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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 scientific 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 with the same kind of combinatorial diversity as 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 each other.

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, from individuals seeking to improve themselves, to neighborhoods seeking a greater sense of community, to nations attempting to function as corporate units, to the entire planet 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 for 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 a science of change. After all, 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 and Lamb 2006; Richerson and 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 prefer not to go. The only solution to this problem is to become wise managers of evolutionary processes (Wilson 2011a).

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 and 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 20th 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 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 language, 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 and 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 the term *evolutionary psychology* (EP), was only the beginning and in some ways led in the wrong direction. In particular, the distinction between EP and the *standard social science model* (SSSM; Pinker 1997; 2002; Tooby and 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 and Rauscher 2002; Wilson 2002a).

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 designed and validated programs that accomplish change on three 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 two 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 wellbeing. 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 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 formulation 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 (EP)*. These 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., Tooby and Cosmides 1992, Pinker 1997; 2002). 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 (1981, p. 501) 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 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 that confront us.

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) as 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' 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. 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' 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, since 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 (p. 417), but his preferred interpretation was that general learning processes themselves were not useful: "we 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 and Hardcastle 2000; Carruthers 2006; Fodor 1983, 2000).

Tooby and Cosmides' (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 and 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." Since our modern skulls house 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 pasts.

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 (1895, p. 106) perceived for cultural evolution when he wrote that "individual natures are merely the indeterminate material that the social factor molds and transforms." 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 non-genetic 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 non-genetic 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 and Richerson 1985; Calvin 1987; Campbell 1960; Edelman 1988; Edelman and Tonomi 2001; Farmer and Packard 1987; Jablonka and Lamb 2006; Plotkin 1994; 2003; 2007; Richerson and Boyd 2005; Wilson 1990; 1995). Evolutionary processes that rely on non-genetic inheritance mechanisms either evolved genetically or were created by humans, as Skinner appreciated in the abstract quotes 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 Machines). 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 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 do not occur 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 was 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, since it is a relatively new topic in animal behavior research (Hill 2010; Laland and Galef 2009; Laland and Hoppitt 2003; Page and Ryan 2006). However, the human capacity for behavioral and cultural change is so distinctive that it borders on unique (Deacon 1998; Jablonka and 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 and Szathmary 1995; Sober and Wilson 1998; Wilson 2011b). 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 a) the reconciliation of elaborate genetic innateness with elaborate open-ended flexibility and b) 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 and 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, since 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 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 upon, 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 upon (Deacon 1998).

Since the term "symbotype" bears a superficial resemblance to the term "meme" (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 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, Boyd, and Richerson 2008; Laland and Brown 2011). The concept of "evolution without replicators" applies even to genetic evolution (Godfrey-Smith 2000). In any case, the term "symbotype" does not refer to a single cultural trait but rather 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 and inhabited 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 and 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 and Mace 2009). Moreover, the four inheritance systems discussed by Jablonka and Lamb (2006)—genetic, epigenetics, learning, and symbolic thought--have been interacting with each other throughout our

history as a species (Richerson and 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 each other 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 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 upon 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 they 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 each other. In addition to the applied academic disciplines, commercial marketers and political strategists attempt to influence behavioral and cultural change -- often very successfully and not necessarily for the common good. The scientific caliber of any particular 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 consider recent developments in evolutionary science. They, 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 might be surprised to learn how much their particular discipline 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 20th 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 by acceptance and mindfulness-based techniques with proven efficacy (Hayes et al. 2011; 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 like 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. 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 and 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 to 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 besides avoidance in their presence (Craske and 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. The fact 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 and 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, Mineka, and Barlow 2001).

Cognitive behavior therapy goes beyond behavior therapy by encouraging clients to re-conceptualize their problems (e.g., Beck 2011). In evolutionary terms, the reason that cognitive therapy adds value to behavior therapy is because 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 person 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 re-conceptualizing 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 and 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, cognitive behavior therapy (CBT) uses this universal human capacity for therapeutic purposes, and 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, Barlow, and Meadows 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 the identify the

negative cognitions associated with physical sensation triggers of recent panic attacks, and practicing replacement of maladaptive cognitions with non-catastrophic 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 upon 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 apply 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. (2011).

RFT derives from the functional contextual wing of behaviorism but 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, an arbitrary learned relation of a particular kind between A and B and B and C automatically results 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 and 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 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 obscure. Using the venerable evolutionary metaphor of adaptive landscapes (Provine 1986; Pigliucci and Kaplan 2006; 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 and 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; Hayes et al. 2006; Wenzlaff and 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 2002b). 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 that 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 the distressing thoughts and feelings that are you have not necessarily chosen. In fact, some of them are downright scary. 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, it supports the key processes of increasing healthy variation and selection by chosen consequences.

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 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 their gene's expression. As soon as we start thinking about the symbotype-phenotype relationship as 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 not only that these methods work: in some cases, we also know why they work, and often the processes of change 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 such diverse problems as chronic pain (e.g., Wicksell et al. 2009), substance use (e.g., Witkiewitz and Bowen 2010), tinnitus (e.g., Westin et al. 2012), worksite stress (Flaxman and 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 induces healthy flexibility that can help people solve panic disorders (Arch et al. 2012), 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 create lives in the face of chronic pain (Vowles and McCracken, 2008). Increasing retention of new behavior by practicing skills is as applicable to experts in almost any field (Ericsson and 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 impacted evidence-based psychotherapy is provided by Arch, Eifert et al. (2012), who randomly assigned 128 patients suffering from a variety of anxiety disorders either to exposure and gold-standard cognitive change methods (CBT) or to exposure and acceptance and mindfulness methods (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 there to the end of a one-year follow up, however, adding acceptance and mindfulness methods led to about 25% additional improvement, while the other group maintained gains but did not continue to improve. In both groups, improvements were best accounted for by greater psychological flexibility toward difficult thoughts (Arch, Wolitzky-Taylor et al. 2012), but ACT improved more on general and thought-specific measures of psychological flexibility (Arch, Eifert et al. 2012; Arch, Wolitzky-Taylor et al. 2012). 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 incidence 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 and Institute of Medicine, 2009) documents numerous effective preventive interventions for all phases of human development, from the prenatal period through adolescence. Figure 1 (below) is from that

report. Each set of brackets denotes an intervention or set of interventions that have 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.

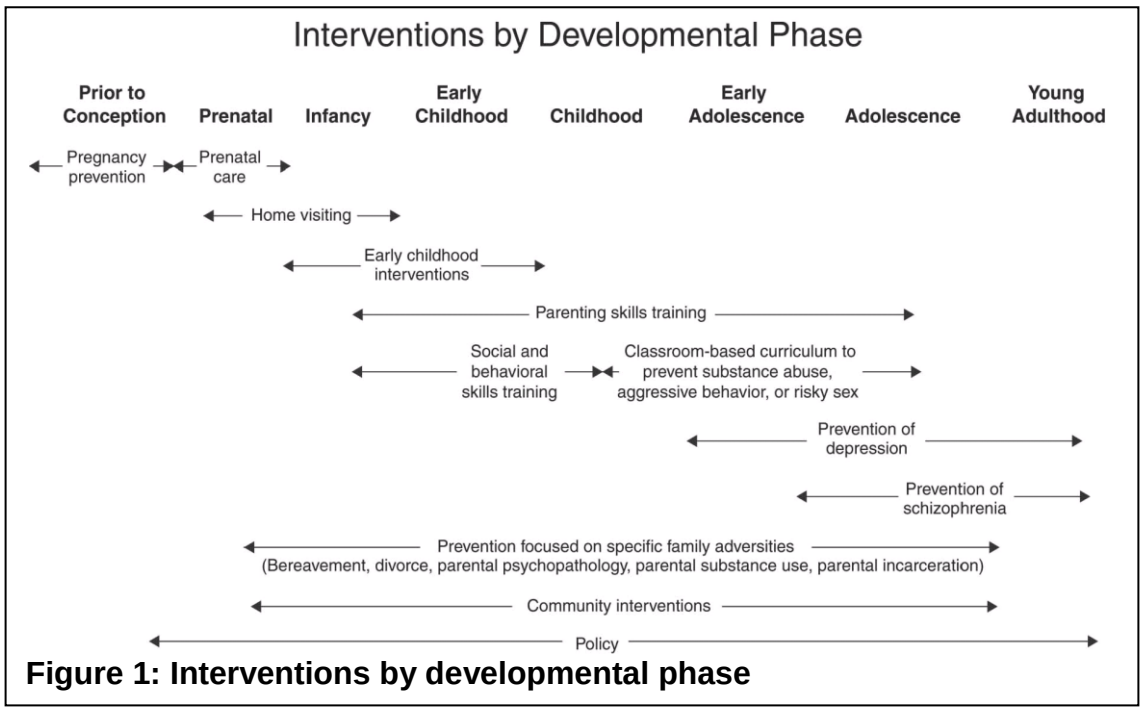

Figure 1: Interventions by developmental phase

Embry and Biglan (2008) compiled a list of over 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 the following two sections. 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 Works Clearinghouse (http://ies.ed.gov/ncee/wwc/), and the Promise Neighborhoods Research Consortium, (www.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 upon their values in selecting their practices, no less than individuals. 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 upon 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 and 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 each other in the past, but, in their most general forms, they become equivalent methods for accounting for evolutionary change in multi-group populations (Sober and Wilson 1998; Okasha 2006; Wilson and Wilson 2007; Wilson 2012).

Table 1: Examples of kernels for selected, indicated, and universal prevention

Kernel	Selected Prevention	Indicated Prevention	Universal Prevention
Prize Bowl/Mystery Motivator: Rewards of varying value are drawn contingent on targeted behaviors (reinforcement)	Reduce alcohol, tobacco, or drug use (Petry et al. 2004; 2005; Stitzer and Petry 2006) 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 1996)	Improve engaged learning and reduce disruptions of whole classes (Bennett 2007; DeMartini-Scully et al. 2000; Madaus et al. 2003)
Goal/Node Mapping: People receive help to analyze a problem and identify steps they can take to resolve it (relational frame)	Reduce relapse or recidivism rates (Collier et al. 2001; Czuchry and 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 and Dansereau 2000; Czuchry and Dansereau 1998; Nesbit and Adesope 2006; O'Donnell et al. 2002)

Kernel	Selected Prevention	Indicated Prevention	Universal Prevention
Omega-3 fatty acid supplementation (physiological)	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; 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 (antecedent)	Reduce community illegal behaviors (Biglan et al. 1995; 1996; Embry and Biglan 2009)	Improve problematic behavior in therapeutic settings (Bacon-Prue et al. 1980; Lyman 1984)	Reduce impulsive or risky behaviors in general population (Houten and Marini 1980; Kehle et al. 2000) Improve academics (Gross and Shapiro 1981; Van Houten et al. 1974; 1975) Promote participation or community goods (Jackson and Mathews 1995; Stokes et al. 1978)

The evolutionary dynamics of cooperation in all social species provides one body of information that can be brought to bear upon 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 and 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 overuse, a problem that can 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 features 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 while others receive the benefits cannot continue over a long term. In the most successful groups, the expectation is that everyone will do their 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 individuals 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 both 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 a group is nested with a larger society, relationships among 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 upon in the next section.

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

Wilson (2011c) and Wilson et al. (2011a) relate the core design features 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 features on their own, as if they were purely instinctive. The reason that Ostrom could derive the design features 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 the design features. Neighborhoods seldom have a strong sense of group identity (a violation of design feature #1). Groups frequently consist of a few beleaguered volunteers who do most of the work (a violation of design feature #2). Discipline in schools is frequently neither fast nor based on a procedure that the students perceive as fair (a violation of design feature #6). Why aren't these design features 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 female mammals had no alternative to breastfeeding, and therefore no reason to evolve a preference for it compared to an alternative. Similarly, throughout their evolutionary history, humans had no alternative to living in small social groups and thus did not necessarily evolve the instincts for creating them when alternatives became available.

It is also important to distinguish between the core design features 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 for an insect, a bird, or a bat. The one-to-many relationship between a design feature and its implementations can be

demonstrated in the laboratory. In one classic experiment, the same phenotypic trait of wing vein length was selected 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 between 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; the one that 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 groups attempting to manage common-pool resources includes groups that were faced with an identical problem, such as different Nepalese farmer associations attempting to manage their irrigation systems (Ostrom 1990). They arrived at different implementations of the various design features (e.g., how to monitor), just as the different populations of drosophila evolved different genes for wing vein length. The groups adapted to their 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 why cookie-cutter policy solutions don't work and groups need local autonomy (design feature #7).

The core design features 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 upon the core design principles and appear to work exceptionally well, compared to the conventional American classroom environment.

An alternative school called the Sudbury Valley School embodies most of the design features and functions exceptionally well (www.sudval.org). The governance of the school is democratic, with students taking part in all of the major decisions, including hiring and firing of faculty. Norms of good behavior are agreed upon by consensus, monitoring is efficient, and conflicts are resolved by a judicial committee that all students and staff members are expected to take turns serving upon. 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 self-motivated learning by the students 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 and Chanoff 1986; Gray and Feldman 2004). Gray (2009, 2012) 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 all cultures have bodies of knowledge comparable to reading, writing, and mathematics. Is there really such a difference between an American boy learning his timetables and an Australian aborigine boy learning his song lines (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 to an elite private school education.

Conventional schools can also implement the design features more than they customarily do. A grade-school teacher invented a set of practices called "The Good Behavior Game (GBG)," 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, has most, if not all, of the core design features 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: but the important fact is that they are *their* lists and not lists arbitrarily imposed upon them 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 like singing a song or dancing for a minute. At first, they play the game for brief periods with immediate rewards. Gradually the game lengthens and occurs without any previous announcement. The rewards gradually appear later, until 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 the group to reward good rather than deviant behavior. Potentially destructive aspects of between-group competition are managed by periodically shuffling the composition of the group. These and other elements of the GBG are now conceptualized as "kernels," as we described earlier (Embry 2002; Embry and Biglan 2008).

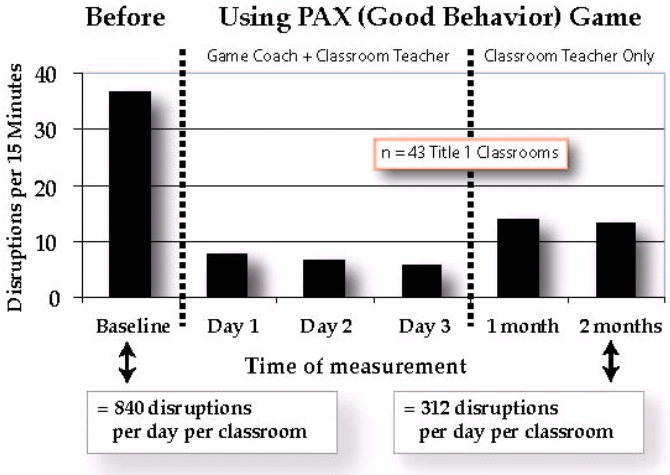

Figure 2: GBG outcomes for 43 classrooms

Not only can the GBG have a transformative effect on classroom behavior over the short term, as Figure 2 shows for 43 classrooms, but it has long-term effects that extend into adulthood. In a longitudinal study that began in the 1980s in the Baltimore City School District, the GBG was implemented in the first and second grades for some classrooms but not others in a randomized controlled design. No intervention took place after the second grade. 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. During grades six through eight, they were less likely to use tobacco or hard drugs. In high school, they scored higher on standardized achievement tests, 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 GBG was especially effective at achieving these outcomes for boys (Bradshaw et al. 2009; Kellam et al. 2008).

These lifelong positive outcomes illustrate the cumulative effect that cooperative behavior can have over the course of child development (Belsky et al. 2010; Del Guidice et al. 2011; Ellis and 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 et al. 2004; Biglan and Cody 2013). This objective can be accomplished surprisingly easily, once the design features that enable groups to function as cooperative units have been identified, as the GBG attests.

Interventions that start during the adolescent stage of the life cycle are inherently more challenging than early childhood interventions, since 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, 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, extended school year, meal and healthcare programs, and so on (Whitehurst and 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 to early prevention strategies such as the Good Behavior Game (Drake et al. 2009). Second, they might have become more difficult to change as *groups*, since peer groups play a larger role in the lives of adolescents than young children. 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 and Saigh 2011).

A new program for at-risk ninth and tenth graders called the Regents Academy, which is the first to be designed explicitly from an evolutionary perspective, has achieved impressive results during its first year (Wilson et al. 2011b). The evolutionary principles used to design the Regents Academy include the core design features, 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, while 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, Ostrom, and Cox, 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 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, the group's reward is contingent on the inter-locking behavior of the group. In Ostrom's cases, the set of principles 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 principle 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 principle 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 and Boyd 2005; Stoelhorst and Richerson 2013; Witt and 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 with chronic warfare, 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 favor practices that eventually lead to their collapse. New empires almost invariably form at the boundaries of old empires, not at their centers, which 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 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) Establish 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 occur 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 printed on cards that clerks could simply hand to the customers. One card read, "I don't think so. Folks like me make about $7 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 2-1/2 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 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.

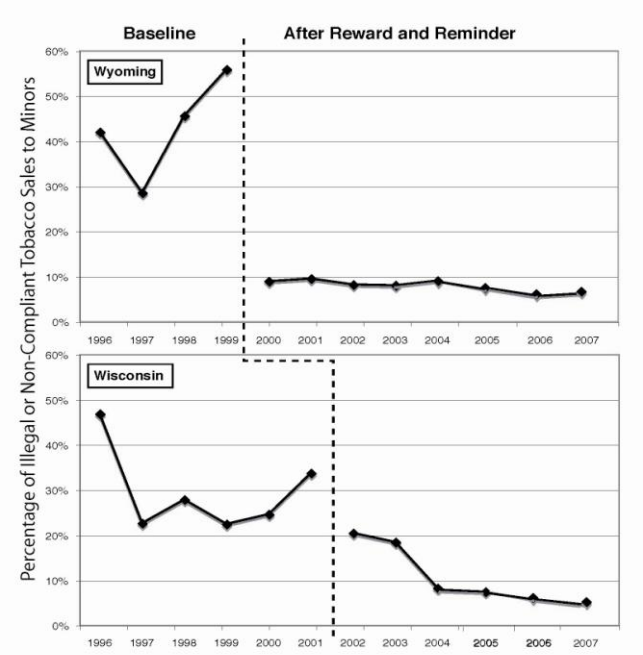

Figure 3: Wyoming & Wisconsin R&R Outcomes

Tallying the financial costs and benefits, the intervention was highly cost effective for the states, thanks to the federal regulation that would have caused them to lose millions of dollars in 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.

Prevention scientists in Australia (Sanders et al. 2002) developed a population approach to improving parenting practices called Triple P (for Positive Parenting Program). 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 of child abuse in America has increased 35% during the past 10 years (http://www.childhelp.org/pages/statistics). Extreme child abuse is the tip of an iceberg of parenting practices that harm the long-term welfare of children, resulting in depression, academic failure, teenage pregnancy, substance abuse, and crime. If we can solve some of these problems by improving parenting practices, we can substantially improve the quality of human life on earth.

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. Parents evolve to maximize their lifetime reproductive success, which can involve withholding support from particular children (Trivers 1972). Men are especially likely to invest in mating effort rather than parental effort. Relations between step-parents and step-children are likely to be especially problematic because there is no genetic interest at all (Daly and 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 within families in a tragic co-evolutionary race to the bottom (Patterson 1982; Forgatch et al. 2008; Reid et al. 2002). Each family member learns that, if another is behaving in an unpleasant manner (e.g., criticizing, teasing, or attacking), then escalating his or her own aversive behavior will frequently cause the other person 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 parents' 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 don't 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).

Over 50 experimental evaluations demonstrate that parents locked in a negative co-evolutionary spiral with their children can learn to adopt a positive co-evolutionary spiral by 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 and 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. The first level involves using mass media to reach parents with information

and advice about effective parenting. The second provides advice to parents from childcare providers and human service workers who frequently contact the parents through brief individual consultations or 90-minute group seminars. Level 3 provides more-intensive training in skills for dealing with circumscribed 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 had 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 implementation cost. Triple P is now

implemented in over 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, other drug use, and delinquency. The table also lists policies regarding 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, which 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. See 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 and policies 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—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 antitobacco 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	Classroom curriculum; parent training; education of community leaders; media	Reductions in tobacco, alcohol, and marijuana use	Pentz et al. 1989a; 1989b; 1989c

Community Interventions Evaluated in Randomized Trials

Project and Target	Intervention	Outcomes	References
tobacco, alcohol, and other drug use	campaign focusing on prevention policies and practices		
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—multiple youth problems (violence, substance abuse, unsafe sex) among early adolescent African Americans	Social skills curricula, focused social competence or social competency curricula plus in-service 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	Both interventions reduced 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 (SF) and one of two school-based drug abuse prevention curricula LST or Project Alert)	Reductions in cigarette, alcohol, marijuana, and inhalant use	Spoth et al. 2007a; Spoth et al. 2007b

Policies

Domain	The Policy	Outcome	References
Alcohol use	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. in press; Wagenaar et al. 2009
	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 and Chikritzhs 2009 Popova et al. 2009
Tobacco use	Increasing the tax on tobacco products	Reduction in youth initiation of smoking and adult rates of consumption	Chaloupka and Grossman 1996; Chaloupka and Pacula 1998; Lewit et al. 1997
	Restrictions on 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

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 and Lamb 2006).

The 1980s and 90s 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 the term "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 them 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 than 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 upon 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 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, p. 67) hint at this fact 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" (Durkheim, 1912, p. 264).

A believer in Jesus sees the world differently than a follower of Ayn Rand, 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, Hayes and Gallop 2012 and Bach et al., in press, for struggles with hallucinations or delusions, or Walton and 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 2011a). 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 if 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, others 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's 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. 2011), 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 which 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 they 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 well-established threats to public

health (e.g., youth tobacco use and 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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