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THE PROBLEM OF KUHNIAN RATIONALITY

Rogier De Langhe

“We must therefore ask how conversion is induced and how resisted. What sort of answer to that question may we expect? Just because it is asked about techniques of persuasion, or about argument and counterargument in a situation in which there can be no proof, our question is a new one, demanding a sort of study that has not been previously undertaken.” (Kuhn 1970, 152)

"Choosing a theory for a given purpose is like choosing a woman to be with. For practical reasons, you can't just examine all the women in the world and investigate all their properties to decide which one is the best. You sort of stick to the one you run into if it seems to work for as long as it seems to work." (Diderik Batens, private conversation)

ABSTRACT

According to Thomas Kuhn (1962/1970), science is characterized by two levels, one within and one between paradigms. The problem of Kuhnian rationality concerns the choice between paradigms, for which no rational basis appears to exist because this choice is inevitably circular to some extent. This is the main reason why Kuhn's view is perceived to glorify irrationality. (ibid. 199) I present two interpretations of the problem of Kuhnian rationality, one based on concepts (the neo-positivist interpretation) and one based on values. I also describe two notions of rationality, optimizing and satisficing. Neither interpretation supports the notion of optimizing, but the values-interpretation supports satisficing, suggesting that if Kuhnian scientists are rational, as Kuhn insisted, they are satisficers. An agent-based model demonstrates that aggregating the behaviour of satisficing agents can account for Kuhn's view on the dynamics of scientific change.

1. Introduction

Thomas Kuhn's "Structure of Scientific Revolutions" is believed to be one of the most important books in 20th century philosophy of science. Yet the book has more enemies than friends and even its friends, fellow historicists such as Imre Lakatos and Larry Laudan have almost invariantly tried to change or reformulate Kuhn's view in search of a historically warranted notion of scientific rationality. Lakatos' notion of rationality is based on a research programme's ability to generate novel predictions, while according to Laudan rationality turns around a research tradition's problem solving ability. For Kuhn there is no paradigm-independent set of rules to decide between rival paradigms. Many commentators took the absence of paradigm-independent rules to imply that paradigm choice must necessarily be irrational on Kuhn's account. Still Kuhn himself maintained that paradigm-choice is rational, although he never developed a specific account of rationality. I will call the problem of finding a conception of rationality that is consistent with Kuhn's account the *problem of Kuhnian rationality*.

The last decade has seen very little work on historicist theories of rationality in general (Matheson 2008). This paper renews interest in the topic of historicist rationality and submits that Kuhnian rationality is one of satisficing, not optimizing. I will demonstrate that this new view provides the unique combination of compliance with Kuhn's account whilst remaining a genuine form of rationality. The paper is structured as follows. First I describe why it is commonly assumed that Kuhn's account has no room for a notion of rationality. Secondly I present satisficing as a possible solution and contrast it with optimizing. In the third section I argue that the assumption that Kuhnian scientists are satisficers is consistent with Kuhn's work. This is done by demonstrating that satisficers are able to rationally choose between paradigms and reproduce the typically Kuhnian features of aggregate scientific change.

2. The problem of Kuhnian rationality

The three most important views on rationality are confirmationism, falsificationism and historicism. Confirmationism is most commonly associated with Carnap's work on inductive logic and stands for the view that scientists should accept those theories that are most likely to be true given the available evidence. Falsification is usually associated with Karl Popper and maintains that scientists should try to falsify theories and reject those falsified such that only those that conform with the evidence remain. Both confirmationism and falsificationism were developed as ahistorical theories of scientific rationality. Should they fail to fit actual scientific practice, then so much the worse for the rationality of scientific practice. An opposed view is taken by historicism, which holds that a good theory of rationality must in some ways conform to the history of science. And should history suggest there is no universal criterion for scientific rationality, than so much the worse for philosophy. And such is the conclusion of one of the most prominent and excentric exponents of historicism, Thomas Kuhn.

Even a simple notion of means-ends rationality reveals that rationality in Kuhn's account is problematic. Let's call this notion 'optimizing rationality'. This conception of rationality states that an agent is rational if and only if s/he chooses that option which most efficiently provides the means to reach a given goal. Applied to Kuhn's account this implies that rationality can be situated at two different levels: the level within a paradigm and the level between paradigms. At the level within a paradigm, rationality is not problematic. The paradigm provides the goals for which scientists try to find the means to reach them. However, for Kuhn there is no single, paradigm-independent set of goals to decide between rival paradigms. This lack of a rational basis for paradigm-choice was responsible for the bulk of the charges of irrationality against

Kuhn. If not brought about by the sheer construction of the problem, which appears to leave no possibility for rationality, then surely by the solution suggested by Kuhn himself. According to Kuhn, choice of a paradigm depends on “persuasion” (ibid. 198) and, if successful, results in “conversion” (ibid. 150). This leads Kuhn to assert that "the superiority of one theory to another is something that cannot be proved in the debate. Instead, I have insisted, each party must try, by persuasion, to convert each other." (Kuhn 1970, 198) In the absence of paradigm-neutral criteria for the acceptance of paradigms, social factors seem to be guiding paradigm choice. Choice based on ‘persuasion’ and ‘conversion’ seems to stand very far from a rational choice and indeed, according to Kuhn himself, misconstructions of this view is the main reason for the charges of irrationality against him. (Kuhn 1970, 199) These charges came from scholars such as Dudley Shapere (1966), Israel Sheffler (1967), Karl Popper (1970) and Stephen Toulmin (1970). The interpretation of Kuhn responsible for this criticism is what Gerald Doppelt calls “the neo-positivist interpretation” (Doppelt 1978, 35). This interpretation focuses on paradigms as linguistic entities and thus understands incommensurability as an incommensurability of concepts. Scientists in different paradigms speak a different language and because there are no common concepts at all, translation, communication and rational argument between paradigms is radically impossible. Kuhn calls this interpretation “seriously misconstrued”:

> [T]he proponents of incommensurable theories cannot communicate with each other at all; as a result, in a debate over theory-choice there can be no recourse to *good* reasons; instead theory must be chosen for reasons that are ultimately personal and subjective; some sort of mystical apperception is responsible for the decision actually reached. More than any other parts of the book, the passages on which these misconstructions rest have been responsible for charges of irrationality.(Kuhn 1970, 198-9)

From the very beginning Kuhn has resisted such an interpretation. To contrast his view with the neo-positivist formulation of the problem of Kuhnian rationality, I will call his view the Kuhnian view. His reaction[1] to the neo-positivist formulation of the problem is to reformulate incommensurability not so much as an incommensurability of concepts (taxonomic incommensurability) but an incommensurability of values (methodological incommensurability).[2] Scientists from different paradigms disagree about what the problems are and what counts as a solution. They disagree about the definition and weighting of the values used to evaluate theories. This renders cvommunication "partial"[3], but not impossible. As a consequence the neo-positivist formulation of the problem of Kuhnian rationality, which requires this impossibility, does not hold water.

Kuhn maintained that scientists were rational in coping with this circularity, but he never developed a specific account of rationality. He did formulate intuitions about how a solution might look like, but because these contained words such as 'conversion' and 'persuasion' the neo-positivists allegations of irrationality were only reinforced. On the view of rationality as conversion there are no explicit rules laid out for why scientists accept a paradigm and there is no benchmark for progress, two key aspects of most accounts of rationality. In what sense can this rationality be more than at best a sociological phenomenon? What guarantees does this form of rationality offer that scientists actually

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[1] in the postscript to the second edition of the Structure of Scientific Revolutions (Kuhn 1970)

[2] A detailed version of this interpretation can be found in Doppelt (1978). This notion is called "methodological incommensurability and contrasted with taxonomic incommensurability (see Sankey & Hoyningen-Huene 2001, Carrier 2008).

[3] Kuhn 1970 p. 198

choose a good solution from a set of alternatives? Nearly half a century after the publication of the Structure of Scientific Revolutions, no satisfactory answers have been reached to these questions. (Matheson 2008)

3. Optimizing versus satisficing rationality

The Kuhnian view of the problem of Kuhnian rationality is driven not by the impossibility of communication but by the circularity inherent in choosing between standards for choosing standards. While choice of theories *within* a paradigm is well-circumscribed by the standards implicit in the paradigm, the choice *between* paradigms is always to some extent circular because the standards used to evaluate paradigms are themselves part of the paradigm. At least a part of the set of goals that constitutes paradigm choice is relative to the paradigm itself, making the choice circular.

> [T]he choice [between competing paradigms] is not and cannot be determined merely by the evaluative procedures characteristic of normal science, for these depend in part upon a particular paradigm, and that paradigm is at issue. (Kuhn 1970, 94)

As a result scientists face multiple equivalent standards; a situation optimizing rationality is unable to deal with. The problem is not the incommensurability between the alternatives. In economics agents are perfectly able to deal with incommensurable alternatives (e.g. labor and leisure) through the use of the utility function which describes the value of one alternative in terms of the other. The catch here is that the problem of choice is not between two alternatives but between two utility functions. It is the paradigm itself that determines the utility function. As a consequence, within a paradigm maximizing is possible but between paradigms the solution cannot be to maximize the utility function because what is the utility function is exactly what is at issue. This perspective makes it very clear that the problem of Kuhnian rationality is not prompted by incommensurability (as the neo-postivist interpretation would have it) but by the inherent circularity in finding standards to judge standards.

Hence the problem of Kuhnian rationality is prompted by the failure of optimizing rationality to deal with the problem of paradigm choice. Optimizing rationality simply cannot manage multiple equivalent alternatives. Since most known conceptions of rationality are variants of this basic form of rationality, most forms of rationality do not qualify as a candidate for Kuhnian rationality. But not all. In the 1950's the economist Herbert Simon conceptualized an alternative form of rationality in which agents do not optimize but satisfice. This kind of rationality is based on satisficing a goal rather than optimizing it.[4] Simon (2008) explicitly notes that satisficing offers a rational solution to problems of choice that involve incommensurable alternatives. And that is what the problem of paradigm choice is. In the remainder of this paper I will develop the insight that Kuhnian scientists are satisficers. In this section satisficing rationality is introduced and contrasted with optimizing rationality. The next section then investigates whether satisficing agents are able to create Kuhnian aggregate patterns such as revolutions and normal science.

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[4] The term was introduced by Simon in his 1956 paper 'Rational Choice and the Structure of the Environment'. See Simon (1976) for a detailed discussion of the origins of optimizing and satisficing rationality.

The optimal rational choice is that choice which is intrinsically the best one given a goal and a set of constraints. The object of optimizing rationality is the decision itself. Optimizing rationality aims to find that alternative, choice or solution which is *intrinsically* the best. On the other hand, the object of satisficing rationality is to reach a certain threshold. The rationality of the decision does not depend on the intrinsic quality of the outcome but on whether or not a certain purpose is fulfilled.

Why is satisficing rationality überhaupt rational? There are two main arguments, one pragmatic and the other fundamental. The first is a consequence of taking transaction costs into account. Once a satisfactory solution has been reached, looking for an even better solution might not be worth the effort given the additional search costs involved. Under this argument satisficing is simply optimizing by taking into account the cost of search. A rational agent should then search until the marginal expected return from searching equal the marginal costs of searching. However, the cost of determining the search cost is itself unknown and potentially substantial. This prompts the very same problem again, triggering a potentially endless line of computations. (Simon 1955) Satisficing, on the other hand, relieves rational agents from these computational burdens. The contrast between both notions of rationality can be made intuitive by considering the problem of finding a sharp needle in a haystack"(Simon 2008). An optimizer would try to find the sharpest needle in a haystack. The effort required then depends on the size of the haystack because the entire haystack must be searched before one can be sure that whatever needle one has is the sharpest. A satisficer, on the other hand, tries to find a needle sharp enough for a given purpose. Interestingly, the effort required does not depend on the absolute size of the haystack (the complexity of the problem) but on the density of needles that have are at least sharp enough for the purpose at hand. Most importantly, the amount of effort required is independent of the size of the haystack. The second argument for satisficing is what Jon Elster (1983, 75) calls “the general argument for satisficing”. Any means-ends rationality (cf. what I called 'optimizing rationality' above) presupposes a fixed framework of means and ends within which optimization occurs. But choice of these frameworks can itself not be the result of a maximizing means-ends decision, because this would presuppose such a framework at a higher level. This leads to an infinite regress that can only be stopped by satisficing. (Winter 1964, 262) The infinite regress is only stopped by being satisfied with a framework that works satisfactorily, irrespective of its being the best possible framework. Analogously paradigms offer such a framework for scientific research and the infinite regress caused by frameworks to assess other frameworks is the same as the circularity noted by Kuhn to describe the problem of Kuhnian rationality. (cf. Kuhn 1970, 94)

In sum, satisificing is an alternative to maximizing means-ends rationality that is designed to operate under the conditions that led commentators of Kuhn to allegations of irrationality. Satisficing provides decision makers with a rational course of action in the face of equivalent options, as is the case in the problem of Kuhnian rationality. As a consequence, satisficing rationality offers a potential solution to the problem of Kuhnian rationality. The fact that agents satisfice when confronted with incommensurable alternatives has moreover been experimentally established (see Simon 1976, 145 for a list of studies).

4. Kuhnian scientists are satisficers

To conclude my argument that Kuhnian scientists are satisficers as far as paradigm-choice is concerned I must demonstrate that an account of satisficing rationality is consistent with Kuhn's treatment of aggregate patterns of scientific change involving normal science and revolutions. I will focus on two particularly pressing questions: 1) is the idea of shared thresholds across paradigms consistent with incommensurability? and 2) is the individual behaviour of satisficing agents consistent with the aggregate patterns of scientific change (normal science, crisis, revolution) Kuhn describes?

(1) I have argued that scientists choose between paradigms by selecting the first alternative that satisfies certain minimal thresholds. This requires Kuhn to grant that scientists across paradigms share the minimal thresholds that need to be satisfied. On the neo-positivist interpretation (cf. section 1) such thresholds are impossible because incommensurability is radical. As indicated in section 1, Kuhn defended himself against this interpretation by emphasizing incommensurability not of concepts but of values. On this interpretation incommensurability is not absolute but merely partial (Kuhn 1970, 198). This must be something other than a conception of what the problem is and what counts as a solution, because these are relative to the paradigm. In a later paper, Kuhn (1977) gives an account of these shared values: accuracy, consistency, scope, simplicity and fruitfulness. Different paradigms share these values but differ on their weight and interpretation. Weight and interpretation cannot be made fully explicit (tacit knowledge) but can be communicated through practical examples of what counts as a representative work in the paradigm: exemplars. These exemplars do not define but embody the weight and interpretation given to the values. Kuhn writes that "[examplars] are the vehicles for the transmission of criteria of choice." (Kuhn 1977, 327) Whether or not a new solution for a puzzle is successful depends on the similarity it bears to the exemplars. (Kuhn 1970, 45).

An exemplar is selected because it conceptualizes and answers a shared need. This need stands outside any paradigm and therefore provides a basis for rational choice. For example different paradigms not only gave different explanations but also different problem statements of the economic crisis of 1929-1932. Nevertheless they responded from a shared need to gain knowledge about this phenomenon. In 1936 John

Maynard Keynes wrote "The General Theory of Employment, Interest and Money" which was the first exemplar to satisfy the need produced by the phenomenon of the crisis. As a consequence the economics profession largely turned Keynesian, until the Keynesian paradigm became unsatisfactory in the 1970's because the needs changed. Keynesianism could not explain stagflation and Keynesian policy recommendations failed. As a consequence the number of economists adopting the Keynesian paradigm rapidly declined. In short, which thresholds are satisfactory is ultimately determined by praxis. In other words, what is shared is a common praxis. Although the puzzles and solutions (paradigms) are incommensurable, the pre-theoretical phenomenon that prompts the construction of paradigms is not.

The emphasis on praxis as the basis for rational choice between incommensurable alternatives is the same in the case of satisficing. Also in satisficing, the thresholds are dictated by practical needs.[5] The minimal sharpness of the needle is determined by the requirements of the purpose at hand. As such for Kuhn to remain rational he must accept that although paradigms are incommensurable to a large extent, a pre-theoretical need is required as a shared basis for competition between paradigms. The alternative is that Kuhn's claims to the rationality of his account are unsupportable.

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[5] The mechanism responsible for the emergence of these standards falls outside the scope of this paper because the problem of how to choose between paradigms already presupposes that multiple paradigms exist. However, on this matter Simon writes: *"Psychology proposes the mechanism of aspiration levels: if it turns out to be very easy to find alternatives that meet the criteria, the standards are gradually raised; if search continues for a long while without finding satisfactory alternatives, the standards are gradually lowered. Thus, by a kind of feedback mechanism, or 'tâtonnement', the decision maker converges toward a set of criteria that are attainable, but not without effort."* (Simon 2008, 244)

One might object that this account does not capture radical value incommensurability. Paradigms, so the argument could go, determine what the problems are and what counts as a solution. Scientists in different paradigms will therefore have different purposes and as such no shared basis for paradigm choice after all. My response is that there is a shared *need* which precedes the problem statement (for example the need to not get lost at sea and die, the need to understand why prices fluctuate in markets, etc.). In light of this shared need it makes sense to call certain paradigms "rivals". Subsequently a paradigm is adopted from the moment one goes on to conceptualise this need and consequently which kind of solution is adequate. Abstract though this may sound, think of the analogy with technological standards. Different technological standards can also exhibit radical value incommensurability. For example breeders of horses and car manufacturers conceptualise their problems in very different ways. The breeder works on improving his selection skills and aims at delivering horses that have high stamina and are gentle in character. The car manufacturer worries about how to keep the combustion engine from exploding and how to convert the engine's power as efficiently as possible in forward momentum. The value of stamina is weighed differently for horses (how long can it run until it needs a break) and cars (cars don't need breaks but do need to get to the next gas station) and the value of gentleness does not apply to cars because machines have no character. Thus these alternatives are radically incommensurable. Nevertheless they both address a common need, mobility. Before cars existed it might have been inconceivable to express one's need for mobility in terms that apply to cars[6], but nevertheless consumers' underlying need allowed them to choose between the two.

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[6] Henry Ford famously declared that if he would have asked people what to produce they would have replied "A faster horse!"

2) Kuhn's account largely treats aggregate patterns of scientific change (normal science, crisis, revolution), while I have so far treated individual scientist's problem of choice. To show that satisficing is consistent with Kuhn's account, I must demonstrate that the interaction of a population of satisficing agents can indeed create the aggregate patterns described by Kuhn. This is possible by making use of an agent-based model. An agent-based model is a computational model for simulating the interaction of autonomous agents to observe the behaviour of the aggregate system. Starting from a decision function for every satisficing agent, the aggregate dynamics of their behaviour can be simulated. To conclude that satisficing rationality is consistent with Kuhn I must show that Kuhnian patterns of scientific change can emerge from the actions of satisficing agents.

I start by constructing a decision function for procedurally rational agents. Before giving its formal form, I introduce it intuitively using the analogy of a needle in a haystack. If one tries to find the sharpest needle in a haystack, the effort required rises linearly with the size of the haystack. On the other hand, if one tries to find a needle sharp enough for a given purpose, the effort required depends on the density of needless that have a certain minimal sharpness. Most importantly, the amount of effort required is independent of the size of the haystack. I now transfer this situation to science. A scientist entering a field must decide which paradigm to invest in (learn the status questionis, the preferred methods, acquaint the members,…). Ideally he would first gain knowledge of all paradigms and then optimize. However, this is circular because gaining knowledge of a paradigm is a very large investment and as such leads right back to the initial problem of which paradigm to invest in. Notice the similarity of this situation to Elster's general argument for satisficing: to choose substantively rational requires a framework, but the choice of frameworks can never be substantively rational because this leads to an infinite regress. Consequently we assume that scientific agent's satisfice with respect to which paradigm to adopt. Since every paradigm is satisfactory against its own criteria, satisficing agents can be modelled as adopting the first paradigm they encounter. This is most likely to be the paradigm adopted by the research group where they were graduate students. Of course there will be exceptions, but as long as the exceptions are normally distributed, the exceptions neutralize each other. In fact this very decision rule has been used in network economics to successfully describe the behaviour of agents deciding which technological standard (e.g. VHS vs. Betamax, Microsoft vs. Apple) to adopt (cf. Arthur 1994). The result of this decision rule is that the number of adopters of a certain paradigm p at time t will be proportional to the number of adopters of paradigm p at t-1. In other words, the probability of a scientist adopting a paradigm depends on the share of that paradigm in the discipline. The more scientists already adopt it, the higher the probability that they will 'convert' you. As such your probability of conversion to a certain paradigm depends on the density of that paradigm in the discipline. Note the analogy with the needle and the haystack, where satisficing depended on the density of satisfactory needles in the haystack.

An investment in a paradigm means producing one piece of work that adopts the standard of that paradigm. Each agent makes one contribution to one paradigm at every turn. Thus the decision function represents how an agent deals with the problem of paradigm choice. Formally the decision function for any procedurally rational agent in a discipline consisting of multiple paradigms can then be written as follows:

$$\pi_n(t)=p_n+c\,\hat{E}(t)$$

For every agent, the probability at time *t* of choosing paradigm *n* is the sum of a function consisting of two parts, one determined by the agent and one determined by the structure respectively. The first part, p_n, represents the agent's intrinsic preference for a paradigm. One possible interpretation of this part of the decision function is that it reflects the intrinsic quality of the paradigm. The second part of the decision function, $\hat{E}(t)$, represents the market share of the paradigm. The weight of this second part can be adjusted by changing the value of the c-parameter. The interaction of the agent's intrinsic preference and the structure of the discipline results in a probability distribution across the different paradigms. The resulting model has been described and explored elsewhere in more detail (cf. De Langhe 2010, De Langhe & Greiff 2010). For the purposes of this paper it suffices to note that the properties of the resulting aggregate dynamics of a community of agents using this decision function does indeed capture key features of the dynamics of scientific change described by Thomas Kuhn.

The main driver of the model and thus of the process of scientific activity which it represents is its own previous states. The model is, in other words, *path dependent*. The agents in the model, scientists, are more likely to adopt a certain paradigm simply because they did so previously. Although at first sight perhaps counterintuitive, the reasons for this strategy are analogous to the reasons cited in the abovementioned literature on the adoption of technological standards:

1) the paradigm becomes better developed with every scientist deciding to adopt it. The paradigm is better articulated and made more responsive to empirical data, better arguments are devised, more experiments are conducted,... (*learning effects*);
2) the different contributions made to the paradigm reinforce each others' value (*scale effects*);
3) the marginal cost of developing the paradigm decreases with the number of adopters[7] (*network externalities*).

[7] Decreasing marginal costs with adoption (and as a consequence increasing marginal returns) are a typical feature of information and network industries. Typically a large initial investment is made (e.g. writing an analyst report of a stock market listed company, writing the code of the Windows operating platform) but its distribution carries a very low cost (copying/emailing the report,

The notion of path depence can account for a surprisingly large number of aspects of the dynamics of science as described in the Structure of Scientific Revolutions.

- Path dependence means initial choices to adopt to one paradigm or the other are reinforced through time. If path dependence is strong enough, this can lead to virtuous circles. In market terms this means that the market exhibits a monopolistic tendency which typically results in a winner-take-all market (cf. Microsoft). This explains Kuhn's insistence that only a single paradigm becomes dominant at a time and the persistence of this period of "normal science" even after it seems to have lost its support (inertia). Conversely path dependence can also account for vicious circles, explaining why the resulting dynamics is not gradual but characterised by sometimes violent and unexpected discontinuities ('crisis' and 'revolution').
- Path dependence introduces time as a variable in the model. The framework ceases to be ahistorical because previous states of the system now matter. The importance of previous states of the system to understand its current state captures Kuhn's interest in

pressing discs), resulting in decreasing marginal costs. Due to decreasing marginal costs there is no optimal number of adopters (the more the better). This contrasts with traditional economic industries. For example car manufacturers face a significant cost with each new car produced and typically have an optimal number of adopters smaller than the maximum. As a consequence the parts of the economy that exhibit this feature have significantly different characteristics. For example Microsoft has a tendency toward monopoly while car manufacturers do not. (See Arthur 1994, De Langhe 2010 and De Langhe & Greiff 2010 for more on this argument and its relation to the division of labor in science).

the history of science, in contrast to the ahistorical approach of his logical empiricist precursors.

- Because previous states of the system, however accidental they may have been at first, are reinforced through time, small events potentially have large consequences.[8] The model's dynamics is in other words *non-ergodic*. This captures Kuhn’s insistence that small events such as idiosynchratic personal factors and accidents of history are relevant for scientific change.
- In the model the strength of path dependence is weighted by the c-parameter. Simulations with different values for c revealed that as c increases there is more variance in cluster size. Intuitively this means that there are more vicious and virtuous circles. It is reasonable to assume that different disciplines in science are characterised by different values for c. A reason for a high c-parameter could be that the discipline has a strong reliance on technological equipment, which is expensive to acquire and requires specific skills to operate. Another reason for a high c could be a discipline's reliance on an extensive formal apparatus through which the influence of previous choices decays slower through time, or because it requires a large learning investment. Based on such an interpretation of the c-parameter, the model predicts Kuhnian dynamics (normal science, crisis, revolution) only in technological and/or formal disciplines. This explains Kuhn's insistence that his analysis is only applicable to the "hard" sciences. It also suggests that the reason why certain disciplines belong to the so-called "pre-paradigmatic sciences", is not

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[8] Think of the proverbial butterfly in the rainforest causing a hurricane.

because they have not yet reached a certain maturity (implying normative judgment) but might simply lie with the nature of their subject matter which lends itself more (e.g. biotechnology) or less (art history) to the application of technology or a formal apparatus.

5. Conclusion

For the last fifty years it has not been clear how Thomas Kuhn's 'Structure of Scientific Revolutions' in what sense Kuhnian scientists can rationally choose between paradigms. I argued that most forms of rationality, namely those based on means-ends rationality, are indeed powerless to present a rational solution to the problem of paradigm choice. However, satisficing rationality, a notion of rationality developed by Herbert Simon, was designed specifically to handle the kind of circularity inherent in paradigm choice. Kuhn himself never developed an explicit account of rationality, but an agent-based model of satisficing scientists shows that the notion of satisficing scientists is indeed consistent with Kuhn's account of scientific change. This paper therefore debunks the argument that Kuhn glorifies irrationality and projects that Herbert Simon's account of satisficing can be taken up as an integral part of the Kuhnian account of scientific change.

Ghent University
Tilburg University
Email: Rogier.DeLanghe@Ugent.be

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