomitant terminologies, that can describe humans and form a basis for a science of intentional change. How correct they are tends to depend on how one interprets the concepts included. A more pertinent question may be: How well do they serve the purpose – in this context, the process of change? Wilson et al. have done an excellent job at introducing the issue, but I believe a further development of their framework is desirable.

Cooperation and emergence: The missing elements of the Darwin machine

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Abstract: The authors present a compelling argument for a science of intentional change by unifying evolutionary psychology (EP) with the standard social science model; however, since its inception, traditional EP models have not held up well to empirical scrutiny. The authors address the importance of cooperation in individuals and social systems, but the Darwin machine they propose does not adequately stress fundamental aspects of evolutionary processes.

The authors present a very nice argument for the integration of evolutionary theory, multiple levels of human development, and intentional cultural change. However, I would argue that the basis for their integration of evolutionary and social change, specifically the "Darwin machine," is inherently flawed. Outside of forced-choice questionnaires, traditional evolutionary psychology (EP) models have had little empirical support from comparative animal, developmental, economic, and medical research; the concepts that EP has proposed, such as anatomically based mating strategies, massive modularity, extreme adaptation, and genetic reductionism, have been strongly attacked and referred to as junk science (Agin 2006; Barve & Wagner 2013; Gibbs & Van Orden 2010; Le Fanu 2010; Muller et al. 2006).

Traditional EP models are based on neo-Darwinian genetic reductionism perspectives that hold genes as the primary determining factor of adaptation; selection operating at the level of the gene will override any selective influence occurring above that level of organization (Alcock 2005; Buss 2004; Dawkins 1976/2006). In doing so, neo-Darwinistic theories have exalted the gene over the organism, so that the essence of evolution and development, and ultimately the entire spectrum of life, is simply different genes competing for survival and reproduction (Wesson 1991). However, when two basic elements interact, the result can be an entirely new structure with new properties that would not be found without the interaction; this is a central tenet of chemistry and development. The organization and interaction of the subunits in a dynamic system can result in novel properties of the system not independently found in the subunits alone (Gottlieb 1992; Zylstra 1992). Considering that virtually all evolved organs and tissues in living organisms are organized as structural hierarchies (Ingber 2006), the emergence of complex organisms and their resulting ecological and social interactions cannot be mechanically reduced to their basic subcomponents (Levin 1998; 2000; Oyama 1985/2000; Wu 1999). A progressive step forward would be to generate a model that encompasses different hierarchal and systems perspectives. Unfortunately, the Darwin machine concept does not completely encapsulate the processes of development during ontogeny that led to the evolution of different scalar levels of selection over phylogeny.

EP and neo-Darwinian theorists have focused so heavily on self-interested genetic propagation that, traditionally, evolution has been synonymous with competitive interactions. Competition resulting in selection is a major aspect of the evolutionary process; however, the emergence of complex organisms requires that interactions must also be integrative and constructive (Nowak et al. 2000). The tenets of classical Darwinism – variation, selection, heritability – do not include aspects of cooperation and collaboration, fundamental mechanisms of biological and social diversity. Whereas the authors address its application in immune system functioning and change at the level of small groups, a Darwin machine concept inherently ignores cooperation as a fundamental aspect to all living systems.

Cooperation among subunits within a system generates a new level of selection by facilitating a self-organizing process, allowing for higher order and more complex structures to be maintained (Jain & Krishna 2001; Michod & Roze 1999). Basic chemical reactions, the building blocks of all living things, will naturally and spontaneously self-organize through cooperation (Stokely et al. 2010). When cooperative pressure is able to override the competitive pressure among horizontally interacting units within a system, a new evolutionary level of selection can then be generated (Reeve & Keller 1999). From genes cooperating in genetic networks within genomes, organelles cooperating within eukaryotic cells, and cells cooperating to form multicellular organisms, to multicellular organisms cooperating to form cultures (Nowak 2006; for review, see West et al. 2007), ultimately cooperation allows for the creation of new levels of organization through the integration of multiple contributors to a single function (Sirois et al. 2008). The opposing forces of competition and cooperation not only define the evolutionary history of living organisms but also define ontogenetic development, just as the generation of the human nervous system requires both cooperative and competitive processes (Edelman 2004; Edelman & Tononi 2000).

The authors do an elegant job attempting to salvage traditional EP concepts; however, it may be beneficial in the long run to simply view traditional EP models as a historical remnant, such as Freudian psychology and radical behaviorism, primarily providing a sounding board for more accurate models. Unfortunately, EP models have not been able to fully reflect the intricate network of biology, ecology, and the multilevel interactions that generate living systems. Although the authors do address that humans develop within differing levels of social and cultural organization, the Darwin machine concept is too limiting in scope for a new science of intentional change. The standard social science model was simply a straw man used to bolster, and possibly sensationalize, a "new" field in psychology.

Evolutionary processes and mother-child attachment in intentional change

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Abstract: Behavioral change may occur through evolutionary processes such as running stochastic evolutionary algorithms, with a fitness function to determine a winning solution from many. A science of intentional change will therefore require identification of fitness functions – causal mechanisms of adaptation – that can be acquired only with analytical approaches. Fitness functions may be subject to early-life experiences with parents, which influence some of the very same brain circuits that may mediate behavioral change through interventions.

In social science, intentional change can be broadly defined as behavioral or conceptual changes guided by an intention; that is, conscious determination to act in a certain way. Among all possible behaviors or concepts that constitute a population of solutions for a specific problem, how to select one or a few winning solutions amid complex agent-environment interactions to optimize adaptation is indeed subject to evolution. When evolutionary process is understood as a Darwin machine with operations of variation, selection, and heredity (as Wilson et al. understand it), what can a Darwin machine do for the science of intentional change?

To answer this question, one can look to the artificial intelligence concept of Evolutionary Algorithms (EAs), which are developed to solve optimization and search problems. EAs are composed of algorithms for reproduction, variation generation, and selection procedures, just like Darwin machines. To run EAs, one needs to specify an initial population (i.e., potential solutions to the problems in question) plus the means to select winning solutions that can be inherited with possible recombination or mutation in the next generation. A fitness function is needed in EAs to determine the fitness score, by summing up values across different factors on a common currency to index how close a given solution is to achieving the aims. For example, the best-looking face can be found by running an EA that has a variety of faces that evolve from an initial generation of population to the next by recombining features from the faces selected by humans. Although the solution (the best-looking face) can be found, the fitness function remains unknown.

Therefore, the science of intentional change that depends on evolution processes will require knowledge of the fitness functions. Indeed, Ostrom's eight design principles that were emphasized in Wilson et al. are examples of the knowledge required to formulate a fitness function, which was not obtained through any evolutionary process. If a Darwin machine cannot operate without fitness function, and the fitness function (e.g., Ostrom's principles) is identified without running the evolutionary algorithm (Darwin machine), then the science of intentional change must focus on the source and properties of the fitness function.

Furthermore, evolutionary theory at its best provides a stochastic approach to study changes, which can be either intentional or unintentional, as opposed to an analytical approach to delineate causal links (mechanistic pathway) that give rise to the changes (intervention). The stochastic and analytical approaches differ in their prediction and explanatory powers. Even when provided with sufficient initial conditions (candidate solutions and the constraints in the environment) and a fitness function, EAs as a stochastic process can provide knowledge of what solution works better than others nondeterministically (therefore with limited explanation power), and the solution cannot be known until computation of numerous iterations is completed (therefore with limited prediction power). On the contrary, an analytical process should be able to predict the outcome and explain the causal links leading to the outcome; for example, applying a hypothesis-testing experiment to test Ostrom's principles with an experiment group versus a control group.

Indeed, multiple aspects of the science of intentional change have been successfully studied in psychology and neuroscience with analytical approaches. One can conceptualize that intentional change involves goal-directed behaviors based on the incentive values of various goals and their related solutions that are encoded and maintained in domain-specific long-term memory systems. Only through analytical approaches were molecular mechanisms of synaptic transmission developed from basic invertebrate neuromuscular preparations (Swain et al. 1991) mammalian brain memory formation and change in hippocampus (Redondo & Morris 2011) and even identified techniques of planting a false memory animals (Ramirez et al. 2013). Brain imaging studies of decision making with multidomain information, a general form of intentional change, have identified the neurocircuits underlying temporal discounting of rewards (Kable & Glimcher 2007) and the common currency of incentive values integrated from social, emotional, and cognitive domains (Ho et al. 2012) – a form of fitness function. In behavioral intervention studies, key mechanisms underlying cognitive behavioral intervention to change an addicted behavior (e.g., smoking) have been identified, such as the self-referential process (Chua et al. 2011; Strecher et al. 2008) and deliberate processing (Ho & Chua 2013).

Notably, a socially inclusive stance, which can manifest in forms of altruism (Swain et al. 2012), in-group identification (Wheeler et al. 2007), and other forms demonstrated in many examples mentioned in Wilson et al., seems to play a key role in promoting positive changes at multiple levels. It may be possible to form a testable hypothesis that recognizing and respecting self and others' perspectives impartially is a central mechanism in promoting intentional behavioral and cultural change. Then, a series of analytical experiments could be carried out to test this hypothesis systematically, as opposed to be randomly conducted to create a sufficiently large population, as prescribed by a Darwin machine.

Interestingly, a hypothesis that one's social "fitness function" can be shaped to be either partial (self-defensive) or impartial (inclusive of others) is consistent with the landmark work in developmental psychology that focuses on parent-infant attachment (Bowlby 1969; 1973). After studying associations between maternal deprivation and juvenile delinquency, John Bowlby postulated his attachment theory based on an innate need to form close affect-laden bonds, primarily between mother and infant. Among studies in brain circuits underlying attachment, for example, Kim and colleagues (2010) showed that mothers who reported higher maternal care in childhood showed larger gray matter volumes and greater functional responses in some of the same brain regions implicated in appropriate responsivity to infant stimuli in human mothers (Swain & Lorberbaum 2008; Swain 2011; Swain et al. 2012; 2014). Thus, by studying the brain basis of the interactive baby-signal/parent-response (Swain et al. 2004) in the parent-infant dyad (Mayes et al. 2005), we may discover candidate brain mechanisms for a psychological fitness function in humans for intentional change.

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The perils of a science of intentional change

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Abstract: The attempt to construct an applied science of social change raises certain concerns, both theoretical and ethical. The theoretical concerns relate to the feasibility of predicting human behavior with sufficient reliability to ground a science that aspires to the management of social processes. The ethical concerns relate to the moral hazards involved in the modification of human social arrangements, given the unreliability of predicting human action.

Whether intended or not, there is an illuminating ambiguity in the subtitle of the target article. The phrase "toward a science of intentional change" can be interpreted in at least two ways. First, there is the science that studies changes in human intentional or representational systems, such as language and culture. This science would investigate the ways in which the human capacity to represent the world has evolved, perhaps using insights from the evolution of other representational and communicative systems found in other species. This leads to a theoretical question about the nature of human cognition, posed through the lens of the theory of evolution. How can human intentional systems both be adapted to solve certain cognitive problems and yet be flexible enough to occupy a variety of cognitive niches?

Second, there is the science that would attempt to achieve changes in human society *intentionally*. This science would be not just explanatory but an applied science such as engineering, deliberately aiming to modify human social arrangements in order to achieve certain outcomes. This leads to a more practical question. How can the human environment be purposely altered in order to encourage cooperation and eliminate destructive behavior? There is also perhaps a third reading of the title, which straddles the first two, and concerns the science that would seek to alter human society by purposely changing our intentional or representational systems. How can human intentional systems be modified in such a way as to re-engineer our social arrangements for the sake of better outcomes? In this commentary, I will try to raise concerns about the answers that Wilson et al. give to each of the first two questions in turn, concerns that also pertain to the third question.

It is tempting to answer the first question in a glib fashion, simply by saying something about striking a balance between adaptiveness and flexibility. Indeed, the authors themselves, in using the analogy of the immune system, acknowledge that there is no reason that adaptiveness and flexibility cannot coexist. It is clearly a matter of achieving the right combination of innate responses (so as not to have to reinvent the proverbial wheel for every variant on a familiar situation) and learning (so as not to come up with an inappropriate programmed response to a situation bearing a mere superficial resemblance to a previously experienced one).

A variety of answers to this question have been given by a number of cognitive scientists working within a broadly evolutionary framework (see, e.g., Buller 2005; Carey & Spelke 1994; Cummins & Cummins 1999; Mallon & Stich 2000). There is a great deal more work to be done on this topic when it comes to specific human cognitive capacities, as the balance is likely to be different when it comes to different human abilities. However, any attempt of this kind seems incompatible with what has been called the "massive modularity hypothesis," which posits "hundreds or thousands" of cognitive modules (Tooby & Cosmides 1995), each specifically designed for a narrowly defined cognitive task. On such an evolutionary model, there is little room for a compromise between adaptation and flexibility, simply because the model emphasizes adaptive cognitive modules to the exclusion of cognitive plasticity. Wilson et al. do not seem to acknowledge that this version of evolutionary psychology is not compatible with what we know about the flexible behavior of human beings.

When it comes to the second question I have two concerns, one theoretical and the other ethical, both of which I think deserve more attention by the authors. The theoretical concern has to do with the feasibility of predicting human behavior reliably enough as to warrant constructing a science of social change. One of the lessons of the cognitive revolution is that human behavior cannot always be predicted, though it can often be successfully explained in hindsight. Not only is the prediction of human behavior not feasible when one restricts oneself only to citing environmental variables; even if one posits internal cognitive states, these states do not always enable one to predict behavior (Andrews 2012). The unreliability of prediction when it comes to complex natural systems, whether meteorological systems, biological ecosystems, or human societies, means that it is risky to intervene to produce certain desirable outcomes. The practice of cloud-seeding in meteorology is just one example of the way in which the attempt to interfere in the workings of a complex natural system can have unforeseen consequences. Similar considerations apply to biological ecosystems: It would be dicey to alter a population's environment in order to get a lineage to evolve in a certain direction. Likewise, an applied science of intentional social change is liable to be on shaky ground, as the specificities of each human community and social context are likely to render prediction quite unreliable.

Given the precariousness of predicting the effect of social interventions, the moral hazards of such attempts at social engineering loom especially large. There have no doubt been various successes when it comes, say, to modifying classroom settings in such a way as to improve learning outcomes; but generalizing from these success stories to human society at large is a risky endeavor. The advantages of enhancing human cooperative behaviors, reducing violence, and other desirable outcomes need to be weighed seriously against the ethical costs of interventions involving social control that may have unforeseen consequences. Among the principles that the authors endorse when it comes to the modification of human behavior is that of "consensus decision making," which holds that people prefer "to do what *we* want, not what *they* want." But if so, then attempts to become "wise managers" of social behaviors are unlikely to be welcome in general, and are liable to backfire.

Incorporating coordination dynamics into an evolutionarily grounded science of intentional change

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Abstract: We suggest the authors' endeavor toward a science of intentional change may benefit from recent advances in informationally meaningful self-organizing dynamical systems. Coordination Dynamics, having contributed to an understanding of behavior on several time scales – adaptation, learning, and development – and on different levels of analysis, from the neural to the social, may complement, if not enhance, the authors' insights.

Inspired by the notion of a "Darwin machine," Wilson et al. aim to reconcile diametrically distinct evolutionary processes, such as innate versus adaptive and domain-general versus task specific, in a move toward a science of behavioral and cultural change. We applaud this step, though we think that the authors' rapprochement between Darwin machines and "multi-agent cooperative systems" requires some elaboration. What seems to be missing are the concepts, methods, and tools of self-organizing dynamical systems tailored specifically to the coordinated activities of living things – how they move, adapt, learn, develop, and so on (Beek et al. 1995; Calvin & Jirsa 2010; Haken et al. 1985; Kelso 1995; Kelso & Haken 1995; Schöner & Kelso 1988; Turvey & Carello 2012; Warren 2006; Zanone & Kelso 1992). Among others, Coordination Dynamics (CD) has long been inspired by the works of Howard Pattee, who understood the significance of biological coordination, particularly the complementary nature of symbolic and dynamic descriptions (Kelso & Engstrøm, 2006; Pattee & Raczaszek-Leonardi 2012).

Instead of opposing genetically fixed and adaptive processes, Coordination Dynamics sees them as dual processes evolving on different time scales. Apparently "fixed" processes are not immutable; they are stable or slowly evolving. In complex systems, processes evolving on slower time scales have been shown to constrain faster ones (Haken 1983). This opens the possibility to inquire under which conditions fast-evolving processes escape such slowly evolving (viz. inherited) constraints and reorganize the entire behavioral repertoire. Evidence shows that by scrutinizing how behavioral stability is lost or increases, it is possible to address the fundamental nature of change on several time scales: behavior (Schöner & Kelso 1988), development (Sporns & Edelman 1993; Thelen & Smith 1994; Thelen et al. 1987), learning (Zanone & Kelso 1992), and adaptation (Warren 2006).

Intentional change acts not on a blank slate but on an initial behavioral repertoire that favors or alters intentional action (Johnston 1981). A basic aspect of self-organizing CD is that elements of any nature tend to coordinate spontaneously when information is exchanged (usually bidirectionally) with the environment, creating "for free" intrinsic coordination tendencies. Such tendencies are not fixed but constitute a dynamic potential – the initial behavioral repertoire – that inhabits the same information space as intention (Kelso 1995; 2002). This is a reciprocal interaction: The repertoire shapes, while being shaped by, intentional forcing. Evidence on both behavioral and brain levels shows that an intentional change of behavior is determined by the relative stability of pre-existing patterns in the repertoire (DeLuca et al. 2010). Such tendencies specify the nature of change-driving parameters, the competitive or cooperative mechanisms involved, the gradual or abrupt pathways of behavioral evolution, and the transfer of acquired changes (Kostrubiec et al. 2012; Zanone & Kelso 1992; 1997). In line with a science of intentional change, CD suggests that the paths and outcomes of behavioral evolution are predictable. Prediction is possible, however, on the condition that the relevant variables capturing coordination tendencies are identified and the initial behavioral repertoire assessed before applying change-driving factors.

If, like the authors, CD rejects the blank-slate tradition, the question arises of how the initial behavioral repertoire prior to learning specifies criteria for selection mechanisms to operate. Although useful, Skinner's (1984) "selection by consequences" leaves open this issue (Timberlake 1990).

In our work on learning dynamics (e.g., Kostrubiec et al. 2012), careful measurement of the initial repertoire allowed the discovery of "selection via instability" and "selection via matching" principles (Kelso 2000). The former predicts that when the initial repertoire contains only a few stable patterns, such that they and environmental requirements are far apart in pattern space, competition arises, leading to instability and sudden, abrupt phase transitions, at which a wide range of unstable, transient patterns are generated. Once one of them succeeds in dominating the system, it tends to persist as a new stable pattern in the repertoire. Conversely, when the required and initial patterns are close to each other in pattern space cooperation between them ensues. This entails a smooth, gradual shift of one of the initial patterns in the repertoire that matches the environmentally required behavior but does not add to the number of patterns in the repertoire itself. Hence, the contingent mechanism for change is "selection via matching."

Empirical data indicate that selection via instability leads to long-term persistent behavior, whereas the outcomes of selection via matching are rapidly forgotten (Kostrubiec et al. 2006).

In the last analysis, cooperation and competition dictate the path of change (viz. smooth or abrupt) and Darwinian-like manifestations (viz. generation, selection, retention) appear as observable *a posteriori* outcomes. A key aspect the authors may consider is that the initial behavioral repertoire and its essentially nonlinear dynamics influence not only how new behaviors are formed but also their sustainability.

Viewing selection as a competitive process, the authors argue that an account of coordination between distinct processes around a given task is required. CD may help in clarifying what cooperation means. Evidence suggests that due to the tremendous degeneracy of living systems, where the same outcome may be produced by different combinations of elements and via different pathways, the significant functional units are context-dependent coordinative structures (Kelso 2009). Coordinative structures are softly assembled; all the parts are weakly interacting. Perturbing one part may produce a remote effect somewhere else without disrupting – indeed preserving – integrity of function. Coordinative structures are collective states whose spatiotemporal dynamics prove to be quite rich, including interesting transient regimes that are neither fully ordered nor disordered in space and time. For present purposes, a system may be termed "cooperative" if it is open to information exchange and hosts numerous context-dependent elements whose nonlinear interaction leads them to coordinate. Viewed in this light, a Darwin machine is a cooperative system in which the slowly and rapidly adapting parts remain separated while transiently interacting. Such dual coexisting tendencies would mean that the coordination dynamics of a Darwin machine are metastable, thereby providing a number of evolutionary advantages (Kelso 2012).

Evolving the future by creating and adapting to novel environments

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Abstract: Adaptation demands effective responses to both recurrent and novel environmental challenges. Developmental plasticity and domain-general mechanisms have important consequences with respect to our human capacity for imagining, creating, and adapting to novel environments. They facilitate the evolution of any cognitive mechanism, no matter how opportunistic, flexible, or domain-general, that is able to solve new problems or achieve new goals.

This brief comment is intended to commend the authors on their ambitious expansion of core evolutionary theory toward an applied social science and to address the first of their two goals: that of sketching a science of intentional change centered on evolution that effectively resolves the "paradox of elaborate genetic innateness and elaborate open-ended flexibility" (sect. 4, para. 2).

The genetics revolution made possible by the technological advances in the post-genomic era has led to fundamental changes in the working paradigm of the genotype-to-phenotype relationship. Rather than separate forces acting on the organism, genes and the environment act together, often in highly complex ways. Rather than immutable, DNA is open to some, perhaps substantial, environmental influence. Rather than the sole biological agent of heritability, the epigenome can also be inherited, it is now clear. Therefore, from a post-genomics perspective, the environment is as crucial as the DNA sequence is for constructing the phenotype.

Matching phenotypes with their environments is the critical adaptive problem (LaFreniere & MacDonald 2013). To be successful, each species (or each cultural group or each individual) must be continuously capable of effectively responding to both recurrent and novel environmental challenges. In this commentary, I highlight two basic processes by which phenotypes become adapted to novel or changing environments: (1) developmental plasticity and (2) domain-general psychological mechanisms.

Developmental plasticity refers to the process by which a given genotype can give rise to a range of different physiological or morphological types in response to different environmental inputs during development. Besides facilitating adaptation of the organism to specific environmental niches, developmental plasticity has important consequences with respect to our human capacity for open-ended change. If the generation of phenotypes is conditional and dependent on external or environmental inputs, evolution can proceed by a "phenotype-first" route with genetic change following, rather than initiating, the formation of morphological and other phenotypic novelties (West-Eberhard 2003). As a result of modularity and plasticity, the organism can respond to new situations that recur with a novel trait, which then is able to spread throughout a population via selection for the ability required to produce the trait. In this view, evolution begins with a recurrent developmental change brought about either by a mutation or (more commonly) by environmental induction. Natural selection then consolidates the trait by modifying genes influencing the regulation of the trait.

Rather than relying primarily on mutations to structural genes within the DNA, evolution more often simply rearranges developmental regulatory genes to create novel structures, often conserving a similar program or module in a host of organisms. Rather than always viewing the organism as passively shaped by the environment, it is often the behavior of the organism that actively *creates* the environmental conditions under which morphological traits are then selected (Wcislo 1989). This is especially true in humans. In this view, the processes of genetic assimilation are set in motion by the behavior of the organism. As a consequence, behavior often takes the lead in evolution, in as much as genetic-based morphological changes often follow the path initiated by behavioral innovations.

Given the evolutionary logic that predominates today in evolutionary psychology (i.e., that recurrent environmental situations have led to modules specifically designed to respond to them), another question that remains is whether there are other types of plasticity capable of dealing adaptively with novel environments. The narrow view of evolutionary psychology criticized by the authors wrongly denies the overwhelming importance of domain-general psychological mechanisms in humans for imagining, creating, and adapting to novel environments. As the authors effectively argue, instead of pitting themselves against their caricature of the social sciences as a monolithic standard social science model, evolutionary psychologists need to embrace aspects of mainstream psychology that are critical in constructing a science designed to manage change. Domain-general mechanisms of classical conditioning, operant conditioning, and social learning enable organisms to take advantage of important contingencies that were not recurrent over evolutionary time (MacDonald 2013). In this sense, human cognitive ability – prototypically human general intelligence and problem solving – enables novel solutions to various human goals. Evolved motivational systems facilitate the evolution of any cognitive mechanism, no matter how opportunistic, flexible, or domain-general, that is able to solve the problem or achieve the goal.

Domain-general mechanisms: What they are, how they evolved, and how they interact with modular, domain-specific mechanisms to enable cohesive human groups

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Abstract: Domain-general mechanisms are evolutionarily ancient, resulting from the evolution of affective cues signaling the attainment of evolutionary goals. Explicit processing is a particularly important set of domain-general mechanisms for constructing human groups – enabling ideologies specifying future goal states and rationalizing group aims, enabling knowledge of others' reputations essential to cooperation, understanding the rights and obligations of group membership, monitoring group members, and providing appropriate punishments to those who deviate from group aims.

The target article proposes that domain-general psychological mechanisms are essential to creating cohesive, effective human groups. I agree, but elaborate on what domain-general mechanisms are, how they can evolve, and how they may control domain-specific mechanisms.

The target article avoids dealing with the difficulties involved in proposing domain-general psychological mechanisms that have been raised by evolutionary psychologists, relying on an analogy with the immune system that does not shed light on the evolution of domain-generality.

Domain-generality is evolutionarily ancient. Although there are a variety of evolved, special-purpose learning mechanisms, learning is also characterized by domain-general mechanisms that are able to achieve evolutionary goals by making novel and serendipitous associations with environmental cues. Such mechanisms are domain-general because they are able to respond adaptively to ephemeral, nonrecurrent environmental regularities that are detectable by the organism's sense organs (i.e., they are not restricted to statistical regularities over evolutionary time, as required by evolutionary psychologists; e.g., Barrett & Kurzban 2012; Tooby & Cosmides 1992; see MacDonald 2013). Such mechanisms can evolve because of the evolution of affective cues (prototypically pain and pleasure) that signal the attainment or nonattainment of evolutionary goals (e.g., satiation of hunger, the pleasure of sexual intercourse) (MacDonald 1991; 2013; MacDonald & Hershberger 2005). This then allows humans and animals to alter their behavior in response to ephemeral, nonrecurrent environmental contingencies.

Affective motivational mechanisms imply a set of adaptive problems to be solved but whose solution is underspecified. Such systems enable the evolution of any cognitive mechanism, no matter how opportunistic, flexible, or domain-general, that is able to solve the problem. Humans evolved the domain-general symbolic systems and reframing processes emphasized in the target article, as well as mechanisms underlying general intelligence, particularly the executive functions of working memory and a central executive able to direct attention and manipulate information that it receives from inputs from specialized, domain-specific mechanisms (e.g., spatial and symbolically coded information) (Chiappe & MacDonald 2005; Geary 2004).

The target article reviews several validated programs for change, but no attention is given to exactly what evolved mechanisms are involved and how domain-specific and domain-general they are. I argue that an evolutionary science of change must carefully tease out domain-specific, modular mechanisms from domain-general mechanisms, and in the case of the latter, must be clear on exactly how they are domain-general and how this promotes change.

An important contrast is between explicit and implicit processing. Implicit processing is characteristic of modules emphasized – often to the exclusion of domain-general mechanisms (e.g., Tooby & Cosmides 1992) – by evolutionary psychologists. Modules are evolutionarily ancient and their operation is fast, unconscious, automatic, and domain-specific (designed to solve specific problems). On the other hand, explicit processing is relatively recent and processing is conscious, relatively slow, effortful, and domain-general (Stanovich 2004). Explicit and implicit processing are intimately related. Particularly important is the effortful control of implicit processing related to social and emotional behavior, including control over evolved modules designed to solve problems of survival and reproduction that were recurrent over evolutionary time (MacDonald 2008; 2009; 2010). The inputs to effortful control mechanisms include a wide range of nonrecurrent information – information resulting not from evolutionary regularities but from explicit appraisals of costs and benefits related to the contemporary world of DNA testing and video recording.

The control of evolved modules by domain-general explicit processing is a critical aspect of behavioral change. MacDonald (2008) describes the psychology and neurobiology of how effortful control can result in behavioral change in the case of aggression, ethnocentrism, emotional behavior, and drug use.

Domain-general mechanisms can indeed produce a wide variety of phenotypes for selection to act upon (the analogy of the immune system used in the target article), but it is not just a matter of randomly producing thousands of hopeful monsters. Explicit processing involves taking in information from a variety of modular systems (e.g., perceptual information, affective desires such as sexual desire), coordinating and integrating it, and making plans of action that may involve effortful control of modular desires (Geary 2005; MacDonald 2008). But it may also include envisioning possible future states (e.g., utopian visions of the future central to Marxist ideology made possible by symbolic processing) and rationalizing group aims (MacDonald 2009; 2010), and finally deciding to act.

Explicit processing is likely unique to humans, or at least is so highly elaborated among humans that there is a qualitative difference between humans and animals. Explicit processing is required to enable at least some of the qualities essential for successful groups noted in the target article, including the following:

Group identity. Some animals have a strong sense of group identity and group boundaries (e.g., van der Dennen 1999) that is presumably modular. However, the rights and obligations of human group membership are typically explicitly articulated – they are often formally written and may be subject to judicial oversight (e.g., being in the military, a union, or a religious sect). The vast differences among human groups in rights and obligations and the fact that rights and obligations may change rapidly in the contemporary world strongly suggest that they are processed explicitly rather than exclusively via evolved mechanisms designed to track regularities of group living over evolutionary time.

Proportional costs and benefits; monitoring. Explicit processing allows people to build explicit representations of others' reputations (e.g., for shirking communal work) and the costs and benefits of actions, thus enabling human cooperation (MacDonald 2008). Whereas modular mechanisms have built-in assessments of costs and benefits (e.g., Buss & Shackelford 1997), explicit representations of others' reputations are able to track rapidly changing, novel environmental contexts (e.g., developing new technology to assess others' reputations) and are able to form explicit memories and written records of past interactions with others, thus enabling indirect reciprocity (e.g., Semmann et al. 2005; Smith 2005).

Punishment; fast and fair conflict resolution. Assessing the fairness of conflict resolution is often complex, requiring explicit knowledge of contemporary contexts incomprehensible by mechanisms attuned to regularities of the evolutionary past (e.g., assessing whether a group member is embezzling funds via computer fraud). On the basis of such explicit assessments, punishment can be finely graded, from gentle reprimands to expulsion, to ensure the viability of the group.

Intentional change, intrinsic motivations, and goal generation

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Abstract: Wilson et al. draw our attention to the problem of a science of intentional change. We stress the connection between their approach and existing paradigms for learning and goal generation that have been developed in machine learning, artificial intelligence, and psychology. These paradigms outline the structural principles of a domain-general and teleologically open agent.

Wilson et al. aim "to sketch a basic science of intentional change centered on evolution." They warn that a critical issue is the lack of a conceptual unification among the involved disciplines. In the same spirit, we believe it is worthwhile drawing attention to a pair of unmentioned and related research areas that have addressed the issue of change in machine learning, artificial intelligence (AI), and developmental studies – namely, intrinsic motivations (IM) and hierarchical open-ended architectures (HOA). Both areas are closely related to the evolutionary psychology (EP) versus standard social science model (SSSM) debate and endorse the SSSM-related "open-ended capacity for change" in contrast to the "elaborate innateness" of EP.

To recap, the main connections between IM/HOA and intentional change are the following. First, thanks to their design-oriented approach, IM/HOA help us to understand the key notions of intentional change and open-endedness. Second, they clarify the details of the Darwin machine whose stability is crucial for "positive intentional change." Third, likewise to Wilson et al., both IM and HOA address the issue of learning new motivations.

The notion of intrinsic motivation aims to model doing something because it is inherently interesting or enjoyable (Deci & Ryan 1985). In developmental psychology, there has been considerable interest in IM as a way to add new goals (Barto 2013; Mirolli & Baldassarre 2013). Is intrinsically motivated behavior the result of innate metacognitive rules such as maximizing novelty, surprise, curiosity, and exploration (Berlyne 1966; Dayan & Balleine 2002; Dember & Earl 1957; Dickinson & Balleine 2002)? Or the outcome of innate motivational open-endedness (Barto et al. 2004; Manzotti & Tagliasco 2005)? Both options are currently being scrutinized (Georgeon et al. 2012; Manzotti 2010; Oudeyer & Kaplan 2007). The objective of these approaches is to apply traditional learning paradigms (respondent and operant conditioning) to explain how an intentional cognitive agent may produce a new goal. Hence, there is a critical difference between being motivated (either intrinsically or extrinsically) and being able to develop new goals. The notion of IM encourages considering intentional change from a learning standpoint. Motivational theories address learning and decision making.

In both machine learning and AI, reinforcement learning (RL) has modeled with success motivational processes. RL "addresses how predictive values can be learned, it is naturally relevant to the study of motivation" (Barto 2013, p. 19). Yet, RL seldom considered the issues of generation and evolution of reward functions (Duda et al. 2001; Sutton & Barto 1998). As a result, RL has not focused enough on the Kantorian key notions of evolution and devolution of stimulus functions (Kantor 1958). Usually, RL assumes that the reward function is given inside a module – the critic – whose nature is left unspecified. In RL, the theoretical point of departure is the study of IM. In fact, IM extend the original paradigm since intentional change may be seen as the result of teleological open-endness (Baldassarre & Mirolli 2013; Barto et al. 2004). Furthermore, convincing experimental evidence about the neural underpinnings of IM has been put forward (Gottfried et al. 2003; O'Doherty et al. 2001). In IM, a revised and open notion of RL's critic is the abstraction representing where and how new goals become part of the agent teleological structure. The notion of IM helps to complete a proper basic scientific foundation for an applied science of intentional change.

We have therefore reached the second area of research we want to draw attention to. To achieve IMs, an agent must be able to represent unexpected external stimuli and states of affairs. Hierarchical open-ended architectures (HOA) are a promising option (Dileep 2008; Kurzweil 2012; Manzotti et al. 2012; Sendhoff et al. 2009). HOAs stand for architectures designed to represent and to interact with a potentially unlimited hierarchy of external stimuli. In fact, if a system could not develop a hierarchically organized manifold of concepts, how could it develop new motivations? Motivational openness must be flanked by conceptual and perceptual openness. A system must be able to extend its stimulus repertoire to use it as a reward. Borrowing von Uexküll's *Umwelt,* a process of intentional change modifies the agent's *Umwelt* (von Uexküll 1957). From a neural perspective, there is evidence that this capability is a by-product of the interplay between the neocortex and the basal ganglia (Daw & Doya 2006; Doya 1999). Interestingly, Doya (1999) maintains that the CNS, although genetically geared toward ontogenetic development, is teleologically open. Moreover, the three main learning paradigms – supervised, unsupervised, and reinforcement learning – seem to be largely unbiased by evolutionary fine-tuning. According to Doya, "the learning modules specialized for these three kinds of learning can be assembled into goal-oriented behaving systems" (Doya 1999, p. 961). This idea runs afoul of the massively modular view of the mind (as is often the case with EP). Two considerations follow. First, the discussion between EP and SSSM may benefit from these models and from the resulting interpretation of neural data. Second, the relation between learning and goal generation is emphasized.

In sum, these findings, together with the HOA and the IM, detail the necessary requirements of the Darwin machine that Wilson et al. advocate as the necessary stable core of any intentional change. In our commentary, we emphasize the relation between the proposed forthcoming science of intentional change and other selected approaches that share key fundamental insights – namely, the exploitation of some models for goal generations (open-endedness, teleological openness, intrinsic motivations). Furthermore, pace Barkow et al. (1992), domain-general learning does not appear any longer a theoretical impossibility. On the contrary, many scholars are working on domain-general cognitive architectures (Dileep 2008; Doya 1999; Horton & Adams 2005; Kurzweil 2012; Markram 2006; Sendhoff et al. 2009). However, these models may shed a new light on why "our ability to change our behavioral and cultural practices lags far behind our ability to manipulate the physical environment" (sect. 1, para. 2). By integrating these approaches with their own, Wilson et at. may strengthen their case and gain a deeper understanding of the basic science of intentional change.

Niche construction is an important component of a science of intentional change

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Abstract: Wilson and colleagues are correct that a modern theory of evolution must go beyond reliance on natural selection. Niche-construction theory, although it does not ignore selection, emphasizes the capacity of organisms to modify environmental states, often in a manner that suits their genotypes. Such matches are the dynamic products of a two-way process that involves organisms both responding to "problems" posed by their environments through selection and setting themselves new problems by changing environments through niche construction.

Wilson and colleagues are to be congratulated for their interest in developing a science of intentional change, which is a critical component of human evolution. They make the excellent point that all too often the biological sciences and the behavioral sciences seem to be miles apart in how they approach human phenotypic variation – a separation that even makes its way down into individual disciplines. To extend the point they make with respect to divisions within psychology, the various social and behavioral sciences in general share an interest in phenotypic change, but each at a different scale of analysis. To grossly oversimplify, psychology tends to focus on the individual, anthropology on small groups and communities, and sociology and human geography on populations. Perhaps the widest lens is used by macroeconomics, which renders human societies as abstract mathematical systems that are brought full circle through highly simplified assumptions about the behavior of individuals. Having these different scales of analysis is a strength, but it also presents a challenge for finding a unified approach to human behavior, which, despite comprehensive reviews in this journal (e.g., Gintis 2007; Mesoudi et al. 2006) and elsewhere (e.g., Laland & Brown 2011; Mesoudi 2011; Mesoudi et al. 2004), has been difficult to achieve (Gintis 2009b).

I suggest there is an important component of the discussion that has been left out of the blueprint for consilience, at least in its explicit form. That component is niche construction, which is the process whereby organisms, through their activities, interactions, and choices, modify their own and one another's niches, thereby acting as codirectors of their own evolution as well as that of others (Odling-Smee et al. 2013). The discussion by Wilson and colleagues is wonderfully preadapted for niche-construction theory. In fact, much of what they state or imply constitutes the basics of the approach. I paraphrase and slightly expand three of their points:

1. Evolution is the overarching process by which organisms change in relation to their environments, not only by genetics but also by mechanisms of phenotypic plasticity that evolved by genetic evolution, including some that count as evolutionary processes in their own right.
2. Complex special-purpose adaptations that arise through genetic evolution result in nongenetic mechanisms of inheritance that are capable of rapidly adapting organisms to their current environments.
3. Many species have the capacity for open-ended learning at the individual level, but humans have an elaborate capacity at both the individual and the social levels as a result of culture, which can be defined as information capable of affecting the behavior of individuals and which they acquire from other individuals through any of a number of social-learning pathways, including teaching and imitation (Richerson & Boyd 2005).

Wilson and colleagues rightly point out that the conventional view of evolution is that species, through the actions of natural selection, come to exhibit those features that best enable them to survive and reproduce in their environments. Under this perspective, "adaptation is always asymmetrical; organisms adapt to their environment, never vice versa" (Williams 1992, p. 484). Alternatively, niche construction creates adaptive symmetry by using and transforming natural selection, thus generating feedback in evolution at various levels (Laland & Sterelny 2006). To quote Levins and Lewontin, "The organism influences its own evolution, by being both the object of natural selection and the creator of the conditions of that selection" (Levins & Lewontin 1985, p. 106). Niche-constructing species play important ecological roles by creating and modifying habitats and resources used by other species, thereby affecting the flow of matter and energy through ecosystems. This process, often referred to as "ecosystem engineering" (Jones et al. 1994), can have significant downstream consequences for succeeding generations, leaving behind an "ecological inheritance" (Odling-Smee 1988).

One key emphasis of niche-construction theory – certainly one that sets it apart from the conventional view of evolution – is the role played by acquired characters in transforming selective environments. This is particularly relevant to human evolution, where our species has engaged in extensive environmental modification through cultural practices. This is why humans have been referred to as the "ultimate niche constructors" (Odling-Smee et al. 2003, p. 28). Humans can construct developmental environments that feed back to affect how individuals learn and develop and the diseases to which they are exposed.

There is good reason to think that selective feedback from human cultural activities to human genes – as well as to those of other species – may be a general feature of human evolution. Given that geneticists have identified several hundred human genes subject to selective sweeps over the last 50,000 years or less, it may be that gene-culture coevolution is the dominant form of human evolution (Feldman & Laland 1996; Laland et al. 2010; Richerson et al. 2010). If so, then there is all the more reason to adopt the kind of analytical framework advocated by Wilson and colleagues, perhaps with an explicit role for niche construction and the emphasis it places on the power of human agency as an evolutionary process (Kendal 2011; Laland & O'Brien 2010; O'Brien & Laland 2012).

Space precludes a side-by-side comparison, but Wilson and colleagues' Figure 1, which illustrates interventions by developmental phase, and their Table 2, which lists community interventions and policies, would be right at home in any study conducted by niche-construction enthusiasts. With slight modification, their Figure 1 becomes a construction chain – a flow diagram that summarizes the immediate and downstream consequences of an act of niche construction and its consequences for other processes, operating at other levels and feeding back into the phenotypes, and often the genotypes, of the actors. It does not matter whether one is talking about planting yams in West Africa, which has tremendous downstream consequences in terms of the balance between malaria and sickle-cell disease (O'Brien & Laland 2012), or Wilson and colleagues' development of community policy to lower juvenile drinking, which has similar consequences in terms of fetal alcohol syndrome, crime, and a rash of other problems. What matters is that we understand that they are both instances of human niche construction and that neither can be understood simply in light of classical evolutionary theory.

Evolving the future by learning from the future (as it emerges)? Toward an epistemology of change

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Abstract: At the core of Wilson et al.'s paper stands the question of intentional change. We propose to extend this notion by introducing concepts from the domains of innovation and knowledge creation. By going beyond their "acceptance and commitment therapy" approach we present a comprehensive framework for a theory of change culminating in the change strategy of "learning from the future as it emerges."

Even though Wilson et al. talk about "evolving the future" and the capacity for positive open-ended change and how it can be brought about in various domains, there is no explicit mention of the perspective of *innovation* and *knowledge creation* as one of the main sources for (intentional) change and bringing forth new realities (except for a short reference to Johnson [2010]).

Wilson et al. pose the question of why positive behavioral and cultural change is sometimes so hard to achieve and why something that seems to be an adaptation occasionally turns out to be inadequate. Our resistance to change seems to have a dilemma that is intrinsic to almost all kinds of radical change or innovation as one of its deeper causes: On the one hand we strive for radical change, we are interested or even fascinated by it; on the other hand we are irritated when confronted with something radically new, because it fits neither into our categories of perception nor into our mental models. The reason for the resistance against such changes seems to lie in this situation of loss of control, which is an unpleasant experience for most humans. So, the original question can be reformulated: How can one produce positive, in the sense of *sustainable*, change that both is *fundamentally new* and *organically fits* into existing structures, or is in continuity with the already existing categories of our cognition (compare Maturana & Varela's [1980] or Luhmann's [1984] concept of *Anschlussfähig/connectivity*)?

On the individual level, the authors tackle this problem by proposing a three-step approach having the goal to increase response variability (sect. 3.1): (1) behavior therapy (BT) (adapting and rewiring behavioral responses), (2) cognitive behavior therapy (CBT) (reconceptualizing the problem space in the symbolic realm), and (3) "acceptance and commitment therapy" (ACT). ACT aims at identifying one's most important life goals in a mindful manner and valuing and firmly following them. The questions of what these goals could be and where they come from on a more general level remain open – finding an answer to these questions is, however, critical for successful sustainable change. What is already a hard question on an individual level becomes even more complex and challenging in the realm of innovation and change on a group/organizational or cultural level. It seems that the processes of increasing variability and selecting according to criteria (where do they come from?) should be complemented by another strategy hinted at by Wilson et al.: mindfulness, attentiveness, or wisdom.

The proposition of this commentary is to extend the above approach to intentional change by introducing concepts from the domains of innovation and knowledge creation. They have their roots in cognitive science, epistemology, innovation studies and organization science (Fagerberg et al. 2006; Fagerberg & Verspagen 2009), and second-order cybernetics (of semantics) (Krippendorff 2006). We propose the following conceptual and epistemological framework differentiating various strategies of change (see also Fig. 1):

1. *Downloading and reacting*: Existing and successful behavioral patterns from the past are downloaded and applied (⇒ no change occurs).
2. *Single-loop strategy* of change/learning (adapting and restructuring): This circular process is closely related to the evolutionary dynamics by adapting to the environment through generating variation and testing it by behavioral expression. Such a strategy leads to optimizing existing structures; oftentimes, it is referred to as "incremental innovation" (Ettlie et al. 1984) and can be compared to the BT approach.
3. *Double-loop strategy* of change/learning (redesigning and reframing) (Argyris & Schön 1996): Humans are not only capable of simply adapting to the environment, but also able to *reframe* their symbolic/symbotype system by *reflecting* on their assumptions or values and changing them (e.g., a change in premises in our cognitive framework, paradigmatic shift in the realm of science [Kuhn 1970], radical innovation [Corso et al. 2009; Ettlie et al. 1984]). That creates a new space of knowledge opening up an unexplored scope of potential behaviors (compare to the CBT approach). Both the single- and double-loop strategies understand change as adaptation and as "learning from the past."
4. *"Learning from the future as it emerges"* (regenerating): Going one step further, our cognition and symbolic capabilities enable us to intellectually deeply penetrate the environment in order to achieve a profound understanding of the *potentials* that are not yet realized in a particular part of the (internal or external) environment – potentials that are hidden, that need to be discovered, developed, and cultivated in order to emerge in the future. This is a rather different strategy, which we refer to as *Emergent Innovation* (Peschl & Fundneider 2008; in press; Peschl et al. 2010). It is partially based on Scharmer's (2007) Theory-U and does not primarily follow the classical strategy of trial and error, variation, selection, and adaptation in order to bring forth change and innovation, but uses deep knowledge about the core of the object of innovation (OOI) and its potentials in order to "learn from the future as it emerges." In other words, these potentials offer a pointer toward the future possibilities that might emerge. This leads to changes that fit into the environment (because they have their basis in the core of the OOI) and are

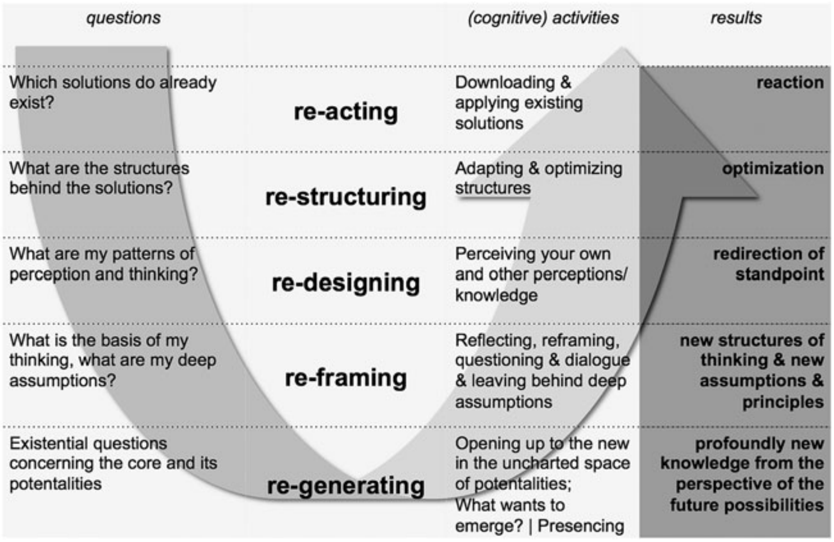

Figure 1 (Peschl & Fundneider). Strategies and levels for dealing with (open-ended) change (they do not exclude each other). (Adapted from Scharmer 2007, p. 29. Reprinted with permission.)

at the same time fundamentally new (because they tap yet unrealized potentials of the core of the OOI).

Although the above framework stresses an epistemological perspective, one can clearly see the similarities to Wilson et al. (sects. 3.1 and 3.2) on a conceptual level. Taking their ACT approach one step further reveals that our fourth change strategy of "learning from the future as it emerges" follows a slightly different procedure, in which the concepts of *identifying* and *cultivating potentials,* as well as *enabling* intentional change, play a central role.

Besides having to employ a whole new set of cognitive and epistemological skills, as well as attitudes complementing the classical variation-and-selection processes (e.g., openness, patience, letting go, coping with loss of control, deep understanding [of the core potentials], etc.), such an approach has far-reaching implications for innovation and creating new knowledge.

The rich detail of cultural symbol systems

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Abstract: The goal of forming a science of intentional behavior requires a more richly detailed account of symbolic systems than is assumed by the authors. Cultural systems are not simply the equivalent in the ideational domain of culture of the purported Baldwin Effect in the genetic domain.

Wilson and coauthors suggest adopting a more inclusive view of evolution, framed not by genetic inheritance alone but also by the epigenetic, learning, and symbolic modes of inheritance discussed by Jablonka and Lamb (2005). They argue, by analogy with the immunological system, that behavior is produced through an innate component (the modularity model of the brain) coupled with the capacity for individuals to exhibit novel, short-term behaviors (the blank slate model). They place particular importance on the symbolic mode and introduce the term *symbotype* to refer to a network of symbolic relations with the combinatorial capacity, using a few symbolic elements, to produce substantial variation for selection to act on, much like the combinatory possibilities provided in the genetic system by having two alleles at each locus in a chromosome.

There are two problems with their characterization of the symbolic domain. First, they assume that what is expressed in the symbolic/cultural domain is an epiphenomenon of prior patterning: "These higher-order [symbolic] relations *are abstracted from immediate physical properties*, becoming somewhat independent of them, and once established are maintained by their utility, coherence, and role in a social community" (sect. 2.4, para. 2, emphasis added). They posit a sequence going from patterned behavior to cultural traits maintained through their functionality, much like the supposed Baldwin Effect (Simpson 1953) for genetic assimilation. Viewing culture as codification of already existing patterns of behavior assumes culture change stems from selection acting directly on behavior: "symbotypes evolve based on what they cause the organism to do" (sect. 2.4, para. 2). Second, despite the reference to symbolic systems and the constraints on their formation, the authors' analogy with the immunological system implies variation – derived through combinations of symbolic elements – is determined primarily from interaction with the external environment. The immunological system generates variation guided by novel external inputs, not in an independent, *sui generis* manner. Of course, the material consequences of interaction with the external environment are critical to any society, regardless of its cultural framework, ideology, or beliefs.

Missing is delineation of both how the posited interaction is culturally mediated and the way one part of a group's adaptation can become the impetus for other aspects of its cultural adaptation. For example, the adaptation of the Netsilik Inuit to the extremes of an Arctic coastal environment required them to obtain large quantities of salmon during their summer runs, caribou during their migration to the south, and seals through their breathing holes in the Arctic ice during the winter (Balikci 1970). The labor required for obtaining resources varied from one or two families for obtaining salmon to around 20 families for winter seal hunting (Balikci 1970). Each activity, especially seal hunting, was culturally framed with regard to participants and the distribution of resources obtained (Read 2005). For seal hunting, seal meat and blubber were distributed through a culturally defined system of sharing, referred to as *niqaiturvigiit* (Damas 1972), via sealing partners who were distant or nonrelatives and represented the parts of the seal a man would receive from a seal obtained by his partner (Balikci 1970; Van de Velde 1956) – with the meat distributed by the wife of a hunter to the wives of the sealing partners (Van de Velde 1956), thereby being defined as belonging to an extended family (Damas 1969). Each person in a winter camp, then, knew in advance who would get what parts when a seal was killed. Both with seal meat and other resources, complementarity between males and females was expressed through their respective roles as producers and maintainers of resources (Read 2005).

The Netsilik increased the likelihood of surviving under Arctic conditions by skewing the biologically determined sex ratio toward males (Smith & Smith 1994) by the equivalent of extended abortion targeted against a newborn female before she was named, the latter being the point at which a newborn took on the status of being human and became part of their moral world (Balikci 1970). The resulting shortage of females and the high value placed on sons as hunters were an impetus for cousin marriage (Read 2005), which had the effect of reducing the size of the network of close kin relations, thereby requiring winter sealing camps to include families without close, culturally defined kinship ties in a society in which even distant kin, let alone strangers, could be the source of personal violence (Rasmussen 1931). The Netsilik greatly reduced the risk of conflict among distantly related families over any perceived inequity of shared seal meat by their system of sealing partners and meat distribution through wives. In this instance, a solution to one aspect of their interaction with the Arctic environment (skewing the sex ratio) had consequences for the structural organization of their society with regard to marriage (cousin marriage) that, in turn, affected how they interacted with their environment with regard to seal hunting that required large winter camps composed of sealing partners for its success (Read 2005).

More generally, the problem with assuming that what is expressed in the cultural, symbolic domain derives from prior patterning is underscored by the cultural kinship systems that evolved as part of the transition from face-to-face social systems that characterize primate societies to the relational systems central to human systems of social organization (Leaf & Read 2012; Read 2012; Read et al. 2009). Cultural kinship systems have a generative logic that accounts for the structural properties of a kinship terminology system (Bennardo & Read 2007; Leaf & Read 2012; Read 1984; 2001; 2007; 2010; 2013; Read & Behrens 1990; Read et al. 2009; 2013), hence is neither emergent from nor due to the codification of patterns of behavior. Using Clifford Geertz's distinction, culturally determined systems of kinship are models for, not models of, behavior (1973).

The goal of developing a science of intentional behavior is laudable, but depends on having a better understanding of the rich detail regarding the interplay among environment, social context, and cultural construct.

Is the science of positive intentional change a science of objective moral values?

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Abstract: I examine whether Wilson et al.'s argument for a science of positive intentional change constitutes an argument for a science of objective moral values. Drawing from their discussion, I present four reasons for thinking that it may be and some considerations on why it may not be. Concluding, I seek help from the authors.

In the beginning (the Logical Positivist one) was the distinction (between science and values), and to violate it was to commit an egregious fallacy (the naturalistic fallacy of deriving values from facts).

In "Evolving the Future: Toward a Science of Intentional Change," Wilson et al. argue for a theoretical foundation for the sciences of human behavior, including intentional behavior, based on a generalized theory of evolution by natural selection, and they present substantial evidence for successful positive applications of theories of intentional change to problems faced by individuals, groups, and larger populations.

Have our authors disavowed the distinction and committed the fallacy? Maybe and maybe not. I argue that they have provided us with good reasons to disavow and commit. But, maybe, my naturalistic proclivities lead me astray. So, in the end, I turn to our authors for assistance.

Roughly, logical positivists told us that, on the factual side of things, the natural and social sciences were unified hierarchically (physics on top and the social sciences at the bottom) by deductive and reductive relationships reflecting, respectively, epistemic and ontological features. On the value side, science deals with facts; and values find their bases elsewhere.

Nevertheless, they and their successors have conceded that values may affect the selection of research projects and scientific applications. But only cognitive values, such as heuristic, predictive, explanatory, and unifying power, can serve as means to establish the truth of scientific claims. No noncognitive values (e.g., moral values) enter into either the *justification* or the *content* of scientific claims. Therefore, the idea of a science of values is incoherent, and indeed, known historically to be pernicious. Though challenged by feminist philosophers and advocates of the strong program in sociology of science, this separatist view endures, particularly in the biological sciences, where attempts to formulate and put into practice such sciences of values as social Darwinism and Nazi race science have tarnished any aspiring science of values.

Our authors address the more limited question of the unity of the biological and social sciences, arguing that a generalized theory of natural selection unifies all these disciplines. In doing so, they implicitly both reject a reductionistic unification of the sciences, one based on a mechanistic account of the causal factors, and offer an emergentist one. Key to their account is selection by consequences (a broadly teleological process) that distinguishes the activities of living things from nonliving. Change has two sources: both antecedents and consequences bring about significant changes.

What explanation by consequences captures is the goal directedness of living things, including humans and their achievements. The genetic, social/cultural, and intentional consequences explain the presence of the capacities and processes that achieve them. They explain the why of things. The law-like regularities explained by these selection accounts are natural norms: As that is the consequence to be achieved, then you ought to do this. So reason number one for understanding our authors to be presenting a science of values: They are arguing for explanatory sciences of natural *norms*.

Now for reason number two: Our authors present very strong evidence that we have a science of intentional change embodied in a comprehensive theory of cognitive behavioral change and its multiple successful applications. We understand the natural mechanisms that lead to successful intentional actions and know how to apply them intentionally and successfully. Our authors are claiming that there is an empirically well-established explanatory science of *intentional* natural norms.

Here is reason number three: They claim to be proposing an intentional science of "positive" change. The human behavioral sciences and their applications are successful not only because they provide reliable means for carrying out goals whose positive character has been *independently ascertained* by some nonscientific means. They are positive because they also provide reliable means for knowing what are worthy human goals. The sciences of human behavior are sciences of *ends and means*, not merely means. Our authors are arguing for a science of *objective* values.

A fourth reason: Consider the kinds of positive consequences that the applications of the science of intentional change produce and the theories of intentional change explain: avoiding harmful substances, fostering good educational practices and parenting skills – no need to mention the many more. These positive consequences fall under one or other of the categories of behaviors that researchers have found people throughout the world consider part of the moral realm: (1) care/harm; (2) fairness/cheating; (3) liberty/oppression; (4) loyalty/betrayal; (5) authority/subversion; and sanctity/degradation. Our authors are arguing for a science of objective *moral* values. Maybe so.

But, maybe not! Theoretical and historical reasons prompt a traditional reading: The application of theories that enable successful intentional change ensures, merely, that, given *any* goal of intentional change (whether worthy or not) that might be achieved using the methods of behavior therapy, cognitive behavioral therapy, or "third wave" cognitive behavioral methods, that goal likely will be obtained. The consequences aimed for derive from the *preferences* or *decisions* of the individual, group, or population. The science of intentional change does not tell us what goals to pursue. Hence, our authors' science of *positive* intentional change tells us the best way to achieve our goals, but not what makes them *positive*. We have a science of values, manqué. Moreover, that science adheres to the venerable fact/value and nature/norm distinctions. And it does not commit the naturalistic fallacy, thereby escaping any new versions of the likes of social Darwinism or Nazi science.

Yet, our authors' language wavers between objective descriptions of positive consequences and passages where positive consequences are described in terms of what is preferred or desired. And, alas, some passages are open to either reading.

The inevitability of normative analysis

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Abstract: Wilson et al. make the case for taking control of our future using evolutionary analysis. However, they are entirely silent on the ethical questions that must be addressed. This piece emphasizes this problem and notes that the relevant answers will require nontrivial analysis. This is where the humanities become relevant – in particular, philosophy and cultural anthropology.

Wilson et al. are wise to note the troubled history of attempts to apply evolutionary science to designing human futures. Not only should we remember social Darwinism (as they point out) and eugenics (including involuntary sterilization laws that were sometimes enforced in the United States until 1981), but we should also be cognizant of the myriad social and ethical ramifications of recent developments such as the Human Genome Project (Murphy & Lappé 1994; Sarkar 1998). Given this background, it should be obvious that any discussion of intentional social change using evolutionary principles should include explicit discussion of relevant normative issues, especially: (1) What kind of future should we want? and (2) Who makes this decision and how? It is surprising that these questions are not broached in Wilson et al.'s discussion.

There may be two reasons these questions were not broached by Wilson et al. in their discussion: These questions are relevant for any social policy-making process, regardless of whether it is guided by evolution; and the actual examples of behavioral change that Wilson et al. discuss (preventing child abuse, substance abuse, etc.) are relatively mundane and uncontroversial.

Those reasons are insufficient. First, Wilson et al.'s discussion makes it clear that the ultimate goal is to use evolutionary principles to guide much more substantive behavioral changes than the ones discussed in detail in their paper. This ultimate goal leads to problematic territory. For example, they take it for granted that group-level interests are at least on par with individual-level interests. But when we are dealing with human individuals, this is a normative assumption that requires normative justification. In simple situations, such as the classroom examples they discuss, the problem does not appear to be serious. But not all situations will be that simple. For instance, group harmony (*if* that is an appropriate interest) at a provincial or national scale, in religiously regimented societies, may sometimes be achieved only by abrogating individual interests, however they are framed (desires, rights, etc.). Whether, and to what extent, such abrogation is permissible or even desirable seems to vary widely in different cultural contexts – note the contrast between the liberal or radical individualism of most neo-European frontiers compared with the communitarianism of several traditional African and Asian societies.

Whether evolutionary reasoning allows such group interests to be achieved (i.e., it provides the appropriate techniques) does not in any way resolve the normative question of whether this is a goal that should be followed. What evolutionary reasoning does show, however, is that such conflicts are often to be expected. Therefore, instead of advocating intervention based on evolutionary reasoning, I wish to suggest that the appropriate lesson to draw from evolutionary analysis is that more effort be directed toward analyzing and resolving normative issues before we seriously consider intervention as an admissible policy option. This will require insight from a variety of disciplines; obviously the social sciences, but also the humanities, especially philosophy and cultural anthropology.

Second, Wilson et al. appropriately distinguish between short-term and long-term interests and use evolutionary reasoning to show that, once again, conflicts are to be expected. Part of the motivation for using (hierarchical) evolutionary principles is to ensure that long-term interests do not suffer from the pursuit of short-term desires engendered at the level of genetic evolution alone. But what should be regarded as these long-term interests? Even banalities such as the survival of the human species require normative justification – and human survival is sometimes even denied as a relevant goal in discussions in environmental ethics (Ehrenfeld 1978; Sarkar 2005; 2012). But leaving banalities aside, how should we identify long-term interests? More important, how should we act on them. Besides normative desirability, such cases additionally involve deep (probably unquantifiable) uncertainties about the future. Wilson et al. refer several times to climate change, and that is an apt example: scenarios and models help us specify future *projections,* which are not even precise enough to be dubbed *predictions* (Bray & von Storch 2009).

Making ethically appropriate decisions in the face of such added uncertainty raises a further set of normative problems about how to weigh uncertainty against ends (new problems for "practical reason"). The point is that if we are genuinely interested in long-term goals (as apparently required by the evolutionary perspective), such problems posed by deep uncertainties will be standard. (Evolutionary reasoning supports this conclusion: Few would claim any ability of contemporary evolutionary theory to predict the long-term future.) Formal decision analysis clarifies many such problems in the policy realm (Sarkar 2012) but by no means provides algorithms for their solution. I am not claiming that we should therefore abandon evolutionary reasoning or worry about long-term goals; what I am claiming is that we should address our normative problems right from the beginning.

Now, it may turn out that we cannot resolve these normative problems. In that case, I suggest that the appropriate lesson to draw is to proceed with caution – not to let technological virtuosity blind us to our ethical responsibilities. I am glad that Wilson et al. are arguing for an attempt to emerge from the shadow of social Darwinism, eugenics, and the like, and deploy whatever evolutionary insights we have in the design of public policy. Nevertheless, we should move carefully. The ethical problems may turn out to be more intractable than the technological ones.

Let the social sciences evolve

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Abstract: We agree that evolutionary perspectives may help us organize many divergent realms of the science of human behavior. Nevertheless, an imperative to unite all social science under an evolutionary framework risks turning off researchers who have their own theoretical perspectives that can be informed by evolutionary theory without being exclusively defined by it. We propose a few considerations for scholars interested in joining the evolutionary and social sciences.

Wilson and colleagues argue for the integration of evolutionary theory into the human behavioral sciences in order to bring about a science of intentional change. Such an integration is sorely needed: Given current rates of anthropogenic environmental damage, we need to change not only our management of the earth, but also the culturally guided mindsets and the institutions that shape perception and guide behavior. In particular, cultural evolution through selection on guided variation and between-group competition can help us understand how to effect intentional change through direct influence on both variation and selection pressures. But the way in which we approach such interdisciplinary work will play an enormous role in its success.

Evolutionary theory has much to offer the social sciences. Evolutionary theorists have done a better job than most at formalizing the processes of change among individuals in a population responding to internal and external pressures, resulting in useful and versatile constructs such as the adaptive landscape, the red queen, and the hawk-dove game. Frameworks, however, come from all over. Game-theoretic formulations such as the prisoner's dilemma originally came to evolutionary theory via economics and political science. Many fields have frameworks and constructs that would be valuable to a science of intentional change. Consider *dynamical systems theory*, which provides a formal framework to how interlinked systems change over time. Evolution, as a theory of change, is related, but dynamical systems theory can be discussed independently and can also help us understand the behavior of individuals and groups. Examples include the dynamics of romantic bonds and marital conflict (Cook et al. 1995; Ferrer et al. 2012), relationships between psychotherapists and their patients (Liebovitch et al. 2011), the development of personality (Nowak et al. 2005), and the dynamics of opinions and social identities (Deffuant et al. 2000; Smaldino et al. 2012). Much insight can be gained without an explicit invocation of evolution.

More importantly, vaulting evolutionary theory to the top of the theoretical totem pole risks alienating researchers who might be receptive to input from an evolutionary perspective but are hesitant to consider it as an overarching framework. Social scientists and scholars have no wish to be colonized by a "universal Darwinism" (Hodgson 2005). They have their own theoretical perspectives that can be informed by evolutionary theory without being exclusively defined by it. An imperative to draw all social science into the evolutionary framework risks turning off researchers who could otherwise benefit from the wisdom accrued by evolutionary thinkers. We think this can be avoided. The question is not how can evolutionary theory unite the social sciences, but how can it serve and connect them in order to fill important gaps.

One particularly striking gap concerns the processes of endogenous cultural change. Anthropologists study culture, but often without reference to the cognitive mechanisms that make culture possible, or the use of quantitative models. Psychologists study human cognition and social behavior, but rarely the population-level consequences of culturally guided behavior. Economists study the societal distribution of resources and the dynamics of individual choice, but treat preferences as exogenous and ignore culture. And most social sciences have not adopted methods for modeling emergent or endogenous behavior within social systems. Although there are exceptions, disciplinary traditions have developed in such a way that endogenous cultural change is rarely addressed directly. Evolutionary theory could provide the necessary links between these different approaches.

We propose a few considerations for scholars interested in joining the evolutionary and social sciences. One place to start is to recognize that evolutionary theory has already spread widely across the social sciences. There are evolutionary traditions in psychology, but also in anthropology (Alvard 1998; Boyd & Richerson 1987; White 1943), economics (Dopfer 2005; Veblen 1898), and sociology and organizational studies (Aldrich 1999; Hannan & Freeman 1977; McKelvey 1982). These are the frontlines of the integration of evolutionary thinking with the complexities of human behavior and society. Each of these traditions, however, remains marginal in its own field. They are not integrated, and they use different lexicons and highlight different processes. One way to pull the social sciences together is to foster links among the different extant evolutionary subfields.

We also caution against diving too deep into evolutionary theory without carefully establishing a grounded framework and definitions. In this regard, it is more productive for the evolutionist to take steps *backward* to establish a common set of referents than it is to push *forward* with the complexities of one's theory without first establishing trust. The terms "symbotype" and "Darwin machine" are examples of terms that, although they are well defined, may push too far forward into the domains of the very social scientists that Wilson et al. are trying to court.

Social scientists are wary because they see evolutionists making big assumptions (e.g., Lumsden & Wilson 1981). But the core of evolutionary theory is so simple that it should never offend anyone, if presented appropriately. *Adaptation occurs when selection acts on heritable variation*. The general theory makes no big assumptions about the strength of selection or the sources of heritability or variation, only that adaptation occurs when all three combine. This disarmingly simple idea is a good candidate for a unifying behavioral framework. Evolution has also provided many valuable insights on phenomena such as maladaptation, path dependence, and the interactions between levels of selection. But the value of these insights cannot be realized unless evolutionists take a step backward in learning the full complexities of the topics their colleagues study. Wilson et al. do this as well as anyone.

We agree that evolutionary perspectives may help us organize many divergent realms of the science of human behavior. We suggest that evolutionary research will be welcomed if evolution is used as a way to connect topics in behavioral sciences, thus providing value from the bottom up, rather than suggesting reorganization from the top down. The contribution by Wilson et al. is an important step toward making those connections.

Conservation combats exploitation: Choices within an evolutionary framework

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Abstract: Intentional change when viewed as making a risky or intertemporal choice with evolutionary relevance helps us understand its

successes and its failures. To promote future-oriented ecological rationality requires establishing a linkage between nongenetic, cultural, and symbolic selections and genetic adaptations. Coupled with biophilic instinct, intentional conservation is more likely to prevail against evolved desires of environmental exploitation.

As Wilson et al. argue in the target article, evolution must be at the center of a science of change. We agree with the need to incorporate social and cultural learning into a general evolutionary framework. However, in our view, it is a daunting task, if not impossible, to integrate domain-specific "massive modularity" theories of evolutionary psychology with "blank slate" theories of learning and conditioning. In this commentary, we focus on the proposal of Wilson et al. concerning phenotypic plasticity that enables organisms to respond adaptively to their environments, including successfully making intentional cultural changes at scales ranging from individuals to small groups to large populations. We discuss intentional and cultural changes within an evolutionary framework of decision making.

One way of connecting extant literature of judgment and decision making with the theme of intentional change is to consider change as part of risk and uncertainty. Risks are often measured in terms of expected changes as gains or losses. Uncertainty is inherent in changes perceived in opportunities or threats, in benefits or harms. Throughout human evolution and individual life history, we live with uncertainties and deal with risks. Some of the risks are evolutionarily recurrent, whereas others are evolutionarily novel. Recurrent risks forge evolved innate mechanisms to deal with them, whereas novel risks result in actions that are less prepared and more variable and malleable. To understand why some intentional changes succeed and others fail, identifying risks as evolutionarily recurrent or novel is necessary. In addition, the understanding of social and cultural factors that activate or inhibit risk management mechanisms in modern times is important.

As an example of how the risk preference of people adapts to unique features of social group living and cultural systems, Wang (1996a; 1996b; 2002; 2008) demonstrated that the framing effect, an irrational risk preference reversal due to different ways of framing or phrasing the same choice outcomes (Tversky & Kahneman 1981), occurs in large anonymous group contexts. However, the framing effect disappears in evolutionarily typical small group contexts and adapts to cultural specifics. Data from the United States show that group size, which separates the framing effects from no framing effects, is very close to Dunbar's number of 150, which serves as an upper curtailing for social interactions (Dunbar 1988; 1993). However, a Chinese sample of group size–dependent framing effects shows a higher group size at the switching point (Wang 1996a). This finding indicates a larger conceptual scope of "we-group" has adapted to a culture of higher population density, lower mobility, and more extended social connections. Moreover, new studies found that work experience in large corporations significantly reduces framing effects (e.g., Shimizu & Udagawa 2011b). These studies suggest experience-induced changes in group size–sensitive risk preference, which adapts to the environment and culture of an organization.

Another example of cultural adaptation was revealed in a cooperative behavior field study. Rao et al. (2011) found that behavioral changes on an even larger scale of communities can happen automatically due to "selection by consequence," or social transmission, as expected by Wilson et al. in the target article. The degree of prosocial behavior after the devastating 2008 Wenchuan earthquake increased proportionally with the level of residential devastation. When threatened by natural hazards, mutual aid can serve as an adaptive mechanism to increase the survival chances of individuals.

Wilson et al. argue, "Left unmanaged, evolutionary processes often take us where we would prefer not to go." An example in decision making relevant to the above observation is the study of delay of gratification and self-control. People discount the future when they prefer a smaller and sooner (SS) reward to a larger and later (LL) reward. When viewing intentional change as a choice between SS and LL rewards, a set of interesting evolutionary questions can be derived. Some possible questions are: To what extent should natural selection favor a choice preference that is future oriented and green? To what extent can symbolically, culturally, or religiously made changes (e.g., future-oriented green choices) overcome, counterbalance, or change unmanaged evolutionary desires of environmental exploitation?

One nongenetic system that may promote future-oriented choices is the symbotype. According to Wilson et al., a symbotype is a network of symbolic relations that regulates behavior in a way similar to a genotype that produces a phenotype. To achieve such a goal, we argue that education via symbotype is necessary but not sufficient. It takes *evolved* conservation desires to combat effectively *evolved* exploitation desires (see also Penn 2003; Wilson 1984; 1993; 2002). Cultural adaptations are foremost biological adaptations. Rational planning is often victimized by seeking pleasure. The success of intentional changes therefore depends on establishing an effective link between intentional behavior and a consistent and stronger reinforcement or prevention mechanism (e.g., conditioning or emotions). Such mechanisms should be hardwired, evolutionarily stable, and intrinsic.

Ecologically destructive humans are also ecologically protective (Penn 2003). In his book *Biophilia*, E. O. Wilson (1984) proposes that humans have instinctive aesthetic preferences for natural environments and other species. Available evidence indicates that education is not sufficient for evoking conservation behavior (e.g., Hirst et al. 1981; Miller et al. 1975). An evolutionary perspective suggests that environmental education will be most effective for triggering changes when it shows how the destruction of the environment harms *individual* interests (Heinen 1995; 1996; Ridley & Low 1993; Wilson 1984). Moreover, joint forces of symbolic and religious systems should be more efficient than either one alone. Cumulating evidence shows that education plus cultural, traditional, and religious beliefs are an effective means to promote environmental protection and conservation of local biodiversity, as practiced by the Chinese ethnic minorities (e.g., Luo et al. 2009; Hongmao et al. 2002; Xu & Wilkes 2004). The suggestion that our evolved "human nature" is a source of environmental exploitation and degradation is not a claim that nothing can be done, but a warning that effective conservation will have to incorporate an understanding of relevant evolved psychological processes to modify human actions (Wilson et al. 1998, p. 517).

Authors' Response

Collaborating on evolving the future

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Abstract: We thank the commentators for an extraordinarily diverse and constructive set of comments. Nearly all applaud

our goal of sketching a unified science of change, even while raising substantive points that we look forward to addressing in our reply, which we group into the following categories: (1) What counts as evolutionary; (2) Ethical considerations; (3) Complexity; (4) Symbotypes, culture, and the future; (5) What intentional cultural change might look like; (6) An evolving science of cultural change; and (7) Who decides?

We thank the commentators for an extraordinarily diverse and constructive set of comments. Nearly all applaud our goal of sketching a unified science of change, even while raising substantive points that we look forward to addressing in our reply.

R1. What counts as evolutionary?

We are not surprised to find this question posed by a number of commentators, as we encounter it almost daily in our interactions with colleagues across disciplines. We think that the best articulation of the evolutionary paradigm is by Niko Tinbergen, who shared the Nobel Prize in medicine with Konrad Lorenz and Carl von Frisch for helping to found the science of ethology, the study of animal behavior. Tinbergen wrote his classic 1963 paper, "The Methods and Aims of Ethology," to explain why the study of behavior should be regarded as a branch of biology. At the time, it was not obvious that it was possible to study a behavioral trait, such as aggression, in the same way that an anatomical trait, such as a deer's antlers, could be studied. Tinbergen pointed out that four questions need to be asked for any product of evolution: its function, its mechanisms, its development, and its history. These questions can be as profitable for behavioral traits as for physical traits.

We think that Tinbergen's four questions work as well for a science of intentional change as for the science of ethology, or indeed all the behavioral and life sciences. Every trait with a functional basis must be understood in functional terms. It will have a physical mechanism, which is typically the result of a developmental process, and it will have a history. This is true for culturally derived traits no less than genetically derived traits. When all four questions are linked to issues of variation and selective retention, they define an evolutionary approach.

There is no consensus among evolutionary biologists that the term "evolutionary" should be equated with Tinbergen's four questions. Even Tinbergen used the word *evolution* primarily to describe the history question. It is common for other evolutionists to associate evolution with function but not with mechanism or development. There is unlikely to be a consensus anytime soon, but at least we can be clear with our own usage: We associate the evolutionary paradigm with Tinbergen's fully rounded four-question approach, which can be applied to any product of evolution. We stated this briefly in our target article (sect. 2.2) and perhaps should have featured it more strongly. It does occupy center stage in the lead article of a special issue of the *Journal of Economic Behavior & Organization* titled "Evolution as a General Theoretical Framework for Economics and Public Policy" (Wilson & Gowdy 2013), which provides a useful complement to our *BBS* article.

A common complaint about broad definitions of evolution is that they lose meaning. By including everything, they explain nothing. But consider the standard definition of *genetic evolution* as any change in gene frequency, whether by selection, drift, linkage disequilibrium, or any other force. It is important to have a general accounting system that includes all forms of genetic change. The accounting system is meaningful when it includes meaningful categories. Thus, just noting that something evolves has little meaning, but documenting that it evolves *by* selection, *by* drift, or *by* linkage disequilibrium is meaningful.

The same considerations apply to a science of intentional change. It is important to have a general accounting system that includes all products of variation-and-selection processes. The accounting system is meaningful when it includes meaningful categories. There are more categories for a science of intentional change than for genetic evolution, to include Darwin machines with nongenetic inheritance mechanisms. We will return to this point below when we discuss various forms of forward-looking change discussed by some of the commentators.

Another common critique of an evolutionary perspective is that it does not add value to other perspectives, but merely reinvents what has already been discovered. This will certainly be true some of the time; other perspectives do not get *everything* wrong! Nevertheless, there are strong reasons for concluding that a fully rounded four-questions approach can add value to any sizeable human-related subject, as discussed in more detail by Wilson and Gowdy (2013).

Against this background, we can consider some of the specific points raised by the commentators. **Grinde** thinks that the differences between genetic evolution and other evolutionary processes are greater than their similarities. Perhaps the term "evolution" should be reserved for genetic evolution. At the very least, policy efforts should focus on cultural, not genetic, evolution. We share Grinde's distaste for the "unsavory" eugenics policies inspired by evolutionary theory in the past, but we do not think that they should unduly influence our current conceptual framework or current policies that meet appropriate ethical standards (see next section). Evolutionary theory has been so gene-centric during the last century that a central message for the future must be "there is more to evolution than genetic evolution" (Jablonka & Lamb 2006). Furthermore, the thrust of concepts such as gene-culture coevolution, developmental systems, and niche construction is that genes play a role in larger systemic processes, but should not be conceptualized as privileged units within the larger system. We, therefore, prefer to maintain our broad use of the term "evolution" and think that Grinde's concerns can be addressed by defining meaningful categories of evolution inside a large systems-based approach.

Andersson, Törnberg, & Törnberg (**Andersson et al.**) stress,

> We need to follow more in the tracks of recent moves toward a causal–mechanistic understanding of evolution in biology than in the tracks of neo-Darwinism. Darwinism – which is what Wilson et al. really mean by "evolution" – is necessary but not sufficient here; we also need to mind the multilevel organization that evolution produces and that scaffolds Darwinian dynamics.

Similarly, **Grotuss** seems to equate our treatment of the Darwin machine concept with narrow-school evolutionary psychology, when we think that our treatment is consistent with his own position. We hope that our reliance on Tinbergen's fully rounded four-questions approach makes this clear. That said, we acknowledge that our target article spent less time on questions of causal mechanisms, so we appreciate the emphasis and additional information provided by these and other commentators, as is addressed in more detail below.

Commenting on the successful change efforts that we review in section 3 of our target article, **Burghardt, Stuart, & Shorey** (**Burghardt et al.**) state, "it is unclear what is evolutionary about them. More specifically, it is unclear how evolutionary theory either guided their development or anticipated their success, other than their being a product of variation and selection." This critique conflates two questions: (1) When does a process count as evolutionary? and (2) When does an explicitly evolutionary perspective add value to understanding an evolutionary process that has not yet been explicitly approached from an evolutionary perspective? We can imagine a similar critique being leveled against Darwin's effort to interpret past knowledge from an evolutionary perspective!

Wilson and Gowdy (2013) provide a general argument for why explicit evolutionary theorizing is likely to add value to the study of any sizeable human-related topic. On the issue of prospective impact, it is worth noting the role that explicit evolutionary thinking has played in the history of the applied behavioral sciences, such as B. F. Skinner's concept of selection by consequences, which have been central historically to some of the very programs that we are examining.

Burghardt et al. provide an interesting and illustrative challenge as an expression of their concern that integration must go beyond post hoc stories to "the prospective analysis we need to move forward": Would it have been possible to predict beforehand the failure of a program such as the Drug Abuse Resistance Education (D.A.R.E.) program over comprehensive cognitive-behavioral exposure treatments for anxiety, such as those developed by Barlow et al. (1989)? We think that indeed it was possible, and in two ways.

Evolutionarily sensible therapy programs have found ways to foster healthy variation, selected by criteria of importance to those being worked with, in a way that is sensitive to contextual features of their life, occurring at the right level of selection (individuals; couples or groups), and in which retention of gains is fostered. The scientific development programs of such therapies often reflect the same process: They focus on data relevant to a variety of stakeholders and, as data come in, theories, methods, and techniques are altered in a continuous development cycle sensitive to those outcomes. In both of these areas (focus and development) it is easy to predict on evolutionary grounds that programs such as Barlow et al.'s cognitive behavior therapy (CBT) program will succeed, whereas programs such as D.A.R.E. may not.

The Barlow et al. approach originally included a number of traditional CBT techniques such as cognitive modification, relaxation, and breathing training, among others, but went beyond traditional stimulus exposure to include exposure to emotions and sensations themselves. Research showed that these innovative methods increased tolerance of anxiety and fostered greater flexibility and greater ability to learn in the presence of anxiety cues (Craske et al. 2008). Indeed, measures of psychological flexibility drawn directly from those used in Acceptance and Commitment Therapy (ACT) have been shown to mediate the outcomes of such programs (e.g., Arch et al. 2012b). The program itself has been continuously revised since its creation, dropping and adding elements. These data-driven changes increasingly aligned the protocol more with evolutionarily obvious ideas, as would make sense if the analysis in our target article is correct.

The latest and highly effective iteration to grow out of this development work, for example, now consists of only four modules: "increasing emotional awareness, facilitating flexibility in appraisals, identifying and preventing behavioral and emotional avoidance, and situational and interoceptive exposure to emotion cues" (Ellard et al. 2010, p. 88). All of these remaining modules are focused on increasing the contextual sensitivity of action and on augmenting emotional, cognitive, and behavioral flexibility. Although these changes were not driven by evolution science, they are easy to understand from that perspective, and any evolutionist examining the data and changes would appreciate the consilience between the focus of these remaining elements and evolution science findings.

In contrast, D.A.R.E. sought to use social persuasion methods to ingrain a rigid "zero tolerance" approach to drugs. Police became teachers to increase the authoritative impact of rule-based training; specific rules were modeled and repeated, such as "Recognize, Resist, and Report," as if greater behavioral rigidity could solve the problem of drug use. Dissemination was aggressively based on fundraising and publicity, not on data collection and continuous program modification. When research suggested that increased awareness actually led to greater curiosity and *increased* drug experimentation (Rosenbaum & Hanson 1998), the response was to criticize the research findings and even to attempt to keep journals from reporting them, even as negative evidence kept pouring in for decades (Lilienfeld 2007). Therefore, at both content and process levels, we think that evolutionary concepts would readily meet the challenge **Burghardt et al.** described.

The best test of the value of evolutionary thinking, of course, is empirical. Although we are unaware of any meta-scientific studies of this kind, some programs described in our target article were indeed explicitly driven by evolutionary thinking, whereas other programs developed in the same time frame or through the same funding mechanisms were not. This allows a naturalistic test of **Burghardt et al.**'s concerns. For example, the design of the PeaceBuilders violence prevention strategy was explicitly grounded in the evolutionary paradox that human groups are the greatest vertebrate predator of humans, and other human groups are the best source of safety from predatory humans (Embry 1991; Embry & Flannery 1999; Embry et al. 1996). This program showed larger effect sizes (Flannery et al. 2003; Vazsonyi, et al. 2004) than did more than a dozen other strategies not informed by evolutionary theory that were funded at the same time, most of which had iatrogenic or weak results (Grossman et al. 1997; Guerra et al. 1997; Jaycox et al. 2006; The Multisite Violence Prevention Project 2009), and it was the only strategy randomized trials showed reduced medically coded violent injuries (Krug et al. 1997).

Smaldino & Waring express concern that "an imperative to unite all social science under an evolutionary framework risks turning off researchers who have their own theoretical perspectives that can be informed by evolutionary theory without being exclusively defined by it." We agree that very important framing issues must be kept in mind. The problem is even worse than Smaldino & Waring describe, because many people are already turned off by past associations with evolution within their disciplines and so are not starting from a neutral position. Nevertheless, it is important not to let past associations interfere with future goals – a first rule of therapy – and our goal is for evolutionary theory to have the same kind of generality in the human-related disciplines as it does in biology. Dobzhansky's (1973) dictum, "Nothing in biology makes sense except in the light of evolution," needs to be expanded to include our own species, including our cultural and behavioral diversity; and this expansion needs the same positive connotation that the dictum already has for biologists.

Getting to there from here for any particular person or discipline might be difficult. Personal and cultural evolution is a path-dependent process across a rugged adaptive landscape. But we have found that with the appropriate framing, the transition can also be easy. The fear associated with evolution as a "totalizing" theory is that one's current perspective and expertise will be rendered obsolete. In contrast, it can be affirming to learn that one's perspective (e.g., social constructivism) plays a central role in the human evolutionary story, that it can be generalized beyond one's current disciplinary boundaries, and that one's empirical expertise (e.g., the history of witchcraft in Europe) can be just as important from an evolutionary perspective as from other perspectives, because all theories must draw on empirical information. It can be even more affirming to realize that one's area (e.g., human symbolic thought) can fill an important gap in core evolutionary theory, as we tried to stress in our target article. Integration as a two-way street is alluring, not threatening.

R2. Ethical considerations

Ethics is a foremost consideration for any change effort. The question we need to consider is whether the ethical considerations are different for a change effort centered on evolution. We think that for the most part, the answer is no.

Consider one reason change efforts often fail: because people have incomplete information, and what they think will work falls victim to unforeseen consequences. This hazard exists for anyone attempting to accomplish anything on the basis of any rationale. We emphatically do not think that evolutionists already have answers that can be implemented in a top-down fashion. In fact, there are grounds for thinking that such omniscience might never be possible for highly complex systems, as pointed out by some of the commentators (**Andersson et al.**; **Bodor & Fokas**; **Grotuss**; **Ho, Torres-Garcia, & Swain (Ho et al.)**; **Kostrubiec & Kelso**; **O'Brien**; **Read**; and **Smaldino & Waring**). This humbling fact calls for a different approach to policy formulation and implementation that is more experimental; in other words, one that involves highly orchestrated variation-and-selection practices. We will say more about this in the section on complexity.

Another reason why change efforts fail is that they benefit some people at the expense of others and the group as a whole (the fundamental evolutionary paradox of humans and common-pool resources), even when the decision makers think that they have the welfare of everyone in mind. This is a hazard for change efforts from any perspective and speaks to the need for checks and balances, including inclusive decision-making processes, which might be consensus decision making in small groups or representative forms of decision making in large groups. An evolutionary perspective reinforces this message, if reinforcement is needed, because it highlights the potential conflict between levels of functional organization. What counts as good for any given social entity is likely to undermine functional organization at higher levels. This is in contrast to the economic metaphor of the invisible hand, which makes it seem as if lower-level self-interest robustly contributes to higher-level functional organization. The evolutionary perspective makes it crystal clear that adaptation at any given level requires a process of selection at that level, which includes the deliberative selection of policies in addition to other variation-and-selection processes.

The standard formulation of the naturalistic fallacy is that "is" does not imply "ought." Just because something evolves does not make it good or right. We hope it is obvious from our target article that we are mindful of the naturalistic fallacy: One of our major themes is that left unmanaged, evolution often takes us where we do not want to go. For the most part, we think that the evolutionary perspective helps to clarify the "is" without changing the "ought." That is why most of the practical applications that we review in the target article are ethically unproblematic. Who does not want to empower neighborhoods, improve learning outcomes, and so on?

At a deeper level, however, the concept of "ought" needs to be understood from an evolutionary perspective. One of us (DSW) interviewed the distinguished moral philosopher Simon Blackburn (available at http://www.thisviewoflife.com/index.php/magazine/media/evolution-and-morality-i-simon-blackburn). The interview begins with a discussion of morality in general terms before exploring the relevance of evolution. Here is a transcript of Blackburn answering the question "What is morality?"

> I think at its simplest it's a system whereby we put pressure on ourselves and others to conform to certain kinds of behaviour. That's the side of morality that is perhaps most obviously associated with rules, with boundaries to conduct, with limiting criminal behavior when the rules are transgressed. On top of that, there's an element of morality that is concerned more with our sentiments and emotions; for example, with sympathy and our capacity to feel sympathy at others' distress and a corresponding motivation to do something about it. So there are two sides to morality, one more coercive and the second more gentle and humane.

That definition of morality, which was stated without reference to evolution, cries out for an evolutionary explanation as a set of mechanisms that enables groups to function as cooperative units. That is why moral philosophers such as Blackburn are taking evolution seriously to clarify the nature of morality. In this fashion, the evolutionary perspective is relevant to our understanding of "ought" in addition to our understanding of "is" without committing the naturalistic fallacy in any naïve sense.

We do not mean to underestimate the complexity and divisiveness of many ethical issues, but this is a problem for any and all perspectives regarding "what is moral."

Moreover, an evolutionary perspective can shed light on the cultural and situational diversity of moral values that contribute to differences that are hard to reconcile (e.g., Haidt 2012). Tinbergen's four questions are useful in this regard. If the *function* of a moral system is to orchestrate the functional organization of groups, and if moral systems evolve by gene-culture coevolution, then different *mechanisms* are likely to evolve in different cultures or for different situations within the same culture. These *historically* based differences are likely to become problematic with the admixture of cultures during modern history. Detailed knowledge of function, mechanism, and history (along with development) in conjunction with one another will be more useful for resolving difficult ethical issues than will the absence of such knowledge.

Against this background, we can address the major ethical points raised by the commentators. We agree with **Rottschaefer** on the need to establish a body of facts as value free as possible, which can be consulted by a set of values to derive courses of action. Therefore, it is important to be explicit about a fact/value distinction. The body of facts can be greatly clarified from an evolutionary perspective, which does not challenge the naturalistic fallacy. However, the concept of a value system itself needs to be understood from an evolutionary perspective, a project that is already in progress among moral philosophers, without committing the naturalistic fallacy in any naïve sense. From a practical standpoint, we think it is important to be as explicit as possible about one's facts, one's values, and how they are combined to lead to a practical course of action, so that every component of the process can be examined and challenged if necessary.

It is true that any science invented by humans has been used, and most certainly will be used, for good or ill – especially toward other human groups in the latter case, if past is prologue for the future. Our ancestors' invention of stone tools bears witness that we used such tools not just to secure a meal or build shelter: We also used those tools to kill other humans.

The inherent question in our paper is not whether humans can have scientifically proven tools for intentional cultural change: We do, by any sensible measure, which we resolved to illustrate. Most of our reviewers seem to agree that we have done so. The question that **Rottschaefer** asks and we have tried to answer is how will we use that explicit technology of intentional change in ways that humans agree is "good" or valued by all. The technology of intentional change is not the question: It is how we use it.

Nearly all the commentators who focused on ethics mentioned the sorry history of social Darwinism in the past. This is understandable, but it is also important to draw the right conclusions from this history. Take the slaughter of one group by another, as an example. It is first and foremost an outcome of the between-group competition that takes place throughout the animal world (e.g., ant colonies raiding other colonies) and has taken place throughout human history. It has been justified by religion, patriotism, and intellectual ideologies of all stripes. It should surprise no one that evolutionary theory was added to the arsenal of justifications for exterminating other groups, once it became available. When used, it became a causative factor in a mechanistic sense, but does this mean that removing it as a causative factor will reduce the problem of between-group conflict? Perhaps not, given so many other functionally equivalent justifications to choose from (back to Tinbergen's distinction between function and mechanism).

We certainly agree with the need to be vigilant about ethics in general terms, but we should not be unduly influenced by the justificatory role that evolution has played in the past. Efforts to alter the course of genetic evolution provide an example. The idea of selectively breeding people predates Darwin, as it is suggested by the artificial selection practices of plant and animal breeders for centuries. It was implemented as a policy in nations such as England, America, and Germany under the belief that because traits such as criminality and joblessness were under strict genetic control, it was ethically acceptable for the state to deny some of its citizens the right to reproduce. We should never forget this history and the role played by evolutionary theory per se, but neither should we allow the history to place current considerations of genetic evolution for "evolving the future" off-limits (contra **Grinde**). A key discovery in evolutionary biology during the last half century is that evolution takes place on ecological time scales, in our species no less than in others. We think that current knowledge, which emphasizes the interplay of cultural, developmental, situational, genetic, and epigenetic factors in the expression of undesirable traits, will provide the best protection against naïvely eugenic prescriptions and lead to policies that are ethically humane.

Sarkar raises a number of important ethical issues, including (1) the distinction between group and individual interests, (2) acknowledging cultural diversity, (3) focusing on normative issues before rushing to intervention, (4) insights from a variety of disciplines such as philosophy and cultural anthropology, and (5) the difficulty of achieving normative consensus on the largest and most recalcitrant problems. We agree, and wish only to stress the added value of considering these issues from an evolutionary perspective. People distrust being told what to do "for the good of the group" for the best of reasons: because it makes them vulnerable to exploitation. Moral systems that include respect for individual rights are protected against exploitation from within. Taking cultural evolution seriously means attaching the same importance to cultural diversity that evolutionary biologists accord to biological diversity. Human moral systems require shared norms of good conduct enforced by rewards and punishment. These norms must be established before action is taken. Disciplines such as philosophy and cultural anthropology are not rendered obsolete but are essential to the integration. Elements of moral systems that take place relatively easily at small scales, such as reaching a consensus on normative issues, take place with more difficulty at large scales, requiring proceeding with caution. To Sarkar's point, this is why we emphasized the Nobel Prize work of Elinor Ostrom on common-pool resources, which provides an empirical way to resolve some of the ethical issues associated with human exploitation and fairness.

Khalidi and **Aitken** stress the poor track record of social engineering in the past and the inherent unpredictability of complex human social systems that makes prediction difficult or impossible. They seem to think that we have Watson's (1925) boast about molding individuals or Skinner's *Walden Two* (1948) in mind. We turn to the issue of complexity in the next section.

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R3. Complexity

A major theme of the commentaries concerns the need to adopt a systemic approach that does justice to the mechanistic complexity of human social systems (**Andersson et al.**; **Bodor & Fokas**; **Grotuss**; **Ho et al.**; **Kostrubiec & Kelso**; **O'Brien**; **Read**; and **Smaldino & Waring**). Particular approaches to complexity that were discussed include developmental systems theory, niche construction theory, generative entrenchment, gene-culture coevolution, and dynamical systems theory. Bodor & Fokas make the important point that the most profound and important social changes, such as the attainment of Western-type social organization, evolve over a period of centuries and not by anyone's intentions. The same goes for many technological innovations. The implication seems to be that intentional change should not and perhaps cannot entirely substitute for unintended cultural evolution.

Our reliance on Tinbergen's four questions indicates our willingness to acknowledge the importance of mechanisms and development in all their complexity – but that is a far cry from doing them justice. There is a reason why the approaches listed above are relatively new trends in evolutionary biology. Their very complexity makes them more difficult to study than functional approaches that treat heritable variation as a black box. Only very recently has our understanding of biological mechanisms reached the point where all four empirical questions can be asked in conjunction with one another. Comparable understanding of the behavioral and symbolic Darwin machines that underlie cultural evolution lags far behind. As the theoretical biologist Robert Boyd (personal communication) puts it, our understanding of the mechanisms of cultural evolution is comparable to our understanding of the mechanisms of genetics before Mendel.

Learning how to accomplish positive change in systems that are too complex to make accurate predictions about requires us to combine the best of our knowledge with experimentation. This observation might seem mundane, but explicit experimentation is by no means the norm in many policy circles. Even when policies are evidence based, the evidence is typically gathered in certain settings and may not apply to other settings. One of the messages of Elinor Ostrom's work is that even though the core design principles provide a recipe of sorts for creating efficacious groups, cookie-cutter implementations do not work because the best implementations depend so much on local context. There can be no single fisheries policy for the coast of Maine, for example, because every bay will require special considerations. Creating effective social cooperation requires an approach to experimentation that is sensitive to local context, which is new even for policy circles that strive to be evidence based in other respects.

We think that an explicit evolutionary perspective will add considerable value to this enterprise, beginning with the observation that the human ability to learn and transmit useful information evolved by genetic evolution in the context of small groups and can be expected to break down in larger groups. Unless additional mechanisms evolve by behavioral and symbolic evolution that interface with our genetically evolved mechanisms, then cultural evolution will work poorly. Such mechanisms have evolved over the course of human history, which means that we should study traditional cultures (including religions) very respectfully to learn how they function as well as they do. **Read**'s description of the Netsilik Inuit provides an example of this kind of functional contextualist approach.

If the mechanisms of cultural evolution are a product of gene-behavior and gene-symbolic coevolution, then what worked in the historical past does not necessarily work in the present, given the enormous changes in social organization and communication technology that have taken place. We should focus on examples of failures of cultural evolution, such as the absence of sufficient variation, practices that work but do not spread (such as that discussed by **Gray**), and practices that are harmful but nevertheless spread because they are falsely perceived as good. We think that many examples of dysfunction in modern life can be traced to a breakdown of the mechanisms underlying cultural evolution, similar to the breakdown of the immune system that occurs when modern environments depart from ancestral environments (Hanski et al. 2012).

Elinor Ostrom provides a simple example for common-pool resource groups in one of the last articles that she completed before her death (Ostrom 2013). In a small-scale society, useful practices that are learned by some individuals are quickly noticed and copied by other individuals. Not so for a modern common-pool resource group, which has a limited ability to communicate with other groups – despite the massive growth of communication technologies that are driven by aberrations in selection by consequences such as advertising revenues but have not yet been behaviorally integrated into group functioning. By the simple expedient of facilitating interactions among common-pool resource groups, they were able to compare notes with one another, enabling best practices to spread when they had not before. This humble example illustrates a critical point: The parameters of an efficient cultural evolutionary process in modern life must be constructed. Neither our genetically evolved abilities nor past behavioral and symbolic adaptations are sufficient. This is what we mean by becoming wise managers of evolutionary processes. It means not knowing the exact solutions, but orchestrating a process whereby the solutions can be derived and spread.

Another important point illustrated by Ostrom's example is that the variation part of a variation-and-selection process is often unplanned. Members of common-pool resource groups tinker with their arrangements. Candidate solutions are often based on serendipity and happenstance. The best solutions quickly spread within a given group, but spreading to other groups will not take place unless a comparison-and-selection process is orchestrated. In short, a well-managed cultural evolutionary process can leave room for unplanned variation, as stressed by **Bodor & Fokas**.

One important property of complex social systems is that variation can be expected at all spatial scales, because small chance differences result in larger divergences rather than remaining small (sensitive dependence on initial conditions; Gleick 1987). Hence, large-scale social units such as nations vary in ways that no one planned but that are highly consequential for military and economic competition over the course of centuries, as stressed by **Bodor & Fokas**. Variation among modern nations remains highly consequential for their capacity to function as corporate units (Acemoglu & Robinson 2012; Pickett & Wilkinson 2009), but the comparison and selection of best practices is highly unlikely to take place at this scale without an orchestrated process informed by evolutionary theory.

R4. Symbotypes, culture, and the future

To varying degrees, some commentaries (**Baumard**; **Costanza & Atkins**; **Grinde**; **O'Brien**; **Read**; and **Wang, Li, & Rao** (**Wang et al.**)) drew an equivalence between our comments about symbotypes and evolution of cultural practices per se. Cultural evolution includes behavioral processes that are not symbolic, and the implications at times differ. In some areas our comments were misunderstood or overextended as a result of failing to track this distinction. For example, Read is concerned that we have the idea that "what is expressed in the symbolic/cultural domain is an epiphenomenon of prior patterning." The basis of the criticism was our suggestion that learning to relate events symbolically is in part a matter of abstracting from physical relationships but becoming somewhat independent from them. For example, small children initially learn to compare based on physical properties such as relative size, but as comparison per se is abstracted and brought under the control of social cues (e.g., "this is bigger than that"), it can be arbitrarily applied (e.g., a dime is bigger than a nickel). This view of one of the key relational processes that allow symbotypes to be constructed is similar to the processes of combining and reading nucleotides in the genotype, but it is quite different from assuming that culture is a "codification of already existing patterns of behavior," as Read understands us to be saying. To the contrary, the combinatorial complexity of these basic relational or symbolic units in their capacity to produce actions is as flexible in various physical and social environments as the combinatorial complexity of the genotype is in its ability to produce a variety of phenotypes in different environments.

Grinde likewise reduces our multidimensional and multilevel argument about evolving the future to distinctions between genetic and cultural evolution. We agree there are important differences, but the plasticity of evolutionary processes is impressive everywhere we look. **Baumard** is skeptical that cultural practices can change human psychology – but symbolic functions are part of that psychology, and we cannot know how far we can take intentional change until we bring together all of the sciences needed to make such an attempt. In this area **Fox**'s central point seems apt: A more detailed awareness of how symbolic behavior evolved and functions is a key part of the task ahead for an evolution science focused on intentional change.

We agree that knowledge is very much needed, and it will be central to answering **MacDonald**'s call for a program of research that carefully teases out "domain-specific, modular mechanisms from domain-general mechanisms, and in the case of the latter, must be clear on exactly how they are domain-general and how this promotes change." To the extent that MacDonald is correct that domain-general processes in the behavioral area evolved via affective cues signaling the attainment of evolutionary goals, symbolic behaviors challenge this general process, as human beings can visit pain on any situation through symbolically driven memories, comparisons, and fears. So far it is applied behavioral scientists and psychotherapists who have lived at the edge of this conflict, and many of their insights seem to provide guidance for moving forward, as we emphasized in the target article. Indeed, we know that acceptance and mindfulness-based therapies work in part by reducing the avoidance of such responses, thus increasing emotional, cognitive, and behavioral flexibility (Hayes et al. 2006). But without a deeper and evolutionarily sensible understanding of symbolic functions, the precision of predictions in a variety of important areas such as these will be weak.

Fox points to a key reason why a deeper understanding of symbotypes is needed: the possibility that we could learn to recast our cultural and personal dialogues about war and peace, much as we are learning to do in approaches that have psychotherapeutic uses. He is right: "If we desire to survive and flourish as a species, then we will need to select for ways of thinking and behaving that favor peaceful outcomes." As psychotherapeutic ideas have been applied to social issues such as stigma and prejudice, it has become clear that some of the ideas about symbolic evolution can indeed scale from the clinic to the society (e.g., Masuda et al. 2007).

Nowhere is knowledge of symbolic functions more critical than in our understanding of the future. In the absence of symbolic behavior, the actual *experience* of the future boils down to the experience of change from one present moment to another. That experience is built in the past, resides in the present, and is "about" the future in the original etymological sense of the word *about*: that is, it is on it or near it, while at the same time being outside of it.

The learning process of the extension of the experience of change into the future is put on steroids once symbolic functions arrive. Human symbolic behavior is bidirectional and combinatorial. We can now *construct* futures that have never been. As **LaFreniere** points out, our "human cognitive ability [is critical in creating] novel solutions to various human goals." **Costanza & Atkins** likewise emphasize the human ability to bring foresight to the evolutionary table by deliberately envisioning the future we want through the use of symbols. They are right to suggest that having different symbotypes available is advantageous, but not if diversity overwhelms the ability to transmit and share common visions for the future. In the same way, the construction of the future needs to be guided, as they note in their explication of scenario planning.

The processes of symbolic construction of change (if… then; before…after) are not bound by the changes that have actually been experienced in the past. The combinatorial properties of the symbotype allow us to do that in a way that is both creative and based in experience, as the human construction of the future can be guided by how such novel constructions have previously helped orient us to the future. That is precisely what scientific knowledge does.

Dowrick rightly focuses on how we learn from envisioned futures. Humans cannot be in the future, but they can project and entertain possible futures. Fundamental to the idea of intentional cultural change is a playful and purposeful envisioning of futures. Dowrick's work is cited in Embry and Biglan's (2008) article on evidence-based kernels, and is used in some of the example studies to change human behavior to decrease unwanted outcomes (e.g., less violence, less addiction) and increase wanted or desired outcomes (e.g., more peaceful, prosocial environments; better health). For example, the underlying

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implementations of the real-world versions of the Good Behavior Game (Embry et al. 2010), as well as earlier work on peaceful, positive schools (Embry et al. 1996), and the national injury control strategies in New Zealand and the United States (Embry 1984; Embry & Peters 1985; Embry et al. 1985) directly involved Bandura's intentional imaginary modeling and Dowrick's self-modeling work in future contexts.

There are multiple ways of using the envisioned future. One way is to use data trajectories, which we do not believe **Dowrick** opposes. That is what programs such as those just described have done. Another is to extend what is meaningful and purposeful: that is, to consider human values. As **Peschl & Fundneider** note, our paper implicitly includes the change strategy of "learning from the future as it emerges." We concur, and thank them for their observation.

Dowrick suggested that we made no effort to include the representation of valued future behavior as an important part of human learning; but although we did not do a deep dive into the issue, the importance of applying values to our construction of the future is mentioned half a dozen times in our article, primarily drawing on the psychotherapy methods we were discussing. It is a mischaracterization of the work of translating relational frame theory into ACT or the work cited by Embry and Biglan on prevention as "limited almost entirely to clinical, developmental, and educational *problems*" (italics original). The application of these ideas is not limited to problems – they apply to human development more generally. For example, when 30 minutes of online exposure of ACT-based values training is provided to college students and they consider what they want out of their education, their grade point averages increase significantly over the next semester, whereas mere academic goal setting has no such effects (Chase et al. 2014). Acceptance, mindfulness, and values methods help athletes compete (Bernier et al. 2009), chess players play (Ruiz & Luciano 2012), health professionals learn (Varra et al. 2008), and gym members exercise (Butryn et al. 2011).

Our article highlighted the potential for reducing major social problems because many believe those problems to be intractable or not avertable; but as **Dowrick** suggests and we affirm, these methods are means of improving development, not just remediating deficits. By showing that there are powerful, simple mechanisms for reducing costly problems through intentional change, a stage is set for a broader discussion that includes moving toward valued futures in a positive sense.

We agree with **Manzotti & Moderato** that we need to understand intrinsic motivation – how an intentional cognitive agent may produce a new goal. That is precisely in line with the need to understand the ontogeny of symbotypes and its resulting teleological effects, which is another way of restating their idea that we require an understanding of domain-general cognitive architectures.

It is worth noting that values constructions are still only "about" the future in that original etymological sense; but science itself provides more tools every day for these symbolic extensions, and in a deep sense, that task is a central aspect of the very history of science itself. That being said, we agree with commentators such as **Sarkar**, **Khalidi**, and others who suggest that we need to be humble and cautious. We are not claiming we currently have all or even most of the tools needed to know all aspects of the future or to control it with precision, nor that we can currently extend our knowledge with precision across very large time spans or contexts in most areas. **Bodor & Fokas** take caution too far, however, in claiming that it is actually undesirable to seek long-term change. Areas such as global climate change demand that we do a better job of acting with regard to the future. It is our argument that only by drawing together scientific knowledge into a greater degree of consilience across the full range of scientific disciplines are we likely to be able to acquire such knowledge. The umbrella provided by evolution science is the means we see to do that.

Kostrubiec & Kelso make a useful point in noting that some forms of selection (e.g., "selection via instability") can be more transformational than other forms. The symbolic domain is one in which that kind of transformational change is especially likely. When the entire purpose or central organizing assumption of a cognitive network is changed, everything changes. That possibility undergirds many of the examples provided in our target article. A deeper understanding of symbotypes may therefore be an especially fruitful area in which to explore Kostrubiec & Kelso's ideas because it will reflect so directly on what we even mean by such issues as "intention."

This concerned some commentators. We are using the word *intentionality* to mean that intervenors or those affected are guided by a verbal purpose or envisioned future. **Aunger & Curtis** argue that most of the behaviors people seek to change are habitual and therefore "not necessarily responsive to intentions." This idea turns intentionality from a feature of the purpose of change to a narrow *method* of change (Aunger & Curtis appear to use "intentionality" as a synonym for "consciously known instructions"), which fundamentally narrows our arguments. Their randomized trial of a hand-washing intervention is a policy-driven public health effort using evidence-based kernels for cueing (the "eye-spots") and the alteration of symbolic relational networks by pledges. It is a wonderful example of evidence-driven intentional cultural change. The intentionality is in the actions of the program organizers and in the values of the individuals who do not wish to contract deadly or harmful diseases while in a public restroom. The method itself certainly need not be instructional or even conscious.

Wang et al. draw the same distinction in their point that "education via symbotype is necessary but not sufficient" and that change depends on establishing an effective link between intentional behavior and an intrinsic and emotional consequence. We agree, especially as many of the behavior change methods we describe seem to work in that way; we simply wish to add that by "intentionality" we did not mean that the methods of change should be instructional or that all those involved in a cultural change must have a conscious intention.

R5. What intentional cultural change might look like

The human sciences are already guiding cultural change to a much greater extent than ever before. We presented examples of evolving science-based practices that are decreasing the prevalence of numerous common and

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costly problems of human behavior. Much of the work thus far has focused on altering these problems at a relatively small scale; even the largest-scale interventions reviewed in this article are at the level of counties and states. However, there are a growing number of efforts under way to bring evidence-based preventive efforts to scale.

Perhaps the most successful example of this effort is the tobacco control movement, which has reduced the prevalence of smoking in many countries by altering a wide range of policies and practices that at the outset constituted a culture of smoking. The principles that underlie the smoking control movement are generic ones that apply to the intentional cultural change we have in mind. Indeed, the movement evolved out of the more general evolution of public health efforts to improve human health that began with sometimes desperate efforts to combat and prevent epidemics.

At the same time, we believe that a substantial convergence is emerging from research in epidemiology, public health, prevention science, neuroscience, and epigenetics that points to specific patterns of behavior that have well-established relationships to human well-being and specific types of environments that select these behavioral patterns and are, therefore, appropriate targets for efforts to influence the evolution of cultural practices. In the interest of space, we summarize this evidence within the framework of the principles that have guided tobacco control.

Identify factors that harm human health, giving priority to the most prevalent and deadly. This principle was initially established with epidemics, but it has been steadily extended to the causes of epidemics once those causes were recognized (e.g., sanitation, the presence of pathogens). Smoking became a target of public health efforts because it was linked to death from cancer, heart disease, and over the years, a growing number of other threats to life (U.S. Department of Health and Human Services 2000; 2004). This same epidemiological principle has been followed in order to identify numerous other unhealthful behaviors, including excessive alcohol use, drug addiction, academic failure, depression, and anxiety (Ainsworth 2002; McEvoy & Welker 2000; Munoz et al. 2012; National Research Council and Institute of Medicine 2004; 2009a; 2009b; Shonkoff 2003; U.S. Department of Health and Human Services 1999; Walker et al. 2005).

Converging evidence points to two contrasting clusters of behavior that have different implications for the well-being of individuals and those around them. One cluster might be called "prosociality." It consists of a set of behaviors, attitudes, and values that have to do with helping others, contributing to the community, and growing as a person (Biglan & Embry 2013; Kasser 2002; 2004; Kasser & Ryan 1993; Wilson et al. 2009). This cluster is associated with greater personal well-being and is beneficial to the group. Indeed, there is evidence that nations that have higher proportions of prosocial individuals also have stronger public policies supporting families and lower levels of carbon emission (Kasser 2011).

In contrast, a set of psychological and behavioral problems that include antisocial behavior, drug abuse, cigarette smoking, excessive alcohol use, academic failure, and depression are highly inter-related (Biglan et al. 2004).This cluster is harmful to individuals and to those around them. Young people with these problems are also more likely to endorse and pursue values having to do with fame and materialism, values that are associated with more problematical personal outcomes (Sheldon & Kasser 1998).

This epidemiological principle also extends to the environments. We are interested in the environments that select these two types of behavior. Considerable research shows that among children and adolescents, the complex of psychological and behavioral problems is selected in family and school environments that fail to nurture prosociality. Specifically, such environments (1) have high levels of socially and biologically toxic conditions, (2) fail to richly reinforce a wide variety of skilled prosocial behaviors, (3) fail to monitor and set limits on problem behaviors, and (4) fail to promote the kind of psychological flexibility that we described in our target article (Biglan et al. 2012).

Establish a goal of reducing the incidence and prevalence of the problem. One reason for the progress of the tobacco control movement has been its laser-like focus on addressing all of empirically established factors that influence the prevalence of smoking. The application of this principle in the present case implies that we need to increase the prevalence of family and school environments that select prosociality and minimize psychological and behavioral problems. That, in turn, implies that from a cultural evolution perspective, we are interested in how we can select environments that select prosocial behavior (Biglan et al. 2012).

Pragmatically implement whatever programs, policies, and practices can be shown to alleviate the targeted problem or reduce the risk factors that contribute to the problem. The tobacco control movement implemented whatever worked to affect smoking (Biglan & Taylor 2000). In our target article, we described one example of a family intervention that has been successful in decreasing the prevalence of abusive and neglectful environments. Other studies of this intervention and numerous other behaviorally oriented family interventions (e.g., Forgatch et al. 2009; Shaw et al. 2006; Webster-Stratton 2000) show that they can prevent the development of the range of psychological and behavioral problems described above. We also described interventions that make schools more nurturing of prosociality. And we described kernels that are beneficial in a wide variety of environments. In short, although there is much to be learned, we agree with the conclusion of the National Research Council and Institute of Medicine (2009b) report on prevention: In principle, we have the scientific knowledge to ensure that virtually every young person develops the skills, interests, values, and habits needed to become a productive and caring adult.

We are unclear about the distinction that **Aitken** makes between treatment and prevention interventions and "moulding the process of evolving more successful behaviour." We believe that the further dissemination and refinement of the strategies we describe are the very processes needed to evolve more successful (prosocial) behavior.

Monitor the incidence and prevalence of the problem and of risk factors that would affect the problem. Monitoring is an essential component of the tobacco control movement and all other public health efforts so that increasingly more effective methods of reducing the problem can be selected (Biglan & Embry 2013). A system for monitoring the psychological and behavioral problems described here

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has been evolving for at least 40 years in the United States. Monitoring the prevalence of nurturing families and schools is in its infancy. We think it likely, however, that as the central importance of these environments becomes clear, appropriate monitoring practices will be widely implemented.

R6. An evolving science of cultural change

The development of a science of cultural change is itself an evolutionary process. Contra **Aitken**, we do not believe that scientific understanding of cultural change is fully developed, and doubt it ever will be, as each major scientific "answer" raises new questions. Rather, we see the processes we have just described as ones that will be continually refined in light of their consequences. Those consequences will include not only the effects of specific change strategies on their targets, but also the acceptance or opposition of citizens and policy makers. Indeed, for the kind of change that is needed, we will have to further develop an evolutionary understanding of the major social forces affecting policy development, including the evolution of capitalism (Biglan 2009; 2011; Biglan & Cody 2013; Biglan & Embry 2013).

We are more optimistic than **Khalidi** is about the prospects for predicting the impact of societal change efforts, but only within fairly circumscribed boundaries. Specifically, we believe that the accumulated evidence on the impact of family, school, and clinical interventions shows that we can construct environments that reliably (though far from infallibly) result in prosocial behavior and the prevention of diverse psychological and behavioral problems.

At the same time, we think that caution about *any* intentional effort to change cultural practices is warranted (Biglan 1995). The numerous examples of human excesses in the effort to influence others' behaviors (e.g., Pinker 2011) make clear that *any* effort to change the evolution of individual or societal behavior must be guided by a system of safeguards. We suggest that the core design principles derived by Ostrom (1990; 2010) for common-pool resource groups and generalized by Wilson et al. (2013) provide a very workable system of such safeguards, which cuts well across different cultures and issues.

As several commentators suggest, any effort to use evolutionary science to guide cultural evolution will require ongoing discussion and the development of safeguards against misuse of that science (as well as every other practice that could harm well-being). Such safeguards are emerging. Prominent examples include the 1975 Helsinki Accords, the 1948 Universal Declaration of Human Rights, and the policies of the National Institutes of Health regarding research involving human subjects.

Some of the most important practices that have evolved in the economically developed world involve corporations and the market system that shapes and maintains these practices (Biglan & Cody 2013). We raise this issue for two reasons. First, we believe that the system of corporate capitalism that has evolved is one of the most important influences on the further development of society. Any effort to improve the prospect that our societies will evolve in a direction that increases the prevalence of prosociality and well-being will require that we develop an effective analysis of how to guide the further evolution of corporate capitalism to support prosociality (Biglan 2009; 2011; Biglan & Embry 2013).

Second, if those with an understanding of behavioral and evolution science hesitate to use that understanding to influence cultural evolution in a prosocial direction, the further evolution of society is simply left to other groups and organizations, many of which are not explicitly focused on improving human well-being. Many of these organizations are themselves making deliberate use of behavioral sciences. For example, the tobacco industry has used very sophisticated research to develop effective ways to market cigarettes to young people and to influence smokers not to stop smoking (National Cancer Institute 2008).

Proposals to influence cultural practices have often been opposed because it was assumed that they must necessarily involve the coercive power of the state (Chomsky 1971). However, the examples we provide make use of positive consequences. Indeed, they typically replace coercive approaches to change. Consider, in particular, the practices of parents. There is growing evidence about the kinds of parenting practices that harm children and make it more likely they will develop psychological and behavioral problems that are costly to them and to society (and that contribute to a lower life expectancy). Yet efforts to target coercive, neglectful, or abusive parenting practices must take place in the context of a democratic society with established policies that protect families from state intrusion. At present, the state can take children away from abusive and neglectful parents, but there are limits on when it can do that and, as a practical matter, there are limited resources for detecting such abuse.

But one can engage in intentional cultural change that prevents, averts, or reduces accepted indicators of child maltreatment by creating easy access for *any* family to learn scientifically proven noncoercive parenting practices in communities. That is precisely what happened when Prinz et al. (2009) offered evidence-based parenting supports to every family in an 18-county study. Simply making such practical tools easily accessible, with no coercion or shaming, had large effect sizes (*es*) on reducing multiple indicators of maltreatment (the smallest $es = -1.09$). The strategy cost only $15 per child. Given the effects of adverse childhood experiences on health, relationships, and life attainments (Shonkoff 2003; Shonkoff & Phillips 2000; Shonkoff et al. 2000), this would seem to qualify as a social good. Prosociality does not imply an absence of social harm. It is possible that some were harmed by a major reduction in child maltreatment in a local sense. Fewer prison cells will be needed, and the businesses that supply those cells will be harmed; fewer people will need expensive health care over their lives, and those providing that care may make less money, and so on. Democratic choices need to be made to balance these social costs.

If one examines the details of the family interventions we described in our paper and those of the many other evidence-based family interventions, one finds that they do not employ coercive means. Indeed, a fundamental principle of all of these interventions (e.g., Chamberlain 2003; Forgatch et al. 2009; Shaw et al. 2006; Webster-Stratton 2000) is that interventionists empathically join parents around the goals that they have for their families and their children. Just as the coercive behavior of parents toward their children is problematic, it is counterproductive to try to coerce parents to change their parenting behavior. Far from abrogating individual rights and coercing change, the interventions that have been developed involve empathic involvement with children and adults that minimizes coercive efforts to change behavior.

So, while acknowledging that there are risks to *any* effort to change behavior, our understanding of the key ingredients of the most effective treatment and prevention interventions makes us less concerned than is **Khalidi** that there will be "ethical costs of interventions involving social control that may have unforeseen consequences."

R7. Who decides?

Scientifically guided efforts to influence the direction of cultural evolution should have no special status in relation to other efforts. Each must compete in the marketplace of ideas, at least within democratic and capitalist societies. If 100 years from now, people look back at the history of cultural change and conclude that cultural change was increasingly guided by an evolutionary science of intentional change, it will be because a growing proportion of the population found that the guidance provided by such a science was preferable to other systems for enhancing their well-being.

We should not be naïve, however, about the social forces that are influencing cultural evolution currently. Social interests collide and groups often pursue their interests selfishly. For example, corporate capitalism has influenced numerous policies, some of which have harmed the well-being of families and schools (Biglan & Cody 2013). An effective analysis of how such practices are selected and can be modified will be key to learning how to guide cultural evolution. In the modern world, the "we" who decides has grown. In the modern world, it includes all of us.

Wang et al. cite cultural differences as well as organizational memberships affecting the important issue of "us versus them" for thinking and acting for intentional change on such issues as helping others, reducing conflict, and caring for the environment. "Us" and "them" can be modified, however, even when an individual or group within the larger group would benefit by being "selfish."

Consider a couple of examples from the paper. The Good Behavior Game creates group interdependent rewards, which means that the child has to "give up" high levels of social reinforcement as an individual for engaging in deviant behavior. This simple strategy immediately has effects on "selfish" behavior in more than 70 studies (Tingstrom et al. 2006). What is extraordinary, however, is that prospective, randomized control trials show that a year of exposure to this simple recipe in first grade has a more than 20-year impact on reducing the pursuit of antisocial behaviors (Kellam et al. 2011). This is not the only example of using interdependent group rewards to reap long-term positive impacts on children (Greenwood 1991a; 1991b). These changes in classroom environments apparently "reset" the early developmental and evolutionary markers that predict human life histories.

Perhaps the best large-scale example from our paper of swapping out short-term individual or small group gains for longer-term social gains for unknown persons is the Reward & Reminder protocol that publicly recognized clerks and stores for not selling highly profitable tobacco products. Any rewards received by clerks were small, and no store received a financial incentive. About 30% or more of the profits of many outlets come from tobacco products. Yet, a status/reputation symbol and small rewards caused tobacco outlets to forgo substantial revenue in a short period of time and to maintain that behavior for many years.

As many commentators note, intentional change has its perils. The possibility of harm is not avoided by maintaining ignorance of, or denying the faculty for, the capacity for intentional change, nor by the pretense of innocence so as to avoid a decision to act one way or another. The lack of perfection for the prediction and influence of human behavior does not eliminate the need for us to continue to learn how to do so at the scale needed to confront the challenges we face. Humans have the capacity to alter our physical and social world intentionally, with effects good and ill, and we do so every day at both large and small scales. Explicitly and implicitly, we have already developed a number of technologies of intentional change. We have eaten from the tree of knowledge, and we left the garden of innocence long ago. Now we must learn how to systematize that knowledge and use it intentionally to leverage our best ideas and practices from the full range of relevant disciplines. Evolution science provides a way to do that. It is time to begin.

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[The letters "a" and "r" before author's initials stand for target article and response references, respectively]

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