agent's *Umwelt* (von Uexküll 1957). From a neural perspective, there is evidence that this capability is a by-product of the interplay between the neocortex and the basal ganglia (Daw & Doya 2006; Doya 1999). Interestingly, Doya (1999) maintains that the CNS, although genetically geared toward ontogenetic development, is teleologically open. Moreover, the three main learning paradigms – supervised, unsupervised, and reinforcement learning – seem to be largely unbiased by evolutionary fine-tuning. According to Doya, "the learning modules specialized for these three kinds of learning can be assembled into goal-oriented behaving systems" (Doya 1999, p. 961). This idea runs afoul of the massively modular view of the mind (as is often the case with EP). Two considerations follow. First, the discussion between EP and SSSM may benefit from these models and from the resulting interpretation of neural data. Second, the relation between learning and goal generation is emphasized.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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