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Thomas Kuhn, Stefan Amsterdamski, and the Cycles of Scientific Development

Abstract

In his most seminal work, *The Structure of Scientific Revolutions*, Thomas S. Kuhn advances a notion that science is embedded in historically contingent constellations of practices and ideas. In this view, history is part and parcel of science. Science develops by transforming that, which it emerges from – a theme later picked up by Polish philosopher of science, Stefan Amsterdamski. Kuhn also noticed important parallels between psychological and historical development. These insights have led him to the conclusion that what scientists do and what the science does are two different things. Scientific development is discontinuous in the sense that it cannot be measured by any external standard. Science is therefore its own judge. This paper identifies critical shortcomings of Kuhn's theory of psychological development, which most affect his vision of scientific development.

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Subsequently, the problem of development is recast in terms of dynamic system theory or embodied cognition. The ensuing insights are organized into a cyclical model, with two main trajectories: one creative, the other generative. It is argued that the cyclical approach permits to overcome the dualisms, which plagued Kuhn's original account (engagement versus criticism, creativity versus rule-following, etc.) and to further develop Amsterdamski's idea that absent universal norms or standards, criticism and rationality are nonetheless possible.

Keywords: *development of science, cognitive development*, *discontinuity*, *developmental cycles, paradigm, ideal of science, criticism*

Thomas Kuhn, Stefan Amsterdamski i cykle rozwoju nauki

Abstrakt

W swoim najsłynniejszym dziele, „Strukturze rewolucji naukowych", Thomas S. Kuhn rozwija myśl, iż nauka jest zakorzeniona w historycznie przygodnych konstelacjach praktyk oraz idei. Historia jest tym samym częścią nauki. Nauka rozwija się, przekształcając to, co zastane, którą to myśl podjął później polski filozof, Stefan Amsterdamski. Kuhn dostrzegł również paralelność rozwoju nauki oraz poznania jednostkowego, co doprowadziło go do przekonania, iż istnieje różnica między tym, co naukowcy robią, a tym co „robi" sama nauka. Rozwój nauki jest nieciągły w tym sensie, iż nie może być mierzony żadną zewnętrzną wobec nauki miarą; tym samym, nauka jest sama dla siebie sędzią. W prezentowanym artykule identyfikuję podstawowe błędy w przyjętej przez Kuhna teorii rozwoju psychologicznego poznania, które najbardziej rzutują na jego wizję rozwoju nauki. Następnie rekonstruuję problem doświadczenia i rozwoju w kategoriach teorii systemów dynamicznych oraz poznania ucieleśnionego. Spostrzeżenia te organizuję za pomocą cyklicznego modelu rozwoju nauki, wyróżniając dwie podstawowe fazy: kreatywną i generatywną. Podejście cykliczne pozwala na przekroczenie dualizmów obecnych w koncepcji Kuhna (zaangażowanie versus krytycyzm, kreatywność versus przestrzeganie reguł.) a także na dalsze rozwinięcie spostrzeżenia

Amsterdamskiego, iż krytycyzm jest możliwy mimo niedostępności uniwersalnych standardów oceny.

Słowa kluczowe: *rozwój nauki*, *rozwój poznawczy*, *nieciągłość*, *cykle rozwojowe*, *paradygmat*, *ideał nauki*, *krytycyzm*

1. Introduction

The *Structure of Scientific Revolutions* was conceived in a specific historical context.[1] The first few decades of the 20th century were the time of great scientific and philosophical upheavals. Until then, one could safely assume that once the groundwork for natural sciences had been laid in the aftermath of scientific and industrial revolutions, scientific progress would be incremental and cumulative. Special and general relativity and quantum mechanics – to restrict ourselves to the field of physics alone – not only transformed our view of physical reality but also challenged the entrenched epistemology. Philosophers became challenged to account for what appeared as a discontinuity in the advancement of science, something that rationalists had difficult time dealing with, for in their minds the only admissible rupture would be that between prescientific and scientific epoch (the problem of demarcation). Thus, the problem of scientific development became the center of philosophical debates to follow, as the discoveries of the early 20th century strongly discouraged commitments to any natural philosophy whatsoever.

It was Karl R. Popper who seem to have captured the spirit of time most fully and set up an agenda for a new philosophy of science. In broad brushstrokes, he attempted to revive a vision of science as an adventurous exploration, an enterprise entailing boldness and risk-taking. In Popper's view, progress of science rests on the shoulders of individual scientists always willing to go against established opinions and ingrained frameworks, knowing full well that their own ideas, too, will someday get into a collision with "facts" and become replaced by better accounts.[2]

These philosophical developments can also be recapitulated as a story of the rise and fall (or "abdication"[3]) of the methodologist. Apart from

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[1] Kuhn 1996.
[2] Popper 1963; 1972; 1992; 2002.
[3] Musgrave 1977, pp. 476, 479.

being based in certain allegedly rational epistemic attitudes (readiness to be proven wrong, or even eagerly awaiting it), science possesses features which allow it to be discussed publicly. Science, in a word, is not only explorative, but also transparent and accountable. In light of critical rationalism, science progresses in partnership with philosophy, whose task is no longer an advancement of natural philosophy, but a provision of formal criteria for an ongoing critical review of scientific hypotheses.

Kuhn was blamed for shattering this vision. According to his historical findings, scientific theories do not tend to simply crumble under the weight of counterevidence. For it is only a provision of an alternative conceptualization that can cause a theory to be dropped. On top of that, theories cannot be compared based on objective criteria such as explanatory power, simplicity, etc., for these are framework-dependent and do not apply universally (except in a very generic way). More generally speaking, Kuhn's most famous book arrived on the scene when the idea of profound scientific change still enjoyed wide currency, but the overall intellectual climate had changed. Recent developments in other scientific domains, such as psychology, anthropology, history, or system theory (cybernetics), suggested that the demarcation line between the allegedly formal (transcendental) philosophy and "substantive" sciences cannot possibly be drawn. This was a huge problem for critical rationalism since the susceptibility of science to external assessment was deemed essential to its rationality.

Long story short, the rationalist camp responded to Kuhn's challenge by embracing what Nancy Nercessian dubbed "cognitive-historical" approach,[4] according to which scientific development indeed follows a universal pattern which, however, can only be revealed stepwise, in the course of detailed historical studies.[5] This approach implies that philosophy of science coevolves with science itself, and consequently, that progress of science means ever better grasp of the nature of scientific knowledge.[6] Kuhn himself ultimately conceded that some

[4] Nersessian 1992, p. 179. Underlying this approach is 'continuum hypothesis' to the effect that there is a relevant continuity between individual cognition, common sense, and scientific practice.

[5] For application of such an approach in historical studies of science, see Nickles 1980; Barker, Chen, Andersen 2002; 2006; Gärdenfors, Zenker 2013.

[6] See also Laudan 1984; Kitcher 1993.

form of continuity between scientific episodes can indeed be identified through a careful analysis of the intervening stages.[7]

A thorough critique of the cognitive-historical framework is beyond the scope of this paper. Suffice it to say that giving up active engagement with science *as it advances* has been considered unsatisfying by both authors of a rationalist persuasion and others.[8] The approach is essentially backward-looking, and if one is not careful, one may end up either justifying every position or theory as covertly rational, thereby rationalizing the irrational, or committing a "whiggish" fallacy of dismissing the past based on the prejudice of the present.

Although the above issues are rarely discussed nowadays, the questions concerning the relation of science to other intellectual domains (or the status of the former within culture), and between current practices and tradition, seem as relevant as always. Now that the dust of the debates has settled, it may be a good time to revisit some of the themes and look at them from a fresh perspective.

In this contribution, I shall break Kuhn's original proposal as delineated in *The Structure…* down to bring out its unexplored potential. I side with Nercessian concerning her judgment that the critical shortcomings of Kuhn's theory can be traced down to his half-baked cognitive psychology. In contrast to Nercessian and others, however, who tended in the direction of classic cognitive theory, I shall try to reframe Kuhn's theses in terms of embodied cognition and dynamic system theory. Whereas the former focuses on rather abstract entities, such as cognitive structures[9] or conceptual spaces[10], the latter is able to capture the individual–collective dynamic. Based thereupon, I will adumbrate a cyclical model of cognitive development, which distributes different kind of activities along two main trajectories, which I here designate as the creative and generative phase. The main advantage of conceptualizing science in terms of phase alternation is that it permits to reconcile all the problematic oppositions that have been brought to light during the discussions of scientific rationality, such as engagement

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[7] Kuhn 1990. For a detailed reconstruction of the evolution of Kuhn's views, see Hoyningen-Huene 1993.

[8] Musgrave 1977; Rouse 1996, pp. 43–67.

[9] E.g., Churchland 1989.

[10] Garderförs 2004.

versus criticism, the individual versus the collective, or creativity versus rule-following. As I intend to show, a cyclical model entails the kind of ongoing criticism as postulated by Stefan Amsterdamski,[11] which dispenses with universal norms without, at the same time, falling back onto reconstructionism and retrospectivism. The ultimate goal of this paper is to show the way for overcoming the dualisms present in Kuhn's original account and, on this basis, to specify the sense, in which history may be considered a part and parcel of science.

2. Kuhn and the problem of discontinuity

2.1. Kuhn's split vision: institutional Realpolitik versus a romantic ideal of creative science

The critical question to ask is the following: which, specifically, feature of Kuhn's conception of scientific change systemically undercuts the possibility of an ongoing philosophical-critical reflection on science? In my assessment, the main factor is Kuhn's half-hearted commitment to developmental theory, which otherwise both informs and is informed by his concept of history.

The core and most contentious tenet of Kuhn's original project, whose basic outlines one can find already in his first book, *The Copernican Revolution*,[12] can be summarized as follows: Scientists are not here to make discoveries; instead, they are expected to use certain tested methods to solve designated, well-defined problems. Scientists are supposed to answer existing questions, not come up with new ones. For example:

> Normal science is predicated on the assumption that the scientific community knows what the world is like. Scientists … never learn concepts, laws, theories in the abstract and of themselves. Instead, these intellectual tools are from the start encountered in *a* historically *and pedagogically prior unit* that displays them with and through their application.[13]

[11] Amsterdamski 1992.
[12] Kuhn 1957.
[13] Kuhn 1996, p. 46.

Were this observation based on empirical findings concerning scientific practices alone –which in part it was–it could be dismissed in the way Popper attempted to do, namely, by stating that scientists conduct themselves incorrectly given the basic aim of science, which is progress. In Kuhn's eyes, however, normal science was much more than a set of bad attitudes and habits that tend to resist reform. The critical part of his argument is this: normal science is a prerequisite for change.

Let's take Kuhn's argument step by step.

The idea that conservative attitude is a condition sine qua non of change was first put forth in *The Copernican Revolution* and presented as a matter of the way science had been done, historically speaking. In *The Structure*…, this critical insight was buttressed by developmental theory. As Kuhn stated explicitly,[14] there is discernable analogy between historical and cognitive development, which is to say that *The Structure*… uses a form of cognitive-historical approach as its primary heuristics.

There is an obvious rationale behind this. For one, science is a human activity: it is something initiated, done, and received by human beings. Also, by the time Kuhn went about writing *The Structure*…, psychology had managed to overcome psychologism, an epistemological position attempting to explain knowledge in terms of subjective states (ideas, beliefs, convictions), and moved in the direction of universal models of psychological development.[15] Of particular interest are what might be called stage models of development.

In *The Structure*…, Kuhn references mainly Jean Piaget, and indeed his conception bears striking similarities with Piaget's model.[16]According to Piaget,[17] within each stage of development, all that is inconsistent with the established structure is relatively easily neutralized or "assimilated." Changes at this point are reversible, which makes puzzle-solving (aka troubleshooting via recombination)[18] possible but also sets limitations upon creative problem-solving, which requires out-of-the-box thinking. When the number (or weight) of inconsistencies outweighs

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[14] *Ibid.*, p. viii.
[15] Köhler 1957; Piaget 1985; Vygotsky 1986.
[16] Kuhn 1996, p. viii.
[17] Piaget 1985.
[18] Kuhn 1996, Chapter IV.

the system's capacity for assimilation, the only way to restore the equilibrium is through what Piaget referred to as "accommodation," which amounts to a far-reaching reorganization of the existing structure and is irreversible.[19]

More generally, stage models entail that progress can only be achieved, through crisis, which signifies a moment when a system has reached the limit of its processing capacity and in order to be able to continue its existence, must seek a new, higher, dynamic equilibrium. In this view, insofar as human cognition and knowledge are susceptible to development, discontinuities are inevitable. The improvement development brings consists in the fact that after the transformation the system has a greater capacity – not just in a quantitative sense, but most of all qualitatively, in terms of the types of internal and external relations and interactions that now become a possibility.[20] Critical for our discussion is the fact that the qualitative aspect is a matter of personal knowledge or expertise, and as such cannot be measured by any external standard.

In many ways, Kuhn's conception follows the reconstructed template. Kuhn's main argument is that were science bent on discovery, as Popper saw it should be, not only would it fail to produce any stable results of practical value, but most importantly – and a bit paradoxically – it would be unable to create anything new.

Of course, part of this sounds like something a rationalist like Popper would readily concede. For Popper, the extant theories and frameworks are but a launching pad for new discoveries. On Kuhn's model this is to some degree true as well; what is different about Kuhn's approach, though, is that refutation cannot possibly constitute a goal of research. Novelty is a relative affair and can only arise against the background of something already there – and this means that a structure must be fully formed before it is changed (in a constructive way, at least).[21] Therefore, scientists must be committed to the advancement of the existing models rather than oriented toward falsification.

In other words, according to Popper, each theory should immediately be broken down into independently testable propositions, whereas for Kuhn, a paradigm operates as an implicit frame for detailed research and as such

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[19] Polanyi, pp. 78–79.

[20] Schore 2015, loc. 1509–1511.

[21] One could also say that the process of explication changes the thing explicated.

must be put to work as a whole. As Kuhn emphasizes time and again, for scientific activity to be possible, knowledge must be embodied in habits, based on exemplars.[22] Therefore, in order to for a paradigm to change, it must be allowed to reveal its ramifications and implications through its practical application, which entails a temporally suspension of criticism.

All in all, according to Kuhn, science transforms itself on its own accord and at its own pace and does not need an external critic and regulator to be able to move forward. In disregarding the phase at which a given scientific discipline is in at a given point, disengaged assessment could only hinder development.

As mentioned above, the idea that normal science is an agent of change is present already in *The Copernican Revolution*, where Kuhn stresses that Copernicus himself was not intent on replacement of the geocentric system, but rather aimed to improve it.[23] In Kuhn's view, it was the accumulation of minor "technical" adjustments that opened new territories of research, which eventually undermined the whole system. A similar story although without reference to the notion of paradigm-based, normal science– Kuhn much later told about Planck's role in the emergence of quantum mechanics.[24]

The Structure… can be seen as an attempt to systematize these ideas and observations and flesh them out philosophically. What makes science progress also makes it ineffable, and hence, on the face of it, not susceptible to criticism.

According to Kuhn

> [A]n apparently arbitrary element, compounded of personal and historical accident, is always a formative ingredient of the beliefs espoused by a given scientific community.[25]

It would be difficult to overestimate what Kuhn's is saying here. Paradigms are not fully consistent internally, because each is formed in specific socio-historical conditions. Not only that, it appears that Kuhn

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[22] Kuhn 1996, Chapter 5, Postscript-1969.

[23] Kuhn 1957, p. 188. Note that my goal isn't to decide if Kuhn's take is correct or not. I cite Kuhn's opinion for hermeneutic reasons, in trying to reconstruct one of the main threads in Kuhn's thinking.

[24] Kuhn 1978.

[25] Kuhn 1996, p. 4.

also acknowledges some individual dispositions as factors responsible for flexing the structure not fully in line with its dominant logic.

He continues in the same vein:

> Normal science, for example, often suppresses fundamental novelties because they are necessary subversive of its basic commitments. Nevertheless, so long as those commitments retain an element of the arbitrary, the very nature of normal research ensures that novelty shall not be suppressed for very long.[26]

Key here is the procedure of paradigm articulation, which is a process whereby science reveals to itself its internal inconsistencies and thereby sets itself up for change.

Kuhn is very specific about this:

> Without the special apparatus that is constructed mainly for anticipated functions, the results that lead ultimately to novelty could not occur. And even when the apparatus exists, novelty ordinarily emerges only for the man, who, knowing with precision, what he could expect, is able to recognize that something has gone wrong. (…) The more precise and far-reaching that paradigm is, the more sensitive an indicator it provides of anomaly and hence of an occasion for paradigm change. (…) The very fact that a significant scientific novelty so often emerges simultaneously from several laboratories is an index both to the strong traditional nature of normal science and to the completeness with what that traditional pursuit prepares the way for its own change.[27]

In a word, were it not for normal science, paradigm change would be completely arbitrary. Strictly speaking, paradigms are not superseded; in a way, they prepare the ground for their own successors. It is in this sense that science develops through an "essential tension" between the forces of tradition and innovation.[28]

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[26] Kuhn 1996, p. 5.

[27] Kuhn 1996, p. 113.

[28] Kuhn 1977, pp. 225–239.

But what would it mean exactly that the old paradigm unearths the path leading to its successor? The analogy between psychological and scientific development again comes in handy. As it gets articulated, the old paradigm gradually exposes itself to change in the same manner in which a developmental stage, once its potential has been fully exploited, produces tensions, which can only be addressed as one moves higher up. We may say that a paradigm does not produce its successor, but rather formulates pressing questions and delineates exploratory strategies necessary to answer them.

2.2 What has gone wrong?

As we saw, in Kuhn's view science is not merely a loose system of language-games, with no purpose beyond the game itself. His model is clearly progressive. It speaks against certain conception of progress, according to which the rate and volume of progress can be measured based on some universally applicable criteria. At the same time, however, it sets itself, and those wishing to follow it, a task of laying out, and contextualizing with historical details, a model of structural transformation of the system(s) of knowledge vis-à-vis their intellectual, cultural, and social backgrounds. As far as the specifics of Kuhn's account, a couple of things seem to have gone wrong. The concept of reeducation is a good example of the confusion present in his work:

> Therefore, at times of revolution, when the normal-scientific tradition changes, the scientist's perception of his environment must be re-educated-in some familiar situations he must learn to see a new gestalt. After he has done so the world of his research will seem, here and there, incommensurable with the one he had inhabited before.[29]

At best, this explanation begs the question. Change is here explained as a result of re-education into a new way of seeing the world (the research domain). But re-education, which is an intentional process, implies the critical shift has already happened. So, it brings us back to the initial question: how and where does change come about, and how does

[29] Kuhn 1996, p. 112.

it spread? What is the relationship between paradigm and the individual through whom it is applied and articulated?

At worst, this suggests that change in science is not organic, as the previous analyses attested, but rather is a socio-political affair: change is a result of an intellectual regime being overpowered by a rival. The top-tier representatives of the previously ruling paradigm are removed from the scene, while the rest gets re-educated.

The problem can be traced down to the fact that the process whereby paradigm articulation leads to change can be understood in two ways. In *The Structure*…, Kuhn struggles to decide between them.

Pulling together Kuhn's various observations concerning the role of paradigm articulation in the detection of arbitrary components, the overall image is at follows. A new paradigm yields an array of issues around which research groups are organized. Each group will subsequently use the paradigm in a slightly different way and explore different facets thereof. Even within the same group, individual scientists will emphasize, often subconsciously, different aspects of the phenomenon in question (see the remarks about arbitrariness above). Eventually, all kinds of anomalies will get detected, which those involved will have a hard time explaining. It often takes the third party to notice the connection between what transpires across different laboratories, but the suggested resolution–which amounts to an emergence of a new system/paradigm – should ease the pain of all involved.

This reconstruction underscores the role of individual expertise and difference in paradigm articulation, and, by the same token, in the advancement of science. On this interpretation, while unanimity and shared commitments are necessary to sustain the process of paradigm articulation, subtle deviations from the common trajectory ensure that the paradigm will be explored thoroughly and finally transformed.

This logic isn't consequently applied by Kuhn, though. His analyses of normal science and scientific training utilize a social constructivist categorical framework, which sees scientists as products of socialization process. Individual scientists are still important since the paradigms must be put to work in order to be articulated and tested. But, instead of construing the relationship between an individual scientist and a paradigm consequently along the lines of personal knowledge and expertise, Kuhn's analyses often suggest that individuals become carriers of the schemata they are exposed to. This invokes an imagery of "body snatching", as if some extra-individual intelligence recruited human bodies for the purpose of self-expansion and proliferation. All other difficulties associated with this notion aside, note that if science were indeed a collective intelligence determined to reproduce itself endlessly, novelty in Kuhn's sense would never arise. A structure of this sort, with its tendency to ruthlessly eliminate any deviation or dissent, is doomed to eventually collapse under its own weight.

All in all, the essential difficulties associated with Kuhn's account of scientific revolutions can be summarized as follows.

The first and recurring problem is the above-mentioned issue of the relationship between the individual and the collective. Kuhn's general approach implies domination of the latter over the former. On the social-constructivist reading, individual scientists exhibit false consciousness: their attitude is that of unquestioned commitment, which some higher-order wisdom utilizes to bring about progress. Instead of creative tension between individual ambitions and the tradition through which they get to be expressed and realized, what we get is a split between Realpolitik on the part of those who do the science and the purported creativity of science itself, which uses its intellectual milieu to further its own progress. Just as a child typically resists some aspects of the process of growing up, though, so may individual scientists resist the very changes they may have occasioned– Planck or Einstein being cases in point. But it does not follow from this that individuals cannot handle the growing pains and eventually accommodate the changes.

On that note, it bears pointing out that the current state of knowledge indicates strongly that the most profound developmental changes concern not so much the ability to represent and manipulate objects as emotional regulation.[30] If we define affect (emotion) as a measure of interactive engagement and an indicator of its quality (positive/approach versus negative/withdrawal), then affect regulation refers to the ability to adaptively regulate the level of engagement as the circumstances require. In a word, affect regulation is the critical feature of the development of a dynamic system, within which the agent and his environ are coupled.[31] As a rule, the more advanced the capacity for affect-regulation, the

[30] Schore 2015, pp. 1397–1399.

[31] Varela et al. 1991; Merleau-Ponty 1973, p. 18.

more novelty and ambiguity the system is able to tolerate. In this light, the ability to accommodate change is a function of regulatory capacity, which in itself is subject to increment.

The second, and foundational problem, is Kuhn's understanding of development. As he himself observes, older paradigms are a turf and fertilizer for new ones. More generally, developmental theory entails systemic connections between successive stages. That is to say, in the developmental framework, the past is a constitutive, not just enabling, condition of the present – and as such it is preserved in it. If that's the case, then change isn't simply a process of one structure morphing into another. Rather, it is supposed to also give us a better sense of what a moment ago was accepted non-reflectively. As mentioned, developmental theory entails the inevitability of crises–ferment and confusion always to some extent precede the emergence of a new gestalt. But at the same time, the emergent gestalt brings new and more encompassing clarity to our experience of the world.

These two problems are of course strictly related. Kuhn understood that a theory of scientific development must somehow weave together the socio-historical and psychological factors but did not quite figure out how to do it seamlessly. Despite his ventures into dynamic system theory, Kuhn's view of development remained essentially cognitivist, focused on the emergence and transformation of categorical frameworks rather than on differentiation and complexification of a dynamic system. As a result, developmental theory gets reduced to a handy metaphor rather than acting as a fully-fledged participant in the project of making sense of scientific change.

3. Stefan Amsterdamski's conception of philosophical criticism of science

Underlying Kuhn's most extreme conception of scientific revolutions is an inference to the effect that if there can be no standards valid across paradigms, criticism of science is entirely counterproductive.

The philosopher Stefan Amsterdamski's conception of scientific development is very interesting in this context. Amsterdamski rejects the universalist model of scientific criticism (aka the demarcation project), but at the same time insists that an ongoing criticism of science is possible and necessary for it to progress.

Amsterdamski's main work, *Between History and Method*,[32] is in a large part a critical discussion with Kuhn's conception of scientific revolutions. The primary source of inspiration for Amsterdamski, though, was the French school of philosophy of ideas, especially the works of Alexandre Koyré.[33] This causes Amsterdamski to focus on large-scale phenomena and disregard the continuum hypothesis, which, as we shall see, adversely affects his theorizing.

Crucial for Amsterdamski's philosophy is a distinction between methodology and philosophy of science. He takes Kuhn's insights concerning scientific practice to apply to paradigms construed narrowly, as sets of know-how pertinent to a research discipline.[34] Amsterdamski concedes that paradigms may indeed be applied uncritically by scientists, and the goal of bureaucratized scientific practice may well be self-reproduction. But scientific practice itself is structured based on an implicit ideas and ideals, which can and must be made explicit and scrutinized if the science is to move forward in the long run.

According to Amsterdamski:

> The concept of the ideal of science as understood here consists of a set of views about the goals of scientific activity and of views defining both the method and the ethos of science at a given period.[35]

More specifically,

> ideals of science imply a particular scientific ethos and internal organization of the scientific community, as well as their understanding of science as a social institution.[36]

In Amsterdamski's view, which he shares with Kuhn, science is not self-sufficient with respect to its resources, and fully autonomous as far as its normative grounding. It operates under specific socio-cultural conditions, which shape its practices and self-concept. Demarcation projects are doomed to fail precisely because there is not a single conception of what it means for a theory to be scientific:

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32 Amsterdamski 1992.

33 Koyré 1957.

34 Kuhn 1977, pp. 293–319.

35 Amsterdamski 1992, p. 14.

36 Amsterdamski 1992, p. 24.

> [S]cientific activity oriented towards a given paradigm would be considered scientific only when its paradigm is consistent with the accepted ideal of science and constitutes its specification or elaboration for a given area of investigation.[37]

In other words, scientific practice is embedded in social milieu, which is historically contingent and "axiologically 'charged." In a Amsterdamski's own words:

> Thus, despite the various attempts of methodologists searching for universally valid criteria of demarcation, science can be distinguished from other types of knowledge in an historically adequate manner only conventionally and normatively: conventionally, because it is a matter of convention to regard a given ideal as universally valid; and normatively, because the choice of any convention is normatively conditioned.[38]

In Amsterdamski's assessment, to try and offer an overarching methodology of science is to treat the ruling ideal of science as unproblematic, which is anything but rational.

This is the bad news (for the rationalist). The good news is that, precisely due to historical contingency, the relationship between ideals and paradigms is not strict. We can picture an ideal as grooves in something like Waddington's landscape, which is to say that the relation between paradigms and ideals is probabilistic rather than deterministic, and therefore does not permit to strictly derive one from the other. This cleavage creates the space for critical reflection.

In other words, just like Kuhn, Amsterdamski acknowledges the constructive role of historical contingency in scientific development. Science's dependency on cultural resources is not a form of contamination. Rather, tradition is the stuff science is made of; we may say that science is a means for explication, refinement, and critical elaboration of ideas currently in circulation. Since no closed linguistic system can be fully coherent, a constant effort is needed to weed out the arbitrary

[37] Amsterdamski 1992, p. 15.
[38] Amsterdamski 1992, p. 12.

accepted assumptions and clear the path for an emergence of new ideas or interpretations which subsequently give rise to new discoveries.

Overall, Amsterdamski alleges that the concept of the ideal of science achieves a couple of things.[39] First and foremost, it accounts for the internal differentiation of science: under an umbrella of one ideal many research paradigms are fostered. Circling back to our discussion about arbitrariness in section 2.1, we immediately notice that the differentiation and variety entail that a dynamic system, comprising an ideal and a plurality of paradigms which it appears to validate, pushes research in many directions simultaneously. It once more proves helpful to conceive of ideals as fields or dynamic systems rather than fixed structures. We can then see that deviations will not immediately undermine a system's dynamic equilibrium. Which leads me to the second of the alleged advantages of the conception of ideal of science as compared with Kuhn's model: these higher-order units take a long time to change, and so revolutions are not as drastic as Kuhn initially suggested.

Two issues arise at this point. For one, the flipside of the circumstance that paradigms are fully dependent on ideals which produced or otherwise sheltered them is that they may survive, in some form, the change of an ideal and be later assimilated by a new one, ensuring some form of continuity. I will expand on this in the final section.

Second, it seems that a *longue durée* perspective adopted by Amsterdamski has blinded him to the fact that Kuhn's point concerning revolutions turned on the nature of developmental change, which retains its relevancy at a micro-historical level (the development of a research project, for instance). In other words, the purported radicalism of revolutions cannot be reduced to the issue of duration – we must genuinely embrace and accommodate the qualitative character of change, which cannot be assuaged by the passage of time.

Even more specifically, what's problematic about Amsterdamski's take is that the dualism of apparently unreflective scientific practice and normatively oriented philosophy is ultimately left unchallenged. As mentioned toward the end of the last section, though, the potential for critical reflection can be derived from embodied practice itself. We will return to that shortly.

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39 Amsterdamski 1992, pp. 14–16.

Before moving on, a few words are in order, concerning Amsterdamski's model of scientific criticism. As already indicated, Amsterdamski did not believe in universal validity of methodological standards. What was offered instead does not amount to a systematic account of scientific criticism, which is understandable given Amsterdamski's historical orientation. What we can gather from his analysis of the process whereby in the modern era the epistemic and technological functions of science were rendered "inextricably linked," is an idea that philosophy's task is to carefully track the apparently logical, but in fact contingent, links among different ideas which come to form a single ideal of science.

Drawing inspiration from Paul Feyerabend, Amsterdamski also stresses the role of pluralism of viewpoints in scientific development. Kuhn, as we have shown, did appreciate the role of plurality in scientific change, manifesting itself as individual idiosyncrasy and historical accident, but he also explained why an unrestrained variety belongs to the pre-paradigmatic, prescientific, stage, and as such must at some point and to some extend be transcended. Amsterdamski's ideas may therefore point in the right direction, but ultimately do not fully accomplish the task.

4. Developmental cycles

We have come to the point where we see that Kuhn's critical insight, to the effect that science progresses through a balancing act between an adherence to tradition and conservative attitude, on one hand, and plurality, explorative spirit, and innovation, on the other, is not so well balanced in its philosophical fleshing-out.

What could help is organizing the key insights of Kuhn and Amsterdamski into a cyclical model of action and cognitive-intellectual development. The cyclical model delineated below is meant to serve a heuristic function by permitting to track transitions between purported stages of intellectual activities, from an emergence of a dynamic equilibrium, down to its ultimate replacement by more encompassing a system. The viability of the model hinges on its capacity to integrate often contradictory features of scientific practices, and the model can be further tested by looking into how well it accounts for successes and failures of various scientific endeavors.

The model distinguishes two phases–*creative* and *generative*–represented by an "ascending" and a "descending" pathway, respectively (fig. 1). The two pathways connect at the bottom and the top, together forming a circle. The points of contact represent critical turning points in the developmental dynamic. In addition, we can imagine a horizontal line cutting the circle across at midline, which represents all that which remains stable and relatively unchanged from one cycle to the next. We shall explain this in more detail below.

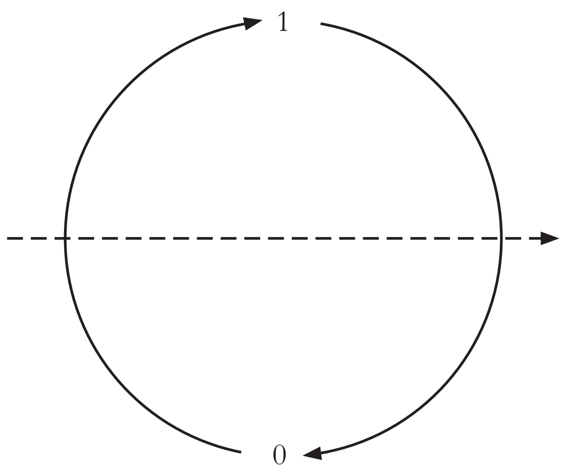

Fig. 1

4.1 The creative phase: from exploration to (self-)knowledge

The creative phase is about learning. As such, it is exploratory and entrepreneurial. It is characterized by a dominance of will over knowledge, or action over reflection. In this phase, people act relatively independently from one another.

The most convenient way of describing the cycle is by taking the perspective of an adept in a certain field of science (although the model has much broader application). At first (point 0), one is likely be quite clueless, without much sense of what one is doing and where one is going. This kind of a tabula-rasa epistemic and existential attitude holds even if one had a clear idea of what one wanted to do going in. It's simply the nature of this early phase that one is overwhelmed by what is happening around. If one persists and manages to resist the temptation of premature disambiguation (which would cause a regress), one enters the next sub-phase, which we may call "will over skill." This is a time when one begins to see what the activity may be about and starts pursuing it eagerly. Many mistakes are made, though. In the next sub-phase, which takes place midway through the ascension, one finally gets hold of the right kind of instructions (via exemplars or instructors) and begins acquiring the necessary skill set.

The horizontal line in Figure 1 represents an uploading of certain established schemas by an individual. These schemas are what is shared across the researchers in a field of study. Each adept, however, will internalize and enact these slightly differently. As Merleau-Ponty points out, the sole fact that a child picks up that, which he or she did not create changes the very thing: "(…) changes intervene, if only because the child inherits conclusions without having lived the premises. Thus behavior that has been learned apart from the experiences which motivated it can be invested with a new meaning."[40]

The final sub-phase of the first phase is a moment when one starts experimenting more boldly with what has been handed down to one and personalizes the acquired knowledge by adapting it to one's needs and the specifics of the problem situation at hand. One acquires intuitive expertise[41] and is able to enter a state of flow.[42]

The consciousness of individuals at this point is not so much false as limited or skewed. Two diametrically different attitudes are conceivable at this point, depending on one's overall dispositions. One may not be able to fully appreciate the extent, to which one relies on preexisting schemas and consider what one has achieved thus far as a product of one's own initiative, inventiveness, or creativity. Conversely, the adept may not realize how deeply he or she is modifying, by just using it, whatever it is they have picked up during learning.

This phase entails that the influence between an exemplar and an individual applying it is bidirectional. Furthermore, we clearly see that, on the presented model there is not anything like preparadigmatic phase in the strict sense. An individual may sometimes experience a state of being like a clean slate, but at the background there are always certain templates

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40 Merleau-Ponty 1973, p. 98.
41 Dreyfus, Dreyfus 1986, p. 30.
42 Csikszentmihalyi 1990.

one may extract and internalize. They may not be anything obvious – the creative character of this phase derives in part from the fact that one can use a template from a different domain and subsequently adapt it to the existing problem situation. In contradistinction to what Kuhn's suggested, brutal socialization isn't required. In fact, since the acquisition of competence entails at least some freedom of experimentation, or even playfulness, coerced uniformity may hinder development.[43]

All and all, the process of extracting a signal from the noise is posited to be an essence of the phase. What this means, however, is that certain options and possibilities are discarded. Relatedly, one also develops a rather lopsided sense of identity, one that requires a sharp demarcation from other individuals or groups or viewpoints. In a word, one is likely at this phase to form one's own sense of self by distancing oneself from one's own past and tradition.

4.2 The critical-hermeneutical moment, and down to the generative phase

On the presented model, the peak of the cycle signifies mastery. One is now destined to act as a role-model for others to follow. This is potentially problematic, though, since mastery being a culmination of the process of development means there can be no higher standard whereby to assess the individual's performance as an expert and teacher. The concept of personal knowledge is an anathema for the critical rationalist in that it seems to remove public accountability in the name of elitism.

I would like to offer a different perspective on the situation. As I shall try to show, mastery is intrinsically hermeneutical and critical. It represents not an extreme of subjectivism but a peak intersubjectivity. It is a moment of reckoning: that which has been, and needed to be, suppressed or discarded at a previous stage, now comes to light and must be integrated, i.e., properly ordered.

To explain this, we must return to the problem of embodiment as a prerequisite of successful practice.

In *The Structure…* Kuhn essentially relies on a what in philosophy of the social science is known as logical connection argument.[44] In the

[43] Panksepp 1998, Chapter 8, 9 & 15.
[44] Landesmann 1965; Winch 2003, p. 109.

most general terms, it means that every norm or rule is coextensive with its embodiment, i.e., with the act or action which manifests it. Therefore, whenever a "body" changes, reality changes as well. This cognitive blueprint is seen clearly in Kuhn's discussion of perceptual shifts in Chapter 10 of *The Structure…*, where he cites the rabbit-duck experiment. But the rabbit-duck switch of perspective undermines rather than substantiating Kuhn's thesis on irreversibility. If we can go back and forth between a duck and a rabbit, then of course both options are equally available to us. That being said, the rationalist does not gain much from this, either – the problem for the rationalist isn't so much whether we can shift the perspective at will as whether this shift is epistemically justified.

I submit that the epistemically justifiable shift should be conceived as an emergence of a higher order principle of organization with respect to both gestalts, which amounts to a formation of a higher-order equilibrium state. Kuhn's fallacy in this regard is due to a failure to distinguish between focal and global[45] or subsidiary[46] types of attention and awareness. While the former is fixed on objects and tends toward maximus stability and clarity of vision, the latter tracks the changing positions and attitudes relative to the focal object.

More specifically, as we explore an object, we constantly shift from one standpoint to another. The whole process is constantly tracked via our background awareness, whereby a dynamic frame is constituted and reconstituted. This kind of dynamical system, as any other, is oriented toward an equilibrium state, i.e., a state where all inputs (qua different viewpoints) are properly integrated. Merleau-Ponty refers to it as a "unified system of me-other."[47]

Let's dive deeper into the phenomenon of global awareness and try to reconstruct crucial moments in the constitution of higher-order psychological equilibrium states.

1) At the most basic level, proprioception, the mechanism for mapping of the positions of limbs with respect to a center (the spine and the head), constantly divides the perceptual field into me and non-me via a center-periphery system of coordinates.

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45 McGilchrist 2019, pp. 43–56.
46 Polanyi 1962, pp. 57–59.
47 Merleau-Ponty 1973, p. 18.

 DOI: 10.4467/2543702XSHS.23.006.17697

This system provides a template for all concepts related to a position in space.[48]

2) For this map to raise to the level of awareness, it must be integrated with an interoceptive map, whereby a subjective feeling of what is happening to one's body emerges.[49]
3) Enter change and movement: higher-order interoception tracks how one's state changes in relation or in response to the movement/action of other bodies.[50] This kind of awareness is based in "a somatotopic representation of the subjective feelings of one's current movements as part of a representation of all feelings from the body."[51] It is interesting to note in this context, still somewhat speculatively, that the earliest forms of interoception produced a form of group awareness, with the primary role of olfaction and gut microbiome. The development of the insular cortex marked a shift to individualized sensory homeostasis,[52] which in turn compelled toward emergence of higher-order me-other systems, based on empathy and mirror neuron system.[53]
4) As already hinted, interoception is stratified: cognitive activities are also mapped out and translated into cognitive feelings, i.e. a form of background awareness of one's cognitive state and epistemic relation with an object, including the way emotions affect the relation.[54]

In other words, from neuropsychological perspective, the higher-order awareness is inherently relational in the sense of being an integrated system of relations among other dynamic systems across time and space. I propose that this level of awareness can be achieved only through a confrontation with alternative standpoints and their integration into a broad system of reference only. The system includes,

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48 Lakoff, Johnson 1996; Damasio 1999, chapter 5; Damasio 2010, Chapter 4; Johnson 2007, pp. 27–31; 188–195.

49 Craig 2009.

50 Craig 2009.

51 Craig 2009, p. 60.

52 Craig 2009.

53 Gallese 2003.

54 Craig 2009, p. 60; cf. Laird 2007, Chapter 8.

but is not limited to, the following kinds of relations: the past me versus current me, tradition versus current practices, the individual versus the collective; one domain of knowledge versus another; philosophy versus science.

Metaphorically, as one reaches the peak of the mountain, one can see and appreciate what one has accomplished, but one is also confronted with the fact that there are other paths leading to the same place, as well as all territories still to explore. When all the individual trajectories converge, two things are expected to happen.

First, they become mutually corrective – the more self-aware one is, the more one is aware of one's limitations. This is a moment when each system is potentially given its due, which comes down to a critique and refinement made possible by confrontation with other perspectives. For example, we can often hear that Einstein refuted the concept of absolute space. But there is more than one way of construing the latter. Some physicists, for example, have offered a conceptualization of absolute space consistent with relativity but at odds with the assumption shared by Mach and Einstein, according to which space without objects in it is inconceivable.[55] On this hypothesis, space is "pseudo-Euclidean" – flat absent matter, curved when filled with it.

We do not have to decide at this point which of the views is correct. What is important to understand is that questions "In what sense?," "From which perspective?," are the key ones at the critical-hermeneutic stage.

Merleau-Ponty makes a very pertinent observation:

> The properties of the fraction do not falsify the whole number. The same is true of the relation between spatial geometry and plane geometry, non-Euclidean geometry and Euclidean, or Einstein's concepts and those of classical physics. The new formulations make the old ones specially simple cases in which certain possible variations have not been utilized and would be wrong only if one pretended to grasp being itself through them. Plane geometry is the geometry of a space where there is a single null dimension, and Euclidean space is a space of n dimensions in which

[55] Gould 1962.

> there are n – 3 null dimensions. Thus the truth of ancient formulations is not an illusion. They are false in what they reject but true in what they affirm. It is possible only ex post to see the anticipation of the explanations to follow.[56]

In this construal, there is a hidden potential in the past conceptualizations which is for us to extract and realize.

Second, the model predicts that as a result of the integration of individual perspectives, an object of now shared attention does not so much change into something else as "thickens," becomes multidimensional and therefore more solid, more real, for everyone.

Essential for this phase is the distinction between me and non-me, where the non-me is nonetheless part of my, and better yet a shared world. Put another way, this is a form of outlook or identity that is constituted in relation to and by contrast with others. In this sense, the fulness of vision purportedly achieved at stage 2 is inherently intersubjective and potentially intersubjectively shared. A sense of interdependence of alternative standpoints and activities leads to an emergence of complex system we may refer to as a society of mind.[57] This kind of system enables complex interactions between people and as such must be contrasted with solipsistic enclosure on the one hand and enmeshment on the other.

Accordingly, the cyclical approach suggests viewing philosophy and science as two independent activities (engagements), which at some point cross paths and enter a mutually corrective and enriching dialogue, thus becoming interdependent.

The model predicts that if all goes well at this stage, one can move on to the next phase, which is generative, reflective, managerial-conservative, and pedagogic. The descending phase is about teaching rather than learning.

The generative phase is where paradigms aka exemplars are strictly speaking produced, for each discipline separately. Blueprints for problem solving emerge in the previous, creative phase, but it is only after the crossing of the turning point that they can become *instituted* in practice and rendered exemplary. Paradigms in this phase are used

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56 Merleau-Ponty 1973, p. 100.

57 Hermans 2016, p. 4.

self-consciously, with an awareness of what they can and cannot achieve. In this light, paradigms are schemas purged of much of the assumptions pertinent to a world view, or ideal out of which they surfaced. For example, Newton's equations are still in use in many branches of physics. They did not become invalidated in the aftermath of relativity–we simply now better understand the perspective from which they appear valid and can more precisely delineate their scope of application.

The hermeneutic turning point also highlights some unresolved issues. Therefore, at the current stage, lifeworlds bifurcate. The now-carefully-elaborated paradigms (the horizontal line going right in Fig. 1) represent an element of stability and continuity, whereas the vertical line leads to a new cycle. What will happen at the turning point of the next cycle, among other things, is that the achievements of this phase will enter a dialogue with new discoveries and, eventually, will get positioned within a new, larger system of reference.

The hermeneutic-critical stage is all about proper timing. The model predicts that if the confrontation happens too soon, or is forced upon individuals or groups, the communication may fall flat as the participants will not be able to see much connection among their respective perspectives or topics. They may in fact think each is dealing with a separate issue, usually accompanied by a conviction that one's preoccupation is more important than another's. The imagery of gravitational centers may help explain this.[58] Two small gravitational fields will for a long while operate independently of one another. As each of them gains in size and momentum in line with their internal logic and rhythm (creative phase), there will come a time when it becomes clear that they are contenders for the same space, i.e., they claim to be solutions to the same problem. What can happen then is either a struggle for dominance or a realization that these are but two perspectives on the same thing, resulting in a reorganization into a higher order system (a format, in Arnheim's words). The longer the confrontation is postponed, the greater the risk of political struggle and an ensuing mandated reorganization, which Kuhn deemed inevitable in the aftermath of change, but which is not inescapable given an appropriate approach.

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[58] Arnheim 1988.

5. Conclusions

As shown above, the cyclical model makes it possible to integrate many opposing insights concerning science, such as creativity versus rule following, direct engagement versus critical reflection, etc., by treating them as phases and stages in a "spiral" process. It entails that each cycle, often over many tribulations, leads to a higher-order dynamic equilibrium.

The cyclical model just sketched out does not entail a strict paradigm–ideal dualism. Rather, it suggests that paradigms emerge out of broad intellectual fields and are instruments of the latter's explication and elaboration. The model predicts that assuming a proper organization of the hermeneutic stage, we get a place when paradigms are set up for future work and ideals are transformed.

The model also points to the fact that although development follows a pattern it also possesses features other than structure, such as tempo and rhythm, which do not easily lend themselves to abstract philosophizing.

The proposed conceptualization designates a place for an ongoing, critical self-reflection. According to the model, the culmination of scientific activity is a moment at which different paths of engagement are brought together into a mutually corrective dialogue. Whatever ensues is expected to balance out continuity (preservation, stability) with discontinuity (openness, novelty). In short, if hermeneutic phase is included in the process, what we get is rationality without universalism.

From the system-dynamic perspective, each system is a product of many vectors, including, but not limited to, past experiences (memory), present concerns, and anticipations concerning the future. What this means is that in relation to every present state, personal and collective history constitutes a perspective to integrate. On this construal, the past, we may say, calls out to the future for its own completion. It does not compel behavior or determine what is about to happen, but rather affects the present by leaving behind questions and delineating a space of possibilities which call for exploration.[59]

As Merleau-Ponty puts it,

> There are two historicities. One is chronic or even derisory, full of misunderstandings, in which each age struggles against the others as against aliens by composing its concerns

[59] Collingwood 1994, p. 60, 230.

> and perspectives upon them. This historicity is forgetfulness rather than memory. It is dismemberment, ignorance, externality. But the other historicity, without which the first would be impossible, is the *interest* which attaches us to what is not ourselves. It is the life which the past in a continuous exchange finds in us and brings to us.[60]

It is in this sense that science could be considered as a part of science itself. New paradigms do not simply emerge out of their predecessors against the will of its representatives. Rather, through application, and given proper organization, different paradigms are bound to jointly reveal a wide net of interdependencies which constitute a dynamic system of knowledge and ethics, a system which accommodates the past and constantly opens itself toward the future.

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[60] Merleau-Ponty 1973, p. 72.

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