# Chapter 6
# Worlds, Algorithms, and Niches: The Feedback-Loop Idea in Kuhn's Philosophy


**Matteo De Benedetto and Michele Luchetti**

**Abstract** In this paper, we will analyze the relationships among three important philosophical theses in Kuhn's thought: the plurality of worlds thesis, the no universal algorithm thesis, and the niche-construction analogy. We will do that by resorting to a hitherto neglected notion employed by Kuhn: the idea of a feedback loop. We will show that this notion captures an important structural aspect of the epistemic dynamics at work in each of the three theses, therefore allowing us to read them as constituting a virtuous epistemic cycle. Finally, we will apply our unified interpretation of the three theses to scientific practice to sketch a novel neo-Kuhnian picture of theory choice.

**Keywords** Kuhn · Feedback loop · Plurality-of-worlds thesis · Niche-construction analogy · No-universal-algorithm thesis · Scientific theory choice

## 6.1 Introduction

Recent scholarship (e.g. Andersen et al. 2006; Okasha 2011; Wray 2011) has emphasized the originality of several works of Kuhn beyond his most famous *The Structure of Scientific Revolutions* (Kuhn 1962). Yet, it remains somewhat unclear how different parts of Kuhn's thought, belonging to different periods of his life, hang together. In our view, it is important to show the connections among these parts to develop a coherent and unified Kuhnian philosophy of science which, in turn, we will use to shed light on contemporary debates over theory choice.

In this paper, we will analyze the relationships among three important philosophical theses expressed by Kuhn: the plurality of worlds thesis, the no universal

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algorithm thesis, and the niche-construction analogy. More specifically, we will give a unified philosophical reconstruction of the conceptual relationships between these theses. We will do that by resorting to a hitherto neglected notion employed by Kuhn: the idea of a feedback loop. We will see that this notion captures an important structural aspect of the epistemic dynamics at work in each of the three theses. In light of this common structural feature, the three theses can be interpreted as constituting a virtuous epistemic cycle where each thesis strengthens another one. Moreover, we will use this unified account to provide an original neo-Kuhnian picture of scientific theory choice, centered around a core loop among scientists, scientific theories, and epistemic values.

Our goal in this paper will be two-fold. First, we will clarify the relationships between three important philosophical theses in Kuhn's thought and, by doing that, we will shed some light on the philosophical connections between different parts of Kuhn's picture of science. Second, we will disentangle the complex relationships among the actors and the processes involved in the practice of scientific theory choice.

In Sect. 6.2, we will present the Kuhnian theses at the center of this work. For each thesis, we will analyze Kuhn's own formulations and the related philosophical context, as well as its reception by Kuhn scholars. In Sect. 6.3, we will introduce the fundamental notion of feedback loop. After presenting this concept in full generality, we will use it to uncover a common epistemic dynamic underlying each of the three theses. Then, we will show how, thanks to the concept of feedback loop, we can provide a unified interpretation of the theses. In Sect. 6.4, we will demonstrate how our proposal allows us to develop an original neo-Kuhnian picture of scientific theory choice. In Sect. 6.5, we will draw some general conclusions about what our proposal achieves.

## 6.2 Three Kuhnian Theses

In this section, we will present, one by one, the three Kuhnian theses around which this paper is centered, i.e., the plurality of worlds thesis, the no universal algorithm thesis, and the niche-construction analogy. For each thesis, we will first analyze Kuhn's original formulations and the related philosophical context, and then we will discuss how the thesis was received by Kuhn scholars and how it relates to contemporary discussions in philosophy of science.

### *6.2.1 The Plurality of Worlds Thesis*

The first Kuhnian thesis that we are going to analyze is the plurality of worlds thesis (PW). The thesis states that scientists working in different paradigms somehow inhabit different worlds. Kuhn originally stated PW in Chapter 10 of *Structure* as a

cognitive illustration of how paradigms are constitutive of the scientific and cognitive practice of a scientific community: "paradigm changes do cause scientists to see the world of their research-engagement differently. (…) We may want to say that after a revolution scientists are responding to a different world" (Kuhn 1970, p. 111).[1] Building upon the resources of Gestalt psychology and the work of Hanson (Hanson 1958), Kuhn crystallized in PW the idea that scientific revolutions are world changes. Put it differently, radical forms of scientific change involve holistic changes in the way scientific communities perceive phenomena.

In his subsequent works, Kuhn changed the formulation of PW in order to fit the development of his thought. As documented by several scholars (e.g. Hoyningen-Huene 1993, pp. 42–63, Bird 2000, pp. 123–136), in the years after *Structure* Kuhn moved away from Gestalt psychology. First, he was drawn to a different kind of theory of perception based on stimuli and, eventually, to a more linguistically-oriented epistemology. In response to these changes, we can find three other versions of PW in Kuhn's later works. We find a second, stimulus- centered, version of PW in "Second Thoughts on Paradigms": "Members of different communities are presented with different data by the same stimuli" (Kuhn 1974, p. 309). A third, language-based, version of PW can be recognized in "Commensurability, Comparability, Communicability": "Different languages impose different structure on the world" (Kuhn 1983a, p. 682). Finally, we can identify a fourth, modal version of PW in "Possible Worlds in History of Science": "each lexicon gives access to its own set of worlds" (Kuhn 1989, p. 22).

Despite the differences in the epistemological background among the four formulations of the thesis, the philosophical core of PW remained stable throughout Kuhn's works. All the different formulations imply, in fact, that paradigms are constitutive of the practice of a scientific community and, therefore, that paradigm changes involve a radical modification of that practice. The exact nature of this modification and of the related epistemological and ontological background have been thoroughly debated by Kuhnian scholars. Specifically, we can distinguish two broad strands of discussion centered around PW in the related philosophical literature. A first strand focuses on the exact nature of Kuhn's epistemology and of his theories of perception and ontology. Many different interpretations of Kuhn's epistemology have been put forward, including forms of Neo-Kantianism (Hoyningen-Huene 1993), Ontological Relativism (Sankey 1994, 1997), Naturalism (Bird 2000), and Perspectival Realism (Giere 2006, 2013; Massimi 2015). The second strand of discussion focuses instead on the dynamics of scientific revolutions and the underlying paradigm changes. The radical scientific changes described by Kuhn have been conceptualized as conceptual revolutions (Thagard 1992), changes in taxonomies (Hacking 1993), changes in the hypothesis space (Earman 1993), changes in reference (Sankey 1994), changes of constitutive principles (Friedman 2001), psychological changes (Bird 2000), and changes in conceptual frames (Andersen et al. 2006).

[1] It should be noted that Kuhn did not use the expression "plurality of worlds" for denoting PW. The expression comes from Hoyningen-Huene (Hoyningen-Huene 1993, Ch. 2) and it was later adopted by Kuhn himself for the title of his last book.

### 6.2.2 *The No Universal Algorithm Thesis*

The second Kuhnian thesis that we are going to discuss is the No Universal Algorithm Thesis (NUA). This thesis states that there exists no neutral, i.e., universal, algorithm for scientific theory choice.

The first, implicit, appearance of NUA is in the 1969 postscript to *Structure* (Kuhn 1970), where Kuhn stressed the impossibility of obtaining a conclusive proof in a scientific revolution (Kuhn 1970, pp. 148, 151–152) and the fact that scientific rationality has a non-algorithmic nature (Kuhn 1970, p. 200). Then, Kuhn explicitly stated NUA in "Objectivity, Value Judgments, and Theory Choice" (Kuhn 1977) as a central component of his picture of scientific rationality: "Values like accuracy, consistency, and scope may prove ambiguous in application, both individually and collectively; they may, that is, be an insufficient basis for a *shared* algorithm of choice" (Kuhn 1977, p. 331).[2] After the appearance of *Structure*, many philosophers accused Kuhn's picture of scientific revolutions of depicting scientific theory choice as fundamentally irrational. In order to counter these accusations, Kuhn further explained his views on scientific rationality by distinguishing his picture of theory choice from the one of his opponents. According to Kuhn, what he rejected in *Structure* was not scientific rationality *tout court*, but only a certain caricature of it, that wants scientific theory choice to be an algorithmic procedure. Against this view, Kuhn put forward NUA, stating that finding an algorithm for scientific theory choice is impossible because of the ineliminable role of epistemic values. Theory choice is always dependent on epistemic values (i.e. values such as simplicity, accuracy, empirical adequacy, etc.) and, even if scientists could agree on which values to consider, the weighting and the application of each value fundamentally involves a subjective element that cannot be eliminated. After the 1977 paper, Kuhn (Kuhn 1983b) discussed again the rationality of theory choice in reaction to a paper by Hempel, re-stating the ineliminable role of epistemic values in scientific rationality, as well as the entanglement of subjective and objective factors underlying them.

NUA and Kuhn's discussion of epistemic values have been extremely influential in shaping the philosophical debates on the rationality of science. After Kuhn, the role and nature of epistemic and non-epistemic values in science has become a central topic in general philosophy of science, generating a remarkably vast literature. Among the strands of this discussion more closely related to Kuhn and NUA we can include the debate on the viability of value-free science (cf. McMullin 1983; Laudan 1984; Longino 1990; Douglas 2000, 2009; Solomon 2001), the related debate on the possibility of distinguishing epistemic values from cognitive and social values (cf. Longino 1996; Lacey 1999; Laudan 2004; Douglas 2013), and the debate on the kind of rationality exhibited by scientific theory choice (cf. Hoyningen-Huene 1992; Earman 1993; Sankey 1995; Okasha 2011; Weber 2011; Morreau 2015; Bradley 2017; Schindler 2017; Shan 2020).

[2] Italics in the original text.

### 6.2.3 *The Niche-Construction Analogy*

The third Kuhnian thesis that we will discuss is the niche-construction analogy (NC). This thesis states that the relationship between scientists and the world is analogous to the one between organisms and their environment in niche- construction theory. Kuhn stated NC in "The Road Since Structure" (Kuhn 1990) to illustrate the specific way in which he sees his philosophy of science as a kind of evolutionary epistemology:

> Can a world that alters with time and from one community to the next correspond to what is generally referred to as "the real world"? I do not see how its right to that title can be denied. (…) In the modern world scientific activity has become a primary tool for adaptation. (…) Can the members of a group properly be said to adapt to an environment which they are constantly adjusting to fit their needs? The identical problem is, for example, currently the subject of much discussion in evolutionary biology. On the one hand the evolutionary process gives rise to creatures more and more closely adapted to a narrower and narrower biological niche. On the other, the niche to which they are adapted is recognizable only in retrospect, with its population in place: it has no existence independent of the community which is adapted to it. (Lewontin 1978) What actually evolves, therefore, is creatures and niches together. (…) Biologically, that is, a niche is the world of the group which inhabits it, thus constituting a niche. Conceptually, the world is our representation of our niche, the residence of the particular human community with whose members we are currently interacting" (Kuhn 1990, pp. 10–11).

If most evolutionary accounts of scientific inquiry draw a parallel between the selection of scientific theories and natural selection (e.g. Popper 1972; Campbell 1974; Hull 2001), Kuhn focuses on a different parallel. Namely, the center of NC is the relationship between scientists and the world in scientific practice. This relationship is, according to Kuhn, one of mutual influence, structurally analogous to the way in which organisms and environments influence one another in niche-construction theory. If, in fact, in the classic Neo-Darwinian framework, the relationship between the environment and organisms is mono-directional, as it is the environment that exerts selective pressures on organisms, which are only responsive to it, niche-construction theory re-conceptualizes the causes of these selective pressures. The environment still exerts selective pressures on organisms, but the response of the organisms can also involve niche-constructing activities, i.e., enacting behaviors that transform the environment, thereby indirectly changing the selective pressures. In niche-construction theory, then, niches are co-constructed by the organisms and their environment. According to NC, an analogous co-construction underlies the emergence of an epistemic equivalent of a biological niche, jointly determined by both the scientists and the world.[3]

Even if NC appeared very late in Kuhn's work, his whole philosophical thought is permeated by evolutionary analogies. Already in *Structure*, in fact, Kuhn

[3] In recent years, there has been an increasing interest in applying the biological notion of niche to the epistemic domain. See, for instance, MacLeod and Nersessian (2013); Rouse (2016); De Benedetto and Luchetti (2023b).

conceptualized scientific progress as being importantly analogous to the way in which biological entities evolve. Moreover, the analogy between scientific activity and biological evolution should have been central to the never-finished book that Kuhn was writing at the time of his death (cf. Hoyningen-Huene 2015). Kuhn conceived "The Road Since Structure" (Kuhn 1990) as a sort of abstract of this book and, arguably, NC should have played an important role in it.

Despite the prominence of NC in one of Kuhn's last articles, this thesis has received far less attention than the two theses discussed above. Most works discuss NC only in the broader context of assessing the role and significance of Kuhn's evolutionary analogies (cf. Hoyningen-Huene 1993; Bird 2000; Renzi 2009; Reydon and Hoyningen-Huene 2010; Wray 2011; Kuukkanen 2012). Moreover, the evolutionary dimension of Kuhn's epistemology, and of the analogies underlying it, have recently been highlighted as central components of a viable Neo-Kuhnian social account of scientific knowledge (cf. Wray 2011; Kuukkanen 2021; De Benedetto and Luchetti 2023a).

## 6.3 The Feedback-Loop Idea

So far, we have introduced three theses that were central to Kuhn's work and that have been subjected to different interpretations by Kuhn scholars. At a first glance, the exact relations among these three theses seem unclear. As we have emphasized, in fact, the plurality of worlds thesis (PW), the no universal algorithm thesis (NUA), and the niche construction analogy (NC) belong to different periods in the evolution of Kuhn's thought. In addition, while they all aim at capturing some insight relative to the developmental process of scientific inquiry, they pertain to different levels of abstraction and do not focus on the same actors. Nevertheless, in the rest of the paper we will show how these three theses can be interpreted in such a way that, together, they can strengthen one another, depicting a novel overarching picture of scientific theory choice.

Before turning to our combined interpretation of the three Kuhnian theses, it will be useful to define the terminology that we will use in our analysis. Since, as we have mentioned in Sect. 6.2, Kuhn's lexicon is often ambiguous and its ontological implications are extremely controversial in Kuhn scholarship, we will technically define our vocabulary. The three notions central to our analysis will be the following: world, worldview, and disciplinary matrix. We will use 'world' to denote the context in which scientific inquiry takes place, in its intuitive sense, devoid of any metaphysical assumption. 'Worldview' will, instead, refer to the set of implicit perceptual, cognitive, and cultural commitments that a given scientific community requires to carry out its epistemic activities. Finally, we will use 'disciplinary matrix' to denote the methodological framework related to a given scientific theory or practice, i.e., the set of symbolic generalizations, methodological assumptions,

values, and exemplars that a given scientific community shares.[4] A crucial difference between worldview and disciplinary matrix is that, despite the fact that both are connected with the epistemic activities of a given scientific community, the disciplinary matrix is often explicitly shared by members of the community, while the worldview can only be objectively identified from outside that community. With this technical terminology, we try to steer clear, as much as possible, from metaphysical disputes. We take, in fact, the above definitions to be ontologically neutral. Supporters of different interpretations of Kuhn's metaphysics might interpret these notions according to their own views.[5] What is important for our analysis are the epistemic dynamics, and the related feedback loops, between these notions, and not the metaphysical implications of these dynamics.

After this terminological clarification, we introduce a notion that will be essential to our proposal: the idea of feedback loop. We will first present the idea of feedback loop in full generality and then we will show how this notion uncovers a structural dynamic at work in each of the three Kuhnian theses.

### *6.3.1 The Notion of Feedback Loop*

A feedback loop is a dynamic phenomenon in virtue of which the outputs of a certain system become inputs for the same system at a later stage. In other words, a feedback loop occurs when the outcome of a process feeds back into the system. This abstract concept has been vastly used in several disciplines, including engineering, cybernetics, computer science, management, design, and the biological sciences.[6] In the biological sciences, the idea of feedback loop has been deployed across several sub-fields, ranging from molecular to evolutionary biology. We already saw an example of feedback loop in evolutionary biology in our brief discussion of niche-construction theory (cf. Sect. 6.2.3). The dynamics by which niches are co-constructed through the joint contribution of environment and organisms have the form of a feedback loop. The environment selects organisms, which evolve adaptations including behaviors that are able to change the environment. In this way, some products of natural selection feed back into the process of selection itself.

[4] Note that the term 'disciplinary matrix' was used by Kuhn, for a certain period of his life, to disambiguate the term 'paradigm' (cf. Kuhn 1974). Even though Kuhn uses this term with a meaning very similar to ours, we use this term in the technical sense defined above.

[5] For a recent perspective on the ontological commitments of Kuhn's talk of 'worlds' and 'worldviews', see Hoyningen-Heune (2023).

[6] In philosophy of science, the idea of feedback loop, as an epistemological category, has not received much attention. Exceptions include, for instance, (Wimsatt 1986; Hacking 1995, 2007; Agazzi 2008).

### 6.3.2 *Feedback-Loop in NUA*

Kuhn explicitly used the idea of feedback loop in "Objectivity, Value Judgment, and Theory Choice" (Kuhn 1977). After his discussion of the role of epistemic values in scientific theory choice that we recalled in Sect. 6.2.2, Kuhn suggests that in the process of theory change also values change. Consequently, according to Kuhn, epistemic values should be considered, to a certain extent, as historically changing entities, since "both the application of these values and, more obviously, the relative weights attached to them have varied markedly with time and also with the field of application" (Kuhn 1977, p. 335). Thus, despite Kuhn holds the core set of epistemic values to be relatively fixed across time (cf. Kuhn 1983b), there is a pattern of covariance between values and theories, whereby changes in the role or weight of values often follow changes in scientific theories[7]:

> Many of these variations in value have been associated with particular changes in scientific theory. Though the experience of scientists provides no philosophical justification for the values they deploy (. . . ), those values are in part learned from that experience, and they evolve with it. (. . . ) What may seem particularly troublesome about changes like these is, of course, that they ordinarily occur in the aftermath of a theory change. (Kuhn 1977, p. 335).

Kuhn further qualifies this covariance as "a feedback loop through which theory change affects the values which led to that change" (Kuhn 1977, p. 336). Thus, while epistemic values operate a direct selection among theories within a scientific domain, the outcome of this selection feeds back into the values, by producing modifications on either their application or their weight. In this way, theories operate an indirect selection on values through this feedback-loop mechanism, as depicted in Fig. 6.1.

### 6.3.3 *Feedback-Loop in NC*

As we mentioned above, the idea of feedback loop is central to niche-construction theory. Niche-construction theory challenges the central neo-Darwinian assumption that the environment must be regarded merely as an external variable of evolution

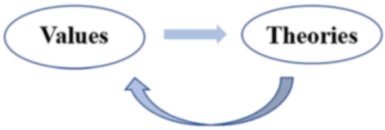


**Fig. 6.1** The feedback loop between epistemic values and scientific theories

[7] It should be noted that another aspect of epistemic values that Kuhn held as historically stable is the problem-solving ability of a given paradigm, an ability that is key for his account of scientific progress (Kuhn 1962, Ch. 13).

by natural selection. On the contrary, niche-construction theorists emphasize that the environment can be modeled, at least in part, as a variable internal to evolutionary dynamics. In fact, organisms can fit the environment not only by evolving adaptations, but also by transforming the environment through their activities, such as the modification of local resource distributions, the choice and change of habitats, or the construction of artefacts (Odling-Smee et al. 2003). These niche-constructing activities enacted by organisms indeed emerge in response to environmental selective pressures but, by transforming the environment, they contribute to changing those pressures. This, in turn, prompts further adaptive responses from the organisms that affect their fitness. In other words, while the environment operates a direct selection on organisms, organisms indirectly contribute to modifying environmental selective pressures by enacting niche-constructing behaviors that transform the environment. Clearly, not all the selective pressures coming from the environment are influenced by the niche-constructing activities, but only a proper part of them, that is, those coming from the environmental niche. This is the step- wise analysis of why the co-construction of niches by organisms and environment is structured as a feedback-loop dynamic.

We take this feedback loop dynamic to be a central component of Kuhn's NC. The analogy between niche-construction and scientific development is based on the fact that both phenomena instantiate a feedback loop. Just like the environment exerts selective pressures on organisms, the world operates a direct selection on the beliefs that scientists can hold, in that it constrains the possible interpretations of natural phenomena. Then, just like organisms can evolve adaptive behaviors that can transform the environment, the epistemic activities that scientists enact have an impact on the world. More precisely, their epistemic activities co-construct the worldview in which scientists operate. This amounts to an indirect contribution of scientists' activities to the selection of beliefs, that is, in a partial modification of the selective pressures analogous to the one resulting from the niche-constructing activities of organisms. In this way, therefore, we can see Kuhn's NC as being structured upon two feedback loops (Fig. 6.2).

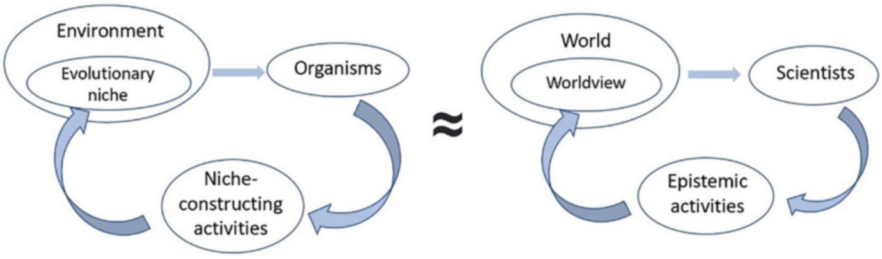


**Fig. 6.2** The analogy between the feedback loop in niche-construction theory and the one involving scientists and the world

### 6.3.4 Feedback-Loop in PW

The feedback loop we identified to interpret NC can also be taken as a starting point to further clarify PW. In fact, the feedback-loop relationship between scientists and the world, having as a central component the epistemic activities of scientists, can be taken as a blueprint for better characterizing the genealogy of worldviews.

In Sect. 6.2.1, we stressed how the philosophical core of PW, common to all Kuhn's formulations, is that paradigms are constitutive of the practice of a scientific community. We propose that a feedback-loop dynamic is the mechanism that explains how this constitutive relationship arises. Scientific communities adopt the disciplinary matrices within which they operate. In turn, these disciplinary matrices, as Kuhn (Kuhn 1970, 1974) has clearly stated several times, shape the worldviews held by scientists. This is because adopting a disciplinary matrix requires accepting a set of exemplars, models, and commitments that fundamentally structure the beliefs and practices of a scientific community. In this way, while scientific communities directly select disciplinary matrices, these matrices indirectly influence scientific communities. It is through this feedback-loop dynamic (Fig. 6.3) that a plurality of worldviews, can be co-constructed by scientific communities and disciplinary matrices.

### 6.3.5 Three Theses, One Cycle

So far, we have seen how the feedback-loop idea is at work in each of the three Kuhnian theses. First, we highlighted how Kuhn explicitly characterizes the relationship between values and theories underlying NUA as a feedback loop.

Then, we argued that the analogy between scientific development and niche construction expressed in NC is structured upon two feedback loops. Finally, we explained how a feedback-loop mechanism is involved in the construction of the multiple worldviews postulated by PW. In this final subsection, we will show how these three theses and their feedback-loop dynamics constitute, together, a virtuous epistemic cycle where each thesis strengthens another.

A first connection can be drawn between NUA and NC. More precisely, NUA is key for understanding the exact nature of the feedback-loop dynamics underlying NC. The feedback loop related to NUA constitutes, in fact, the only explicit mention

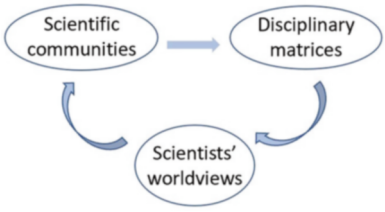


**Fig. 6.3** The feedback loop between scientific communities and disciplinary matrices underlying PW

of a feedback loop in Kuhn's writings. Kuhn, in describing the mutual influence between scientific theories and epistemic values in scientific theory choice, shows us how he understands this feedback-loop dynamics in terms of a primary, stronger, direct selective influence (the one exerted by epistemic values on scientific theories), followed by a secondary, weaker, more indirect selective influence (the one exerted by scientific theories on epistemic values). In Kuhn's words, "historically, value change is ordinarily a belated and largely unconscious concomitant of theory choice, and the former's magnitude is regularly smaller than the latter's" (Kuhn 1977, p. 336). This pattern of a primary, stronger, and direct selective influence, followed by a secondary, weaker, and more indirect one, enables us to clarify Kuhn's analogy in NC. In both niche construction and scientific development, in fact, we find a combination of a main selective influence (environment ➔ organisms; world ➔ scientists), that is prior in time and stronger in its effect, and a secondary selective influence (organisms ➔ environmental niches; scientists ➔ worldviews), occurring after the primary one and producing weaker effects.

A second connection can be drawn between NC and PW. More precisely, NC explains the mechanism by virtue of which scientific communities and disciplinary matrices co-construct the different worldviews depicted by PW. The way in which scientists indirectly modify the world through their epistemic activities is structurally identical to the way in which disciplinary matrices contribute to the co-construction of a worldview. What happens at a global scale in the first case, that is, with respect to the development of science as a whole, happens also at a local scale in the second case, i.e., with respect to the epistemic life of individual scientific communities. Whereas in NC the influence of scientists only feeds back into world via an indirect selection, in the local scale pertaining to PW the role of scientists is reversed, as they exert the main selective influence on disciplinary matrices. Instead, the role that scientists play in NC is played in PW by disciplinary matrices. Disciplinary matrices are, in fact, passively adopted by scientific communities and they actively influence their worldview. As the influence of worldviews feeds back into scientific communities, we can see how worldviews are co-constructed by the niche-constructing activities of disciplinary matrices together with the direct selective influence of scientific communities.

Finally, a third connection can be drawn between PW and NUA, More specifically, PW gives reasons for NUA and for its premises. In Sect. 6.2.2, we saw that the main reason that Kuhn gives for denying the possibility of a general algorithm for theory choice is the variability in the application and the weighting of epistemic values between different scientists. PW offers a plausibility argument for such variability. If, in fact, according to PW, different scientific communities work within different worldviews, due to the feedback-loop dynamics between scientific communities and the disciplinary matrices that they adopted, we can see how the application and weighting of epistemic values are very likely to vary from community to community. This is due to the fact that disciplinary matrices are constitutive of the worldview of a scientific community. In adopting a disciplinary matrix, a scientific community implicitly accepts also exemplars, models, and commitments that structure the scientists' worldview. Scientists having different worldviews are likely to

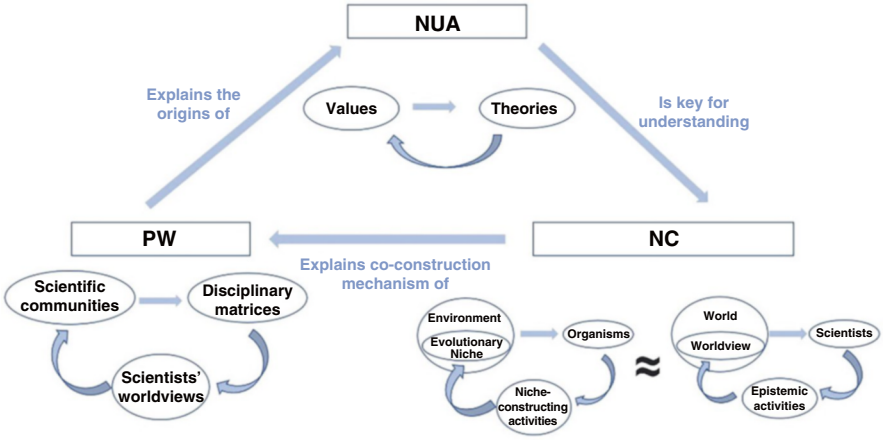


**Fig. 6.4** The virtuous epistemic cycle connecting the three Kuhnian theses

differently weigh and apply values such as simplicity, accuracy, empirical adequacy, and the like.

By virtue of this triple connection, and thanks to the feedback-loop idea, we can now see the three Kuhnian theses as forming a virtuous epistemic cycle (Fig. 6.4).

## 6.4 A Neo-Kuhnian Picture of Theory Choice

So far, we have seen how the three theses, thanks to the idea of feedback loop, strengthen one another and constitute a virtuous epistemic cycle. In addition to clarifying the conceptual connections among different parts of Kuhn's thought, our proposal gives us also an original Neo-Kuhnian picture of theory choice.[8] This will be the focus of the present section.

As we already stressed in our analysis above, the three theses describe the dynamics of science at different levels of abstraction and they involve different actors. NUA looks at science from a very idealized perspective, as it focuses only on the relationships between scientific theories and epistemic values, blurring away the human and social components of scientific theory choice. NC works instead at the global level of the scientific process, looking at the general relationship between scientists and the world. Finally, PW focuses on the local relationships between a scientific community and its disciplinary matrix, zooming in on the specific

[8] We want to stress that, by calling our picture of theory-choice 'Neo-Kuhnian', we just want to highlight the fact that our proposal builds directly on the interpretation of Kuhn's philosophy developed in the previous sections. Of course, identifying the extent and exact nature of Neo-Kuhnian philosophy is challenging and rests beyond the scope of this paper.

epistemic dynamics of groups of scientists. Yet, these different actors and processes must be somehow integrated in actual scientific practice.

The following diagram provides a synthetic sketch of how we conceptualize the relationships between the actors and the processes described by the three Kuhnian theses in scientific practice (Fig. 6.5)

Before describing the diagram, let us stress two important limitations. The first limitation of our diagram is that it includes only the actors and processes that figure in the three Kuhnian theses. Obviously, there are further actors and further processes involved in theory choice that do not figure in this diagram. The second limitation of our diagram is that, for reasons of space and readability, we represented only the practice of theory choice relative to a single disciplinary matrix (and a single scientific community). In reality, many different communities and disciplinary matrices can co-exist and their interrelationships are of extreme importance for understanding scientific theory choice. Yet, practical limitations preclude us to add further matrices and worldviews to the picture. Instead, we chose to focus on what happens within a single scientific community and a single matrix.

After these remarks, let us take a closer look at the diagram. This diagram structures the relationships between the actors and processes connected with the three Kuhnian theses in the following way. The smallest concentric circle in the diagram represents a given disciplinary matrix. Within this matrix, we find laws and models of scientific theories, epistemic values, and the related epistemic activities. A larger circle in the diagram represents the worldview that a group of scientists adopting the aforementioned disciplinary matrix hold. As we emphasized at the beginning of

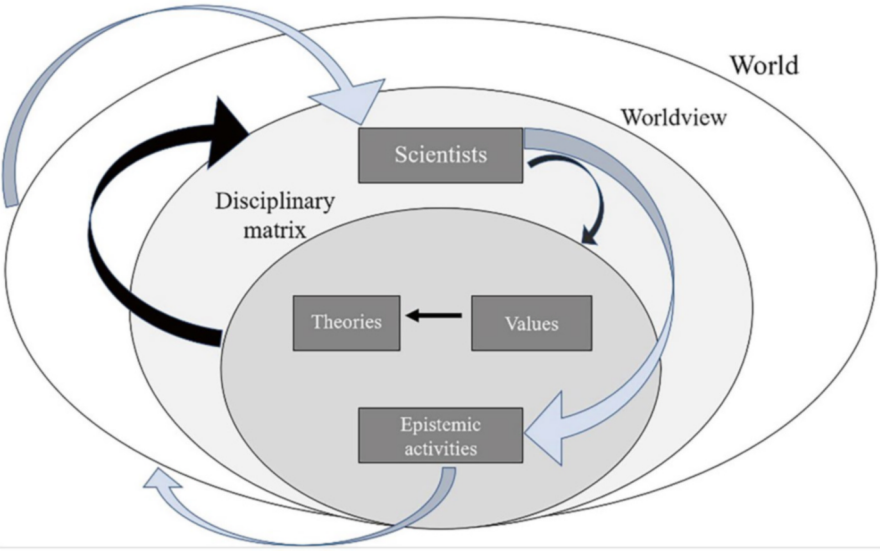


**Fig. 6.5** The complex interrelationships between the actors and the processes depicted by the three Kuhnian theses

Sect. 6.3, the matrix itself does not coincide with the worldview, because the former is often explicitly shared among members of a scientific community, contrary to the latter. By focusing on these actors, we can already describe the processes represented by PW and NUA. Scientists adopt a disciplinary matrix, which includes committing to certain laws and models of a theory, as well as to certain values. Both central components of theory choice, i.e., theories and values, are affected by the adoption of a given disciplinary matrix. It is only through the medium of a matrix that the theories selected on the basis of certain values can, in time, indirectly affect the values themselves. This is the loop process represented by NUA. At the same time, the adoption of a disciplinary matrix is central to the loop process represented by PW. A matrix, in fact, implicitly structures the worldview of the scientists that adopt it. By looking at the largest circle in the diagram, the one representing the world, we can understand how the loop process represented by NC fits in the picture. The world shapes the scientists and their beliefs, whose influence, in turn, through their epistemic activities feeds back into the world, via the worldview within which they operate. This loop is a larger-scale version of the two loops that we previously identified. The loop between theories and values and the loop between scientists and disciplinary matrices involve, in fact, central epistemic activities in the general process of scientific inquiry. This is how, the two aforementioned loop process related to NUA and PW can be seen as representing smaller-scale dynamics that scale up to constitute the general loop process described by NC.

Most importantly, among the maze of arrows and circles depicted in the figure above, a further, implicit loop relationship can be discerned. In order to see that, we have to zoom in on three particular actors and their interrelationships: scientists, scientific theories, and epistemic values (Fig. 6.6).

Let us call this loop the *core loop* of scientific theory choice. This loop is of fundamental importance for our neo-Kuhnian picture of scientific theory choice, in that it explains how three main actors of this process influence each other.

The first, direct, connection is the one between values and scientific theories. This connection represents the selective influence exerted by values on theories, an influence that is, as Kuhn reminded us, ineliminable. The second connection in our core loop is the one between scientific theories and scientists. This is not a direct connection like the previous one, as represented in our main diagram above. Yet, we saw how scientific theories, since they belong to a disciplinary matrix, contribute to the constitution of the worldview of scientists that adopt the related matrix. By

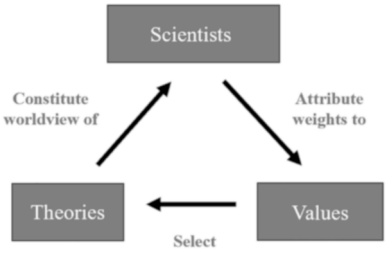


**Fig. 6.6** The core loop of theory choice

being educated and working within a certain disciplinary matrix, scientists acquire a whole array of epistemic, pragmatic, and ontological commitments provided by the very theories they developed. These commitments contribute to shaping the worldview of a given group of scientists. The third connection in our core loop is the one between scientists and values. This is also an indirect connection, always mediated by a disciplinary matrix. By adopting a given matrix, in fact, scientists also adopt a certain way of weighting and applying epistemic values. Different groups of scientists may then weigh and apply differently the same epistemic values, thus creating the feedback-loop effect between epistemic values and scientific theories explicitly mentioned by Kuhn. This third connection closes what we called the core loop of theory choice. By virtue of this triple connection, we can see how scientists, values, and theories dynamically interact with each other in scientific practice.

The dynamic interactions between scientists, epistemic values, and scientific theories captured by the core loop are the main novelty of our Neo-Kuhnian picture of theory choice. In comparison with standard approaches to theory choice, we take epistemic values and the related scientific worldviews to be dynamical and historical entities that change together with the theories they select. This is the lesson of Kuhn's feedback-loop idea in the context of scientific theory choice: the selection of a given theory by a certain scientific community is not a unidirectional process, but a mutual process of co-variance between scientists, values, and theories. As we stressed before, not only do scientists select theories based on certain epistemic values, but also the theories, in turn, contribute to the selection of the worldview of a scientific community and, ultimately, to the weighting and the application of its epistemic values. This bi-directional process of selection involving scientists, values, and theories makes theory choice an essentially diachronic phenomenon. In contrast to many contemporary discussions on theory choice (e.g. Okasha 2011; Morreau 2015; Bradley 2017; Schindler 2017), we take theory choice to have an ineliminable diachronic component, in that all its main actors are historically-changing entities.[9] By highlighting this co-variance between scientific theories, scientists' worldviews, and epistemic values, our Neo-Kuhnian picture of theory choice specifies a further diachronic aspect of the process of choosing a scientific theory, in addition to other diachronic features of theory choice discussed in the literature, such as the inherent diachronicity of certain theoretical virtues (McMullin 2014) and the possibility of diachronic criteria of rationality (e.g. Lakatos 1978; McMullin 1976; Sěselja et al. 2012; Shan 2020).

[9] For a full account of the mutual influence between scientific theories and epistemic values in scientific theory choice, see (De Benedetto and Luchetti 2023b).

## 6.5 Conclusion

Let us summarize the main steps of the present work. We started by focusing on three important philosophical theses introduced by Kuhn: the plurality of worlds thesis, the no universal algorithm thesis, and the niche-construction analogy. First, we have analyzed each of these three theses in its original philosophical context and we have discussed its reception in the literature. Then, we introduced the pivotal concept of feedback loop and we showed how this notion can be used to better characterize the dynamics underlying each of the three theses. Thanks to this novel interpretation, we demonstrated how the three theses can be considered as constituting a virtuous epistemic cycle, in which each thesis strengthens another one. Finally, we showed how this inter-connected interpretation of the three theses allows us to describe an original Neo-Kuhnian picture of theory choice. Specifically, we showed how the different actors and processes described by the three theses are interrelated in scientific practice, singling out a core loop in theory choice that involves scientists, scientific theories, and epistemic values. This complex co-variance between scientists, scientific theories, and epistemic values described by our core loop underlies an hitherto under-appreciated diachronic aspect of scientific theory choice. Understanding the implications of this diachronic aspect of theory choice for a general account of scientific progress, rationality, and objectivity constitutes promising avenues for future work.

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