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# Proposing a Cultural Evolutionary Perspective for Dedicated Innovation Systems: Bioeconomy Transitions and Beyond


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## ABSTRACT

While the Earth system is in overshoot mode with an imminent threat to our social, ecological, and economic systems, cultural evolutionary theory may hold the key to more successfully addressing many of our sustainability challenges. With the aim of illuminating the potential of studying the evolution of a sustainable bioeconomy through a cultural evolutionary lens, this article outlines the contours of a novel research avenue in the form of five propositions. It contributes to current conversations in the literature at the intersection of sustainability transitions, dedicated or mission-oriented innovation systems, and the bioeconomy by raising awareness of the warranted value that a cultural evolutionary perspective has in tackling these grand challenges and addressing how this yet unclaimed potential could be materialized.

**KEYWORDS:** Bioeconomy, Multi-level Perspective (MLP), Multilevel Selection, Coevolution, Cultural Evolution, Sustainability Transitions, Worldviews

**JEL CODES:** B59, E14, E71, H12, O13, O35, Q01, Q50, Z13

Humanity faces various unprecedented challenges, many of which have been caused or at least significantly exacerbated by our industrialized societies, such as extreme weather, melting glaciers, pandemic viruses, and severe biodiversity loss (*e.g.* Jamail, 2019; Lade *et al.*, 2020). Ecologists, economists, and management scholars alike have stressed that the Earth system is already in an overshoot and collapse mode (*e.g.* Bendell, 2020; Gowdy, 2020; Rees, 2020), meaning that there is an imminent threat to the existence of lives and livelihoods on a planetary scale, together with the unsustainability of many of our social, ecological, and economic systems—as also evidenced by the transgression of "planetary boundaries" (Rockström *et al.*, 2009; Steffen *et al.*, 2015). To tackle these grand challenges, researchers from related fields and schools of thought, such as innovation systems (*e.g.* Hekkert *et al.*, 2020; Urmetzer, Pyka, 2021) and the wider transitions studies (*e.g.* Geels, 2002; Köhler *et al.*, 2019), have recently shown increased interest in exploring, explaining, and eventually governing the complex, dynamic change processes of several interconnected systems (*e.g.* socio-technical, ecological, economic; Schlaile, Urmetzer, 2021). Prime recent examples include the work on structural transitions towards sustainable bio-based economies (*e.g.* Pyka, 2017a, 2017b; Urmetzer, 2020) and related work on resource circularity and zero-waste principles (*e.g.* Debref, 2018; Morone, Yilan, 2020).

However, the way humans are overusing natural resources and producing waste and greenhouse gas emissions cannot be understood from economic and technological perspectives alone. It must also be understood as a result

of cultural evolutionary processes – including the evolution of values (*e.g.* concerning nature) and practices (*e.g.* concerning agriculture) – of our societies (*e.g.* Ellis, 2015; Snyder, 2020). While the cultural evolution of the ways humans have interacted with their environment has created conditions conducive to the emergence of many of our current problems, advocates of cultural evolutionary theory argue that a better understanding of these processes holds the key to addressing our sustainability challenges (*e.g.* Brewer, 2015; Waring *et al.*, 2017; Brewer, Riede, 2018; Biglan *et al.*, 2020). In this paper, we propose that a cultural evolutionary lens warrants the potential to form a promising research avenue at the intersection of the bioeconomy, innovation systems, and sustainability transitions studies. To this end, a cultural evolutionary perspective for the bioeconomy is well-positioned to extend knowledge on the antecedents of escalating social and environmental issues, and to inform improved bioeconomy policies that holistically contribute to tackling the grand challenges. Our article contributes to the body of literature devoted to the (intentional) evolution of dedicated innovation systems (Pyka, 2017a; Schlaile *et al.*, 2017; Schlaile *et al.*, 2021; Urmetzer, Pyka, 2021) that support the transition to sustainable bioeconomies. To understand the urgency of such research, it is important to acknowledge that a bioeconomy has the potential to contribute to sustainability transitions; yet, if left unattended, forms of bio-based economies that prolong unsustainable practices – and thereby accelerate the transgression of the planetary boundaries – are absolutely possible and easily conceivable (*e.g.* Heimann, 2019; Liobikiene *et al.*, 2019). In fact, the bioeconomy could be understood as part of a larger paradigm (*e.g.* Urmetzer, 2020), and the current literature demonstrates that how the bioeconomy is envisioned and framed by different stakeholders can be neatly analyzed using a worldview lens (de Witt *et al.*, 2017). This, in turn, makes a focus on the normative orientation and directionality of innovation systems a high priority (Sjøtun, Njøs, 2019; Uyarra *et al.*, 2019; Hekkert *et al.*, 2020), especially for policy-relevant bioeconomy research. It has been shown, however, that the normative orientation of innovation systems is much more complex than the umbrella term of "sustainability" suggests at first glance (Schlaile *et al.*, 2017; de Vries *et al.*, 2021). Sustainability itself is a contested notion meaning very different things to different actors, likewise depending on their worldviews and respective paradigms (Hedlund-de Witt, 2013a). Particularly due to the fact that legitimization for instigating a system-wide (re)orientation towards addressing global social and environmental issues does not lie with a national government alone (*e.g.* Loorbach, 2010; Bosman, Rotmans, 2016), transitions to sustainable bioeconomies cannot be solely brought about by means of top-down approaches (Fritsche *et al.*, 2020). Against this background, this article focuses on the cultural dimension of

sustainability transitions and makes a twofold contribution to current conversations in the literature: First, it raises awareness for the warranted value that a cultural evolutionary perspective offers for tackling our societies' challenges related to sustainability transitions. Second, it addresses how this yet unclaimed potential could be materialized, by drafting the contours of a cultural evolutionary multilevel perspective for dedicated (or mission-oriented) innovation systems for a sustainable bioeconomy.

The paper is structured as follows: The next section gives a brief introduction to the problem and explains our motivation and vantage point. Subsequently, we revisit selected core concepts in research on worldviews and cultural evolution that are especially relevant for understanding multilevel transition processes towards sustainability. Building on these concepts, we then explore what can be gained from these insights for better understanding and to intentionally influence the transition towards a sustainable bioeconomy. The paper concludes by summarizing our conceptual contribution in the final section.

# Development of an Integrated Theoretical Framework

## Cultural Evolution and Transition Dynamics

The works on evolutionary economics (*e.g.* Nelson *et al.*, 2018) and socio-technical transitions (*e.g.* Köhler *et al.*, 2019) have undoubtedly advanced our understanding of long-term and multi-scale change processes (Schlaile, Urmetzer, 2021). The framework of innovation systems (*e.g.* Rakas, Hain, 2019) draws from both of these fields, and it has been argued to offer complementary viewpoints to the "multi-level perspective" (MLP) on socio-technical transitions (*e.g.* Weber, Rohracher, 2012). In the MLP, the economy is conceptualized as part of a socio-technical system where incumbent actors—such as firms and policymakers—together with the prevalent laws and regulation, markets, patterns of production and consumption, etc., form a socio-technical regime, exhibiting a moderate level of structuration (Geels, 2002; Geels, Schot, 2007). At a level with a lower degree of structuration are the socio-technical niches, representing spaces for experimentation with the coevolution of technology, practices, and institutions (Schot, Geels, 2008). Above the regime (regarding higher levels of structuration) is the landscape level, encapsulating long-term geopolitical trends, Earth system processes, and institutionalized cultural value systems. Despite the inclusion of culture into the MLP (as part of the

regime or as an element of the landscape), Göpel (2017, p. 126) argues that "*mindsets, narratives or cultural aspects and their potential structural power in pushing or blocking transformative change*" are under-researched by transitions scholars. Relatedly, we claim that any conception of a viable and future-proof economy – including a bioeconomy – must incorporate an adequate understanding of the interplay between culture, worldviews, and sustainability. On that score, it is interesting to see that calls for opening up the "black box" by taking cultural influences on (concepts and practices of) sustainability more seriously are gaining momentum (*e.g.* Caldas *et al.*, 2015; Waring *et al.*, 2015). One possible way of incorporating cultural aspects into transitions studies is by explicitly investigating the evolution of habits and institutionalized conduct and the dynamics of value systems, norms, and rules with a particular focus on sustainability and bioeconomy. Analyzing the cultural evolution of seemingly nonrational practices may help to better explain why the actors in an innovation system may sub-optimize. It might also indicate how culture-based obstacles to transformative change like opportunism, national pride, and the rat race between nations to stick to unsustainable technologies can be better incorporated in economic models and policy. In an effort to incorporate the interplay of such cultural elements like mindsets and paradigms into the MLP, Göpel (2016) proposes an extended MLP that also seeks to link some of the socio-technical and the social-ecological transitions perspectives. For the purpose of framing this article, we build on this extended MLP proposed by Göpel (2016) as an overarching framework in line with the notion of dedicated innovation systems (*e.g.* Schlaile *et al.*, 2017; Urmetzer, Pyka, 2021) to connect to different strands of the cultural evolution literature. Cultural evolution refers to the understanding that cultural change, including changes in value and belief systems, norms, customs, rules, capabilities, and even technology (*e.g.* Richerson, Christiansen, 2013; van den Bergh, 2018), is an evolutionary process that is fundamentally similar – but in some respect also different from – genetic evolution (*e.g.* Boyd, Richerson, 2005; Mesoudi, 2017). Thus, research on cultural evolution heavily draws on "biological knowledge" about evolutionary processes. For example, it is fair to say that knowing how cultural traits are transmitted, selected, varied, and retained is key to understanding how sustainability-relevant values, worldviews, and institutions (co)evolve (*e.g.* Matutinović 2007; Brooks *et al.*, 2018) and how groups develop norms and moral codes that may shape collective action (*e.g.* Ostrom, 2000, 2014; Atkins *et al.*, 2019; Snower, 2019). In this line of research, a mechanistic view of economies based, for example, on mathematical models focused on equilibria and optimization problems is abandoned in favor of a perspective that considers an economy as an evolving

complex system that is interconnected with the environment and society (*e.g.* Holling, 2001; Debref, 2017; Giampietro, 2019).[1]

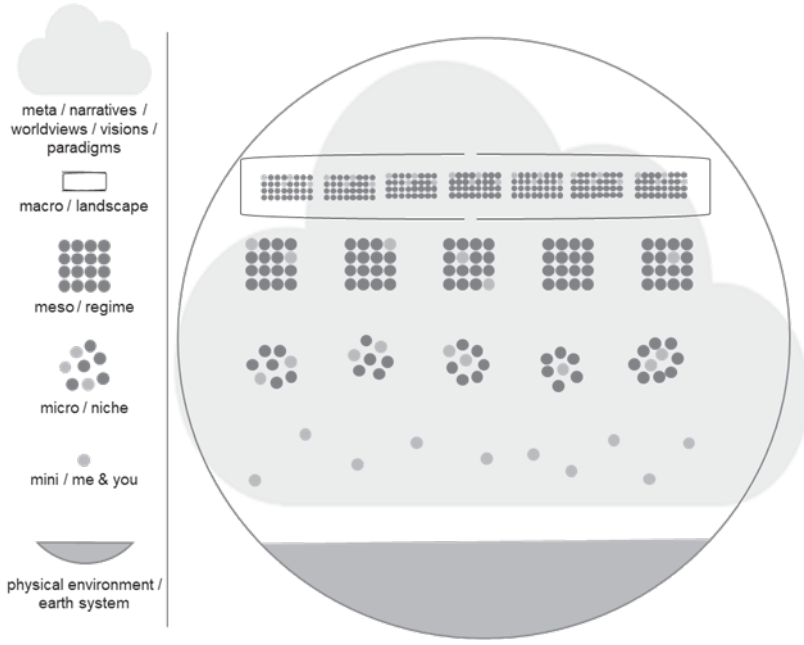
A central feature of an evolutionary perspective is an explicit consideration of the three central and interconnected processes of variation, selection, and retention (*e.g.* Aldrich *et al.*, 2008; Waring, 2010; Brooks *et al.*, 2018; van den Bergh, 2018). Yet, what is varied, selected, and retained in an innovation system is not straightforward as this evolutionary process occurs at multiple levels ranging from the evolution of cultural traits (often called "memes"; Schlaile *et al.*, forthcoming; van den Bergh, 2018; Schlaile, 2021) to biological traits or genes, individuals, or even whole groups, as captured by multilevel selection theory (*e.g.* Wilson, Wilson, 2007; Waring *et al.*, 2015; Kline *et al.*, 2018; Atkins *et al.*, 2019). This points to interesting connections between the MLP by Geels and colleagues and multilevel selection (see Geels, 2020, on a related note).

In the following subsections, we present selected core concepts that we deem relevant for the evolution of innovation systems dedicated to sustainability. Yet, this (eclectic) collection of concepts relies on the authors' prior engagement with the literature and should not be seen as exhaustive as it is not based on data obtained from systematic analyses of a scientific literature database. However, to frame and anchor our arguments, we will build on a slightly amended version of the MLP that builds on Göpel's (2016) graphical representation: Figure 1 shows the different levels of the MLP explicitly including the meta level as an overarching one, pertaining to all levels of structuration. To simplify, we have omitted the arrows that often appear in graphical representations of the MLP, but this does not imply that the dynamics between different levels are deemed less relevant. Moreover, when looking at this graphical representation of multiple interrelated (sub)systems, it is important to remember that "'*wholes' and 'parts' in this absolute sense just do not exist anywhere […] What we find are intermediary structures on a series of levels in ascending order of complexity*" (Koestler, 1967, p. 48).

This leads to *Proposition 1*: The literature on cultural evolution (especially in combination with the MLP) can help to improve our understanding of – and our ability to intentionally intervene in – sustainability transitions on multiple levels.

1. Such shifts in understanding, from a mechanistic to a complex systems perspective, can also be understood as manifestations of the cultural evolutionary process at work.

***Figure 1*** **– The extended MLP; own adaptation based on the representation by Göpel (2016)**




## The Meta Level: The Cultural Evolution of Worldviews

For the purpose of our article, we adopt Göpel's (2016) conception of the meta level as an umbrella for the deeply ingrained paradigms, worldviews, narratives, etc., influencing all of the other levels in different ways. For brevity, we use the terms paradigms and worldviews as almost synonymous and interrelated: For example, a paradigm can be understood as "*a complex set of assumptions, concepts, values, and practices that constitute a worldview for the community that shares them*" (Schlaile *et al.*, 2017, p. 4). Worldviews, in turn, are "*inescapable, overarching frameworks of meaning and meaning-making that to a substantial extent inform how humans interpret, enact, and co-create reality*" (Hedlund-de Witt, 2013b, p. 156). These overarching frameworks are the 'big stories' through which humans make sense of their experiences and the world, giving them answers to existential questions—about the nature of reality (ontology), knowledge (epistemology), human beings (anthropology), ethics and aesthetics (axiology), and how to live with one another (societal vision or social imaginary).

Worldviews have been argued to be essential to understanding our sustainability issues since the historian White Jr. (1967) claimed the root cause

of environmental devastation to be Judeo-Christian theology, emphasizing its reductive, anthropocentric, and exploitative attitude towards nature. Today, this debate continues, with growing attention for the transformative potential of worldviews that relate to nature in more holistic, (re-)generative, and collaborative ways (*e.g.* Yunkaporta, 2020).

Our current predicament – of a vastly pluralistic and intensely polarized global cultural landscape, combined with highly complex, interdependent, planetary issues that threaten the very basis of our human civilization – underscores the urgency of incorporating the evolution of worldviews into our understanding of sustainability transitions (*cf.* Göpel, 2016, 2017).[2] As the climate change case illustrates, progress on addressing planetary issues is hampered without the cooperation between these polarized cultural perspectives for their resolution (de Witt, 2015; Waring, Tremblay, 2016).

The study of worldviews brings a range of different disciplines together that involve theories supporting the notion of cumulative cultural evolution (Henrich, 2016; Mesoudi, Thornton, 2018). More precisely, research on worldviews can draw on developmental psychology and theories of individual development as well as on fields like sociology and theories of collective, societal development. Both these approaches conceptualize human development as characterized by sequential stages; meaning that, in the developmental process, qualitatively different stages can be distinguished that form an irreversible, hierarchical sequence—with posterior stages integrating previous stages, and anterior stages serving as necessary condition for the emergence of the next stage. Thus, new stages do not randomly arise, but evolve out of and are in some sense 'produced' by the antecedent stage.

To unpack that, researchers in constructive-developmental psychology conceptualize individuals as actively constructing their world. As the research shows, these 'world constructions' can gradually become more expansive and complex, as well as less distorted, egocentric, and reactive over the course of the lifespan (Kegan, Lahey, 2016). Ethical reasoning and understanding can, hence, change qualitatively over time, evolving the ways in which humans know and relate to the world – thus moving through 'learning sequences' as observed in the acquisition of any other capability or concept (Stein, 2019). For example, Kohlberg (1984) demonstrated that moral judgments develop through a series of levels, where each level brings about an increase in moral consideration, complexity, and integration. Somewhat similarly, researchers in adjacent fields have attempted to illuminate how whole societies (rather

2. Interestingly, from an evolutionary perspective, worldviews frequently coincide with the formation of social groups and, therefore, reflect higher-level cultural evolution for intergroup competition (Smaldino, 2019).

than individuals) have changed their ways of understanding and engaging with the world over time, adapting to and overcoming the limitations of their life conditions, and building forth on the cultural traits and accomplishments transmitted to them. Conclusions drawn on the basis of the World Values Survey results are a telling example: They demonstrate that modernization is at heart a process of human development, in which economic development gives rise to cultural changes that make individual autonomy, gender equality, and democracy increasingly likely; moreover, they suggest a shift from traditional to secular-rational values, coinciding with the emergence of industrial societies, and from survival to self-expression values, coinciding with the emergence of postindustrial societies (Inglehart, Welzel, 2005; Inglehart, 2018). As Habermas (1979) proposed, stages of individual development actually coincide with historical-structural transformations in the social domain (*e.g.* in moral, legal, and political systems). Collective, cultural worldview-structures should therefore be understood in direct relation to the psychological structures of the individual.

Worldviews can, thus, potentially be considered as expressing different "stages" of cultural evolution. Importantly, we recognize the contested nature of such a developmental view of culture, society, and humanity, which has been deconstructed particularly by postmodern thinkers, because of its Eurocentric, neocolonial, and derogatory implications, and its commitment to an oversimplified ontological parsimony that is out of step with the complexities of the empirical evidence (*e.g.* Hickel, 2017). However, the position as argued for here contrasts in important ways with the notion of development in its modernist connotations – of a triumphalist linear progression from 'primitive' levels to the 'civilized' status represented by the West – and ascribes to a much more complex and dialectical process of change.

The interdisciplinary Integrative Worldview Framework (IWF) builds forth on these insights and translates them into an empirical approach, distinguishing between traditional, modern, postmodern, and integrative worldviews, and finding consistent relationships between these worldview-clusters and a range of opinions, political priorities, and (sustainable) behaviors (de Witt *et al.*, 2016). The IWF aids our understanding of the link between worldviews and a) the sustainability of individuals' lifestyles (Hedlund-de Witt, 2012; Hedlund-de Witt *et al.*, 2014) and b) perceptions of technologies in the bioeconomy (de Witt *et al.*, 2017).

Although more research is needed, these initial findings support the relevance of the cultural evolution of worldviews for a commitment to, and behavioral change in favor of, addressing our global sustainability issues. In a systems thinking language in line with the extended MLP, we would even

argue that the cultural evolution of worldviews is a "deep leverage point" influencing the overall orientation (*e.g.* dedication or mission) and institutions of the innovation system more generally (de Witt, 2016; Schlaile *et al.*, 2021).

Finally, when aiming at explaining and, eventually, influencing the cultural evolution of sustainability-relevant worldviews, it should also be remembered that imitation heuristics and transmission biases (*e.g.* prestige bias, conformity bias, etc.; Boyd, Richerson, 2005; Mesoudi, 2016) play an important role. Thus, sustainability transitions researchers should be aware of the complexity of the meta level and of the various biases involved in cultural transmission. With this, we phrase *Proposition 2*: A combination of the research on the IWF and cultural transmission can address the research gap at the "meta level" of the MLP, thus shedding light on the cultural evolutionary dynamics leading to the emergence and diffusion of worldviews that may either block or promote structural changes towards more sustainable (bio)economies.

## Coevolution in Multilevel (Eco-) Systems of Nested Systems

In line with the MLP, organization and management studies have increasingly referred to ecosystem metaphors to describe a multilevel system hierarchy of intertwined system-in-system dynamics (Aarikka-Stenroos, Ritala, 2017; Jacobides *et al.*, 2018; Hakala *et al.*, 2020), where each sub-system component is nested within a higher level and linked both horizontally (to other components at the same level) and vertically (upwardly and downwardly) through interconnected or "coevolutionary" ties (*cf.* Campbell, 1974, 1990; Lewin, Volberda, 1999). Despite a still rather metaphorical notion of these ecosystem approaches, more recent research on coevolutionary processes in organization and management studies has shown that it is not just possible, but fruitful, to theorize different modes of coevolutionary relations between two or more units of evolution (Abatecola *et al.*, 2020). In an economy, the units of evolution could, for example, be two entities at the same system level (*e.g.* located at the socio-technical regime level in Figure 1), such as organizations or teams of individuals, or it could be entities on adjacent system levels (Almudi, Fatas-Villafranca, 2018).

Moreover, the coevolutionary approach is not limited to entities such as individuals, groups, firms, or industries, as it could also, in a practice-based approach (Breslin, 2016), illuminate coevolution between routine-based practices (*i.e.* evolved and routinized ways of doing things, where, *e.g.*, cultural

norms and institutions at higher system levels have a saying in selecting practice varieties in or out). In the latter version, it is less important who is doing what and much more important how the practice in its own right has imprint on the variation, selection, and retention of interdependent practices.

Furthermore, if a (change in a) unit in an ecosystem (entity or practice) is directly affected and caused by another, related entity or practice, while at the same time reciprocally affording change and adaptation in this other unit in a truly interdependent way, such relations can be considered to be coevolutionary in the strictest sense (Janzen, 1980; Nuismer, 2017; Abatecola *et al.*, 2020). This means that coevolutionary modes of relations are the ties that both horizontally and vertically link various units of evolution such as actors, practices, and cultural norms together in one system with multiple levels.

Coevolutionary relations can be bundled into three distinct modes: mutual (where both parties are beneficiaries in terms of increased survival chances), antagonistic (where one party thrives on the expense of the other, while the asymmetry favors variation in the counterparty which ends the relationship), and competitive (where two sides vie to overcome one another to fill the same niche in the wider ecosystem). It has recently been stressed that various types of ecosystem units, such as organizations, can be involved in all three kinds of coevolutionary relations at the same time but with different counterparties (Abatecola *et al.*, 2020). We assume the same is true for practices where a practice may vie with an incompatible one, while in parallel mutually strengthens and encourages another. At this point, it should be remembered, as van den Bergh (2018, p. 116) points out: "*Coevolution is often used in a loose, imprecise way, namely to denote mere mechanistic interactions between variables or subsystems within a larger system. This misuse of the concept is especially common in the social and environmental sciences*." Being part of the social sciences, the recent advances in theorizing coevolutionary relations in multilevel, evolving systems gives this body of literature power to dispel the concerns about sloppy use of the term. Conceptual precision of coevolutionary relations aids us with better explanations of the nature and evolution of cooperation and competition among entities and practices that are horizontally (within the same system level) and vertically (between two adjacent system levels) linked to many other evolving units. This leads us to *Proposition 3*: When studying the dynamics of sustainability transitions, future research must pay more attention to coevolutionary relations in nested systems of systems. A first step is to make clear whether the processes investigated are – strictly speaking – coevolutionary, or if other types of dynamic relationships are involved.

## Cultural Niche Construction

Transitions researchers aiming at explaining the evolution of socio-technical niches (Figure 1) can also complement their approaches with niche construction theory, which has a prominent role in the "extended evolutionary synthesis" (Laland *et al.*, 2015). As Altman and Mesoudi (2019) explain, niche construction can be understood as "*the general biological principle that organisms do not just passively adapt to their environments. Often, they actively construct their environments, with those modifications in turn affecting their own and other species' evolution*" (p. 487). Cultural niche construction can be seen as a special case where the modifying behaviors are – in part – socially learned, and the consequences of this modification affect subsequent cultural evolutionary dynamics (Laland *et al.*, 2014; Ellis *et al.*, 2016; Brewer, Riede, 2018). A prime example of cultural niche construction is the use of stone tools for cutting and slicing, enabling its users to take selection pressure away from sharp nails and teeth while increasing the fitness of the species as its population grew steadily, but slowly, over the next million years (Henrich, 2016). When the cultural innovation of cooking arose, it took evolutionary pressure away from the large intestinal tracts, making it possible for the increased nutrient efficiencies that are required to grow larger brains (Henrich, 2016).

According to this strand of literature, niches are environmental structures that can be functionally used by an organism to increase its fitness. In some cases, like with birds that establish a nest, the niche may be used by one generation but must be rebuilt in future generations. In other cases, like that of a beaver that builds its dam in such a way that river flows are persistently altered, the niche may be inherited by future generations that did not have to create it themselves (Riede, 2019). Today's humans live in built environments that accumulated an increasing diversity of inheritable niches, which none of us needed to build in our lifetimes, thus providing the foundation for cumulative cultural evolution (Henrich, 2016).

Notably, this cumulative character of cultural evolution is also underlined by the literature on knowledge creation and diffusion in innovation networks (Schlaile *et al.*, 2018; Müller *et al.*, 2021) and the approaches referenced in the section on worldviews above. Such "scaffolding" of cultural development enables cultures to grow more and more elaborate, and the alteration of environments to serve human needs grows with it (Wimsatt, Griesemer, 2007; Caporael *et al.*, 2014). Increasingly, the dual inheritance of culture and biology together (Boyd, Richerson, 2005) has enabled a third inheritance system to arise in the altered social and ecological structures of niches that can be built upon from one generation to the next. This has enabled the

process to become self-amplifying until it achieved exponential take-off and has proven itself to be a force of geological significance as a subset of human cultures gained the ability to alter Earth systems and destabilize Earth's entire biosphere (Ellis, 2015). This "runaway cultural niche construction" as Ellis (2015) calls it, implies that it is not just the burning of fossil fuels or the spread of unsustainable consumption practices that we need to address for transforming our economic systems towards sustainability. More deeply, we must rather learn how to mindfully construct niches so that they coevolve with our inherited biological and cultural heritages to participate in the natural ecological processes of regeneration (Wahl, 2016). As Altman and Mesoudi (2019, p. 491) have demonstrated by studying agriculture with this lens, the literature on niche construction can serve as a bridge between disciplines, thereby "*preventing a false and unproductive nature-culture dichotomy*". Its explanatory power goes beyond agriculture and biotechnology and thus holds promise for a sustainable (bio)economy more generally. Therefore, niche construction theory provides a complementary viewpoint to the MLP's understanding of the niche level, which was originally inspired by allopatric speciation theory (Geels, 2020), by focusing on the feedback between modification of the selection environment and evolutionary trajectories of social practices and technologies (Laland *et al.*, 2014). Thereby, niche construction theory also underlines the fact that innovation is not always beneficial to the ecosystem, and is thus in line with recent discussions about directionality of innovation processes (Laland *et al.*, 2014; Schlaile *et al.*, 2017).

In this context, it is particularly warranted to further explore what the transitions literature that focuses on the niche level – especially strategic niche management (Schot, Geels, 2008; Köhler *et al.*, 2019) – can take up from cultural niche construction theory and vice versa. *Proposition 4*: Cultural niche construction theory complements the literature on socio-technical niches and strategic niche management by explicitly focusing on the (co) evolutionary processes at the niche level, thus providing a more fine-grained view on the interrelated dynamics of culture, directionality of innovation processes, and (un)sustainability.

# Implications of the Cultural Evolutionary MLP Framework for Transitions-Oriented Research on and for a Sustainable Bioeconomy

In a broad sense, the bioeconomy can be understood as an economic "model" (especially in the sense of a guiding principle) embraced by global, supra-national, national, and regional policymakers and scientists. The bioeconomy is, at its core, aimed at moving away from a fossil-based economy towards an economy based on renewable biological resources and knowledge (*e.g.* Hausknost *et al.*, 2017; Pyka, 2017b). Yet, the concept of a bioeconomy is inherently contested and has many different meanings (Bugge *et al.*, 2016; Birner, 2018), ranging from narrow definitions that focus on biomass utilization and industrial biotechnology (thus being criticized for an apparent attempt to commodify all life on Earth; *e.g.* Gottwald, 2018) to a broader concept aiming at transforming modes of production and consumption in a socially, economically, and environmentally sustainable way, informed by biological knowledge (*e.g.* Giampietro, 2019; Vivien *et al.*, 2019; Urmetzer, 2020). In times of a transgression of planetary boundaries and an amplifying human impact on the Earth system (Lade *et al.*, 2020), the introduction of a bioeconomy as a new economic model must be legitimized by its contribution to achieving "higher levels" of sustainability (Vogt, 2018).

The MLP in its "original" form has been frequently applied in the last two decades to describe, analyze, and understand transition processes in socio-technical systems (Geels, 2002, 2005, 2020), recent examples including the transition of the mobility sector (Köhler et al., 2020) or the energy sector (Osunmuyiwa *et al.*, 2018). Notably, the MLP is also being taken up as an analytical tool for making sense of transitions towards bio-based economies. Yet, while several studies analyze the transition towards a (sustainable) bioeconomy through a multilevel lens acknowledging the complexity of systemic change processes (Gottinger *et al.*, 2020), Göpel's (2017) critique of the insufficient assessment of the roles of mindsets, worldviews, or cultural aspects seems to hold also in the bioeconomy context. For example, Kuckertz *et al.* (2020) investigate the role of entrepreneurship in the transition towards a sustainable bioeconomy by focusing on its contribution at multiple levels in the bioeconomy. Tani (2018) analyzes the transition towards a bio-based economy through the lens of strategic niche management. Schiller *et al.* (2020) use the MLP to analyze the transformation of Nicaragua's agri-food system with a specific focus on the interactions between niche and regime. While all these papers focus on relevant aspects of transition processes and highlight

the importance of a sustainable bioeconomy, they do not – or only marginally – incorporate the dynamics of cultural evolution. Only Schiller *et al.* (2020) account for the role of worldviews and societal values to some degree, highlighting the importance of both interpretative and normative anchoring (*i.e.* incorporating agro-ecological thought into individuals' sensemaking and worldviews and incorporating social values and translation of shared goals into public policy). The authors found both interpretative and normative anchoring in the transition process, for example, in the form of changing worldviews. However, this only occupies a small side-part of their analysis and arguably calls for a stronger focus in future applications. By focusing our attention on the meta level (see Figure 1), we may realize that the polarization over grand challenges is usually not resolved through the production of more scientific information as individuals tend to evaluate research findings as well as potential risks and benefits associated with innovations (including biotechnological ones) differently because they are operating from different worldviews (de Witt, 2015; de Witt *et al.*, 2017). In the debate on the emerging bioeconomy, several competing perspectives have been identified.

On the primary production side, Levidow *et al.* (2012, 2013) distinguish between a dominant, genetic engineering and life-sciences oriented view, and a marginal, agro-ecological engineering view. Accordingly, these visions have fundamentally different problem-diagnoses of agro-economic threats and therefore offer radically different solutions. The industrial, techno-optimist vision tends to consider inefficient production methods a prime problem, therefore emphasizing, for instance, genetic modification of plants for greater productivity. In contrast, the agro-ecological vision problematizes the industrial monoculture system, therefore arguing for agro-ecological systems that minimize needs for external inputs (*e.g.* fertilizers), and enhance both ecological and social interactions. Notably, these different perspectives have also been linked to "modern" technologically-optimist *versus* "postmodern" ecosystems-oriented worldviews (de Witt *et al.*, 2017). Others distinguish three bioeconomy paradigms (Bugge *et al.*, 2016; Vivien *et al.*, 2019), again others identify four divergent bioeconomy visions (Hausknost *et al.*, 2017). The official policy papers analyzed by Hausknost et al. (2017), for instance, are based on a vision that combines biotechnological progress with a narrative of green growth, whereas academic, business, and other stakeholders are shown to frequently consider the bioeconomy as a program for technological progress combined with sufficiency, thus requiring much more coordinated and programmatic action by the state. Another potential conflict due to the differential cultural evolution of bioeconomy worldviews arises along the issue of promoting the productive potential of an industrial revolution supported by biotechnologies against the strong social resistance to the production and

use of genetically modified organisms (de Witt *et al.*, 2017; Vivien *et al.*, 2019). Generally, these competing bioeconomy perspectives or narratives show that more targeted research is needed on the cultural evolutionary processes that lead to the prevalence of one over another worldview.

Moving from the meta level to the interrelationship between the different levels, it is important to remember that the coevolution of biotechnologies, agricultural practices, and modes of production and consumption has important implications for the (un)sustainability of the bioeconomy (Altman, Mesoudi, 2019); hence, future research also needs to tackle the question which of these relations are coevolutionary in the strict sense and which relationships in the innovation system represent other types of dynamics.

This complexity and nested hierarchy of cultural evolution on multiple levels points towards the central and policy-relevant issue of how various innovation system actors can intentionally intervene within these complex evolutionary processes (not only to construct cultural niches for the bioeconomy but also to scale cooperation for systemic change across different levels), which brings us to the "Prosocial process". While there are multiple approaches to managing or governing transitions and intervening in innovation systems (*e.g.* see Loorbach, 2010; Bosman, Rotmans, 2016; Köhler *et al.*, 2019; Schlaile *et al.*, 2021; Schlaile, Urmetzer, 2021), there is also a paucity of work on the intentional "design" (in the sense of influencing the (co)evolution; Brewer, 2015) of sustainable bioeconomic entities and practices that adequately acknowledges the complexity of cultural evolutionary processes – across and between the MLP's nested levels. We thus agree with Atkins *et al.* (2019, p. 20), who have argued (in a related context) that "*humanity's next major evolutionary transition needs to move us beyond simplistic ideas of either top-down regulation or laissez-faire bottom-up competitive markets*." In this regard, it must be noted that there have recently been made promising advances at the intersection of contextual behavioral science, evolutionary theory, and the work pioneered by Ostrom that can help address this gap. Particularly, the Prosocial process (Atkins *et al.*, 2019) provides a toolkit for intentionally intervening in cultural evolution, first and foremost by supporting the alignment of individual interests and group goals (known from multilevel selection theory to be located within a field of tension between competition and cooperation).

At the individual/mini level (Figure 1), the matrix known from acceptance and commitment therapy provides an established tool for cultivating psycho-social development by enhancing psychological flexibility (Hayes *et al.*, 2012; Atkins *et al.*, 2019). Utilizing this matrix, the Prosocial process thus helps to create more inclusive, participatory, and empowering or

"nurturing" environments (*e.g.* Biglan *et al.*, 2020) for individuals to become more oriented towards the well-being and interests of others. Hence, on the individual level, the Prosocial process facilitates the cultural selection of unselfishness (Atkins *et al.*, 2019).

By drawing on findings from multilevel selection theory (*e.g.* Wilson, Wilson, 2007), the Prosocial process has the potential to be scalable to different, nested levels. At a more collective level (*e.g.* of groups, organizations, or even societies), it is important to remember that institutions in the sense of formal and informal rules evolve (*e.g.* Ostrom, 2006, 2014) and that there are eight core design principles that determine the efficacy of groups (Cox *et al.*, 2010; Wilson *et al.*, 2013).[3] Importantly, the Prosocial approach generalizes these principles to groups beyond groups managing common-pool resources (Hayes *et al.*, in press; Eirdosh, Hanisch, 2020; Wilson *et al.*, 2020). Arguably, this approach holds the potential to scale up the selection of nurturing environments (*i.e.* prosocial niches).

One can potentially also use the Prosocial process both for action research and in survey research while analyzing the institutional arrangements in (bio) economic systems to identify those of the eight core design principles that are not being met. Consequently, by targeting the formalization of missing design criteria, innovation system actors can eventually trigger the necessary support for dedicated efforts to achieve sustainability-oriented social change (Schlaile *et al.*, 2021).

Prosocial is a framework that enables groups to guide the formation of desired cultural traits—in effect, intentionally creating their own social niches—while increasing the psychological flexibility of their members to participate in this creative process. At the same time, the prosocial group becomes a manageably sized laboratory for creating bioeconomies because it is functioning as a living, evolving system in its own right. However, while the Prosocial process is based on a proven methodology with demonstrated tools, still more work remains to be done to integrate it with complementary approaches and systemic policy interventions for governing and managing sustainability transitions in general and sustainable bioeconomy transitions in particular. In this regard, for example, cultural scaffolding (*e.g.* Wimsatt, Griesemer, 2007; Caporael *et al.*, 2014) is a framework that may help to integrate cultural evolution into the developmental entrenchment of societal structures in the technology and institutional expressions of these cultural

3. These eight core design principles are (1) clearly defined boundaries, (2) proportional equivalence between benefits and costs, (3) collective-choice arrangements, (4) monitoring, (5) graduated sanctions, (6) conflict resolution mechanisms, (7) minimal recognition of rights to organize, and (8) nested enterprises (*i.e.* appropriate coordination among groups in larger social systems).

evolutionary processes in the context of a sustainable bioeconomy. Now, based on this section, a final action-(research-) oriented *Proposition 5* can be formulated: The Prosocial process can be used as a field-tested (action research) approach to facilitating the evolution of institutions for collective action across multiple levels (*i.e.* ranging from mini to macro in the MLP) of bioeconomic innovation systems.

## Summary and Conclusion

The unsustainable way humans are overusing natural resources is a result of cultural evolutionary processes – especially including the (co)evolution of values (*e.g.* concerning nature) and practices (*e.g.* concerning agriculture). While a bioeconomy has the potential to significantly contribute to sustainability transitions, unsustainable forms of bio-based economies following worldviews and paradigms accelerating the transgression of the planetary boundaries are easily conceivable. Sustainability itself is a highly contested notion meaning very different things to different actors, depending on the differential cultural evolution and transmission of their worldviews and respective paradigms. Therefore, how a bioeconomy is envisioned and framed by different stakeholders is highly depending on their mindsets, narratives, or cultural aspects.

As the cultural evolution of the ways our species has interacted with the ecosystems that support us has created conditions conducive to the emergence of many of our current problems, we have sided with other scholars arguing that a better understanding of these cultural evolutionary processes may also hold the key to addressing many of humanity's grand challenges. Arguably, this holds true especially for bioeconomy transition approaches, which are inspired by and rely so heavily on the resources, processes, and services offered by our natural environment (or, rather, the Earth system quite generally). In this context, research on the transition towards a sustainable bioeconomy should be complemented by a view through the lens of cultural evolutionary theory. We have argued that incorporating central concepts of cultural evolution into the MLP is a first step towards understanding the deep "leverage points" of paradigm change and thus shaping dedicated or mission-oriented innovation systems for the transition towards sustainable and regenerative (bio-)economic systems.

While the concrete methodological operationalization and empirical applications of our propositions will have to remain a task for future research, we have already pointed to promising avenues for the bioeconomy, including utilizing worldview tests in empirical bioeconomy research, utilizing the

Prosocial process as an action research (and survey) tool, and taking up findings from niche construction and coevolution research for advancing research on the governance of bioeconomy transitions.

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