Extrascientific uses of physics: the case of nonlinear dynamics and legal theory

Introduction

One task for philosophy of science is examining the implications of scientific research. But philosophers are not the only ones doing this. Literally hundreds of essays are published in academic journals each year purporting to describe the implications of current scientific research for society, art, religion, etc. Among the most popular candidates for these efforts has been the field of nonlinear dynamics popularly known as "chaos theory."

Why should philosophers of science pay attention to these often speculative efforts by our colleagues? I offer three reasons: first, philosophers can offer some needed conceptual clarity. Second, some of the implications explored by our colleagues hold genuine philosophical interest. And finally, the transfer, or attempted transfer, of knowledge from the sciences to other disciplines offers a case study that can illuminate some features of the nature of knowledge. Given the great amount of current interest in issues such as the role of metaphors and specific practices in generating knowledge, the attempts to use chaos theory offer an example worthy of philosophical, and not only sociological, interest.

In what follows, I survey the uses of chaos theory in one particular field: legal theory. After sketching some of the problems and mistakes encountered in these efforts, I outline the possibility of the fruitful use of nonlinear dynamics in thinking about our legal system. I then offer some general remarks about lessons to be drawn from these examples – both cautionary maxims and a limited defense of cross−disciplinary borrowing. I conclude with some reflections on the nature of arguments which seek to establish intellectual authority or epistemic merit by analogical reasoning.

While there are numerous examples of respected scholars drawing analogical conclusions from natural selection (Roe, 1996; Clark 1981) or quantum mechanics (Tribe 1989;Veilleux 1987; Porter 1991), I focus on the rich array of interdisciplinary borrowings that arose from the vogue for chaos theory which peaked in the early nineties. Briefly, chaos theory is study of unpredictable behavior in simple, bounded, deterministic systems. Such behavior is extremely

complicated because it never repeats, and it is unpredictable because of its celebrated sensitivity to initial conditions: even extremely small amounts of vagueness in specifying where the system starts renders one unable to predict where the system will end up. Chaotic behavior occurs only in nonlinear systems, and it is investigated using the mathematical tools that go by the name "dynamical systems theory" or just "dynamics." As a sub−category of nonlinear dynamics, chaos theory gained notoriety for its investigation of patterns, such as "strange attractors" with fractal structure, found within seemingly random data sets.

Metaphorical uses

A large body of philosophical work has addressed the use of metaphor in science (see Ortony 1993), and I will not discuss the technical analysis of scientific metaphor and its role in the application of quantitative techniques. Instead I will examine some of the actual metaphorical uses to which chaos theory has been put. For the purposes of this essay, metaphorical uses will be considered to include similes, analogies, and any other nonliteral employment of nonlinear dynamics as a new conceptual resource. Thus, we are concerned with the borrowing of intellectual resources from nonlinear dynamics (the "source" field) for use in legal theory (the "target" field). As detailed below, these resources can be divided into three rough categories: illustrations, methods, and results.

Metaphorical uses begin by transferring concepts or images from the source to the target field. In some cases, these concepts and images from the source field are used to illuminate, illustrate, or motivate a new way of thinking about the target field. This kind of use of physics can claim a long heritage in American legal thought, from the framers of the Constitution who conceived of it as a Newtonian machine with counterbalancing forces (Tribe, 3) to Justice Benjamin Cardozo who employed the concepts of relativity and quantum physics "as a literary device to symbolize and make vivid the relations among people, social institutions, and legal rules and concepts" (Veilleux, 1978). In these cases the analogy is meant to be merely suggestive, while in the uses described below it takes on argumentative force.

A second class of metaphorical uses translates modes of inquiry from the source to the

target field. In the case of more quantitative fields such as economics, this can mean the application of actual computational techniques. In disciplines such as legal theory, the translations involve more general methodological precepts, for example: Legal reasoning need not derive predictions from exact principles, just as chaos theory provides understanding without predictions from exact laws (Scott, 348−9). In making such arguments, scholars may take issue with the conception of scientific methodology that has informed current thinking about how legal studies ought to be conducted, as in Glen Harlan Reynolds' criticism of the neo−positivism of the "Law and Economics" movement (Reynolds 112−113). Or they may propose a new mode of legal inquiry, for instance an investigation of the changing forms of competitive economic behavior rather than a focus on the best regulatory techniques for production of equilibrium states (Wise, 760, 776) In all such cases, the reasoning takes the form: the target field is like the source field in certain relevant respects, therefore methods of inquiry which succeed (or fail) in the source field can be hypothesized to succeed (or fail) in the target field. Thus, methodological injunctions, warnings, or comforts issue from the metaphorical translation involved.

The third type of metaphorical use takes off from a result that scientific investigation has established as reliable (or claimed to be reliable). Robert Scott provides a contemporary example when he suggests that the pattern of legal decisions handed down by the courts is like a strange attractor, in that the tension between the need for present justice in a particular case and the need for future justice in similar cases generates dynamic swings between the two poles of the "Justice Paradox." The history of such shifts, he claims, "is like the infinitely recurring patterns produced by a swinging pendulum. The patterns are not identical, but are different in scale or size. So, too, the recurring patterns of contemporary legal thought are not simply the recycling of new ideas, not merely the pouring of old wine into new casks. They are like fractals. Each pattern is similar to the past, but different in scale" (Scott 350). This illustrative use is meant to motivate a conclusion based on the results of the science. The pattern of reasoning here is: the target entity is analogous to this source concept; the source concept has a certain property; so the target entity can be hypothesized to have this property as well.

Some Dangers

While many metaphorical uses of chaos theory go disastrously awry, this should not occasion a blanket dismissal of all such work, or the assertion of proprietary and exclusive rights to speak about science. Before engaging in a limited defense of metaphorical uses, it will be helpful to investigate three major types of problems: mistakes about the source field, overly flexible use of scientific terminology, and erroneous inferences from scientific to non−scientific areas of inquiry.

Many specific errors enter the metaphorical discussions of chaos theory due to an over−reliance on popular accounts of the science. Beyond the danger of factual error, there is also the problem of occasionally over−enthusiastic bursts of revolutionary zeal that lead the promoters of a new chaos "paradigm" to declare that it has done away with "Newtonian" perspectives or "Euclidean" laws (Brion 183; Cunningham 590−1).

Surely some attention must be paid to the details of the science, and we should examine what impact a mistake about the source field has for a metaphorical application to the target field. Returning to the example of Robert E. Scott, we find that he suggests "we should look to Chaos Theory as a metaphor for the way to think about the contradictions and the tensions inherent in the legal system. At the initial level, Chaos Theory tells us to accept the contradictions, the disorder, in our legal system. All systems, including the legal system, are unpredictable and erratic" (348). However one feels about the advisability of accepting disorder, Scott's argument suffers because he bases his argument on a mistaken premise. He claims that the first lesson dynamics is that "all systems are chaotic, in the sense that they are subject to irregularities that make predictions of outcomes in particular cases impossible . . . . The butterfly effect teaches us that small differences in initial variables will always produce dramatic variations in final outcomes. By explicitly applying this to law, it becomes clear that even slight differences in the facts of cases result in wildly disparate judicial outcomes. In both instances, disorder is inevitable" (348). But it is simply not true that all systems are subject to the butterfly effect; despite the enthusiasm of some popularizers, sensitivity to initial conditions is merely

widespread, not universal. Furthermore, as Royce de R. Barondes has pointed out, Scott mistakes the indeterminacy of legal decision−making for sensitivity to initial conditions: the fact that judges may issue different results in identical circumstances actually presents a strong disanalogy with the strict determinism of chaotic systems (Barondes 172).

Scott goes on to claim that his initial point reinforces the lessons taught us by Critical Legal Studies, such as Grant Gilmore's rather fatalistic conclusion: "Man's fate will forever elude the attempts of his intellect to understand it. The accidental variables which hedge us about effectively screen the future from out view. The quest for the laws which will explain the riddle of human behavior leads us not toward truth but toward the illusion of certainty, which is our curse" (Gilmore 100). This conclusion rests upon our inability to ever find the laws underlying human behavior, but a better use of chaos theory would actually reinforce Gilmore's point more strongly, saying even if we do find those laws we still won't be able to predict. We once thought that finding the laws governing a physical system made it predictable. On a former analogy, we thought finding the laws governing human behavior would make human behavior predictable. Since chaos theory has shown that laws do not yield predictability in the physical world, the metaphor would be even stronger if the author more accurately understood chaos theory.

A second source of problems is the misapplication of terminology from the physical sciences. This danger plays about the terms "determinism" and "determinacy," and their contraries, in legal thought. Hayes conflates the indeterminate lack of an endpoint with indeterminism, while Porter makes it clear that the debates around Critical Legal Studies are rife with the conflation of these concepts (Hayes 768; Porter 1573). But perhaps the greatest abuse of terminological flexibility afflicts the term "chaos" itself. Many writers, hoping to connect their insights about the law to nonlinear dynamics, rush to claim that a particular type of behavior is chaotic. Jason Scott Johnston constructs a detailed and convincing dynamical model of unpredictable oscillations between bright−line rules and balancing standards in torts decision−making, but not all unpredictable oscillations are chaotic (362). Mark J. Roe presents a number of powerful examples of path−dependence in the evolution of legal forms, but his point is really

that historical contingency can lead to one of several stable final states (642−4). While this illustrates a form of instability, it is not chaos, either. Michael O. Wise seems to conflate chaos theory with the study of any indeterministic, nonconservative, or nonequilibrium system, which may be too broad a class of systems to support any robust metaphorical invocation of chaos (742, 748).

The metaphorical transition from one field to another carries yet another danger: in addition to grabbing the wrong end of the stick, one may also use the right stick in the wrong way. The conclusions drawn from some metaphorical extensions sometimes reach past the details of a particular field of inquiry and attempt to resolve substantive ethical or political issues. Scott, for example, goes on to make a further argument based upon the supposed fact that "Chaos Theorists have also come to the conclusion that chaotic (or nonlinear) processes are −− because of their unpredictability −− more stable than those in equilibrium (linear processes)" (349, citing Gleick 48 but Gleick says no such thing). From here, he suggests that "The phenomenon of patterns formed by unpredictable and irregular human behaviors is reality that should give us comfort in accepting the inevitability of paradox in law. Do not despair because law has fundamental contradictions. It is the very tension whose resolution we seek that keeps our legal system in a dynamic state of continuous renewal and repair. It is the dynamic of the Justice Paradox that keeps our legal system alive" (350). Since the patterns of legal decisions swing between the poles of the paradox, Scott claims that the law is not a linear process and "this nonlinearity, or chaos, is, as the new breed of scientists has observed, healthy" (350−1). This argument that illustrates a number of problems: the author has been misled by reliance on a popularization; he stretches the meaning of the term "linear" to the breaking point; and he makes a rapid and unjustified leap from "is" to "ought." On this last point, Scott himself notes "I realize that this assertion places me in a situation somewhat akin to the 'naturalistic fallacy' committed by the Legal Realists, see supra notes 63−4 and accompanying text. However, . . ." (351. Ellipses in original).

One may wonder why it is worthwhile to spend time on arguments as bad as the ones put forward by Scott. Indeed, they seem valuable only as negative exemplars. Yet his article

spends17 pages carefully tracing out swings in legal metatheory, between the demands of "present" and "future" justice, followed by only 3 pages of speculations on chaos theory. Ultimately, the illustrative use of the chaos metaphor is primary here: the physical sciences are being called upon to provide an illuminating image that can motivate a change in attitude. For if physics is comfortable with unpredictable fluctuations, then perhaps legal theory can relax a bit as well. Scott seems to want to make a methodological shift psychologically palatable to his colleagues, and for this purpose the scientific details matter less.

Generally, an immediate use of scientific facts to ground evaluative judgments commits the naturalistic fallacy. But this does not mean that factual discoveries have no bearing on evaluative decision−making, as attested to by the substantial body of work on moral naturalism. Conceptions of the good life or of moral rightness find themselves constrained by limitations on what types of behavior are possible and what kinds of knowledge are achievable. So attempts to use scientific results to support normative prescriptions should not be ruled out of bounds in general.

Defense of cross−disciplinary metaphor

While it is certainly important to "get the science right," an exclusive focus on technical accuracy or literalism runs the risk of foreclosing the very possibility of promising insights. Although some claims based on analogies with physics are clearly overblown or simply mistaken, some writers such as Laurence Tribe have cautiously framed their work as exploratory:

> "...my conjecture is that the metaphors and intuitions that guide physicists can enrich our comprehension of social and legal issues. I borrow metaphors from physics tentatively; my purpose is to explore the heuristic ramifications for the law; my criterion of appraisal is whether the concepts we might draw from physics promote illuminating questions and directions." (2)

In criticizing Tribe, Scott, and others who have employed chaos theory in legal scholarship, Royce de R. Barondes sometimes implies that reliance on metaphor is always inadequate and must be secondary to quantitative analysis. For example, he complains that

“The core of Dean Scott’s analysis relies on metaphor. The discussion does not reduce the analyzed environment to quantitative terms and apply an analysis to those terms; it does not even specify the variables being considered” (164) and goes on to assert “the limitation in that discussion to drawing metaphorical links and avoiding a complete quantitative specification permits his discussion to conceal its flaws” (173). But surely metaphor is sometimes appropriate and illuminating, as Tribe suggests. Metaphor can do more than obscure, and quantitative analysis is sometimes inappropriate and obfuscatory itself. Indeed, Barondes goes on to say that “in the absence of plausible corresponding assumptions and a reduction to useful conclusions, the metaphor provides solely an interesting line of thought to be pursued, the support for whose conclusions remains to be proved,” but that is all Tribe claimed for it in the first place (174). Barondes even allows that Tribe’s metaphorical use of general relativity way “may raise productive lines of constitutional analysis” and may have been raised by his exposure to physics, so it is all the more puzzling why metaphor is treated so dismissively elsewhere in his essay (176).

The mere fact that metaphorical interpretations of chaos theory fail to engage in rigorous quantitative analysis, or that they use scientific terminology in nonstandard ways, cannot serve as serious criticisms. Any attempt to portray such uses as simply misunderstandings of the science or dismissable speculation rules out the possibility of acknowledging that the results of a physical science can inform our thinking in the humanities or social sciences, including legal theory. Yet such connections are not meaningless or mistaken simply because metaphorical −− it is one of the main theses of this essay that such comparisons can be significantly made and criticized and defended. Indeed, to condemn anything but literal use as unacceptable "misuse" would not clarify our language and eliminate muddle−headed mistakes. It would instead render communication impossible (Davidson 1984).

Interdisciplinary borrowings present not only the bare possibility of fruitful metaphorical uses of chaos, but can make a genuine contribution to jurisprudential discourse by suggesting a way beyond the fruitless conflict between conservative legal scholars and the radical school of thought known as Critical Legal Studies (CLS). Chaos theory seems a likely candidate for entry

into the jurisprudential debates of recent decades precisely because they centered on issues of predictability and determinism (or, as it is frequently called, “determinacy”). On one side, partisans of the “Law and Economics” movement insist on the importance of predictable judicial outcomes. For example, Judge Posner believes that the goal of legal studies is “to make precise, objective, and systematic observations of how the legal system operates in fact and to discover and explain the recurrent patterns in the observations −− the ‘laws’ of the system” (Posner 437). Allied conservative legal scholars take up the same note, as in Robert Bork’s constitutional jurisprudence which Reynolds describes as demanding “a powerful predictive ability as the test of legitimacy for constitutional theory” (113). The contrary position is represented in the writings of the CLS movement, which holds that legal principles do not and cannot yield strictly predictable results (see, for example, Gabel & Kennedy 1984, Singer 1984). From the CLS perspective, legal decision−making is so fraught with biases in the service of existing power structures that it eventuates in random and indeterministic results whose only pattern is that the rich get richer.

Into this fray steps Glenn Harlan Reynolds, who suggests that in surveying the patterns of decisions made by the Supreme Court, for example, chaos theory can help us to steer between the twin perils or rigidity and nihilism: “Despite this unpredictability, the actions of the Supreme Court are not random. Just as there is structure within chaos, so there is pattern of sorts within the actions of the Court −− pattern that itself reflects recursion and sensitivity to initial conditions, and that exists on both large and small scales” (114). While allowing that the Court isn’t actually “chaotic” in the same strict sense as a physical system, Reynolds argues that chaos theory nonetheless calls into question the idea that the prediction of particular cases should be a goal of legal studies (116). In this, he draws a powerful analogy from the methodological lesson of nonlinear dynamics that exact quantitative prediction is not always possible, so that science can learn much from attending to larger−scale patterns and underlying order. If even physics need not obey Posner’s methodological strictures, why should legal studies? (for a similar point about history, see Dyke 1990).

Hayes also defends the integrity of legal rules against the all−out assault of those who

insist on legal indeterminacy, but he rests his defense of legal principles on the image of the fractal, which he sees as a genuine boundary that is nonetheless not a straight line (766). Brion seems to be making a similar point when he defends the autonomy of law from the CLS camp's claims that judges are simply tools of the powerful: "By analogizing to chaos theory as a means of description, we can see that structure is not the necessary condition of integrity; a disordered surface of legal doctrine does not thereby entail a law incapable of constraining what people do in seeking to achieve justice" (199). But his argument suffers from a confusion of the chaotic with the merely disordered. Overall, the force of Reynold's argument is strongest because the analogy make substantive contact with the methodological issues of predictability and orderliness, even if the use of chaos theory is not strictly necessary in order to see past a stale opposition in legal theory.

Metaphorical uses are especially useful as an "antidote" to a previous importation from science. This function can occur at two levels. First, a metaphorical translation from the source field can serve to defamiliarize stagnant assumptions that were originally posited on the basis of earlier such importation. As Tribe describes it, our vocabulary has lagged behind our evolved understandings, so our questions and answers are still expressed in a way that does not reflect our new perceptions. Therefore, "interdisciplinary comparison brings greater awareness of preconception, and it is the unearthing of such tacit knowledge that often creates the possibility of choice and intellectual progress" (3). Reynolds points out that even if these metaphorical explorations do not help us learn new and interesting things about the law, they can at least help clear away old ideas about scientific methodology and free us from models that have been abandoned by physicists themselves (116−70).

This defamiliarization can open up the possibility of new models or, as Wise puts it, new values: "the system of scientific ideas the law has borrowed does not model reality realistically and does not represent well values that legal institutions have found it important to vindicate. The system's greatest strength is its familiarity. The very familiarity will make it more difficult to change" (771). For Wise, defamiliarization is the first step towards a more substantive antidote function: the replacement of outmoded models in the target field. Following the work

of Philip Mirowski, he traces the importation of conceptions of atomistic individuals and equilibrium−seeking systems into economics from Nineteenth−century physics, and he goes on to lament the importation of these independent rational maximizers into legal thinking (727−730; Mirowski 1989). The chain of importations carries a risk: the target field can be stuck with a sclerotized conceptual framework insulated by the leftover authority of a now−debunked view: "Economics' deliberate emulation of physics closely paralleled law's borrowing of economic, each claiming the prestige of someone else's ideas. Justification by authoritative analogy breaks down when the source of the borrowed ideas changes its mind" (730. See also Hayes, 765). In this way, a new use of physics both "unfreezes" the older usage and proposes a new direction. Metaphorical extension can be misused, sometimes grievously. But it also has a respectable use when reconceptions of the physical world can lead us to rethink our picture of the social world.

Concluding Epistemological Remarks

One striking fact must be mentioned: law reviews are edited by law students. Furthermore, there is some indication that law review articles simply do not serve the same purpose as essays in the journals in other disciplines. Such articles serve better as guides to the literature on a certain subject than arguments for substantive points of legal theory. In this context, chaos theory can serve the rhetorical function of invoking the intellectual authority of the physical sciences. To subject such an article to a rigorous criticism of the argument presented may in fact simply miss the point. Without seeking to perpetuate the ancient quarrel of rhetoric and philosophy, I will focus in these concluding remarks on the question of which uses of science ought to persuade, rather than on the question of which uses do in fact persuade.

The problems encountered by metaphorical uses bring to mind the distinction between the contexts of discovery and justification. Does the use of chaos theory takes place solely within the context of discovery and thus have historical and psychological interest but no epistemic import within the context of justification? Recent challenges to this distinction have argued that the processes of discovery are not separate from justificatory practices (see, for example, the essays in Nickles, ed. 1980). In some cases, appeals to and connections with other

disciplines carries weight −− not only borrowed intellectual authority (a sociological factor) but the appeal of coherence between theories (a widely recognized epistemic virtue). While metaphorical extensions perforce cannot claim strict coherence with the statements of other theories, they promise broad coherence of intellectual frameworks.

More generally, the structure of such analogical arguments is as follows:

I. In source field S, result r holds good (or c is a useful concept, or use method m)

II. Target field T is like S in the following relevant ways . . .

III. r* is analogous to r (c* to c, m* to m) in T

Therefore,

IV. In T, the analog r* holds good (c* is a useful concept; do m*)

Now, the conclusion certainly isn't firmly established by this argument, but neither is such an argument completely without force. Some epistemic merit does indeed accrue to r* (c*, m*) because of I, II, and III. For while no two fields are exactly alike, no two situations are exactly alike, either. The application of a rule to a new situation requires an inductive leap of some kind −− a finding that the new situation is relevantly similar to past situations where the rule applied (Wittgenstein, 1958). We cannot be total skeptics about such leaps because they are what make our practices, including our practices of doubting, possible. So all applications of concepts, methods, and results involves some "carrying across" to a new context, some "meta−phor" to a different situation. To deny out of hand any merit to the above argument would indeed necessitate skepticism about virtually all inductive inference, which in turn would sabotage the practices within the source field itself.

Even if analogical arguments of the type outlined above do not provide anything like a sufficient justification for accepting their conclusion, they nonetheless generate another, more limited, reason for assigning some normative epistemic merit to r*/c*/m*. For such an argument can raise the conclusion to the level of being a promising hypothesis and thus an active candidate within the "context of pursuit." If the sharp line between the "context of discovery" and the

"context of justification" can no longer be maintained, it will not do to simply relegate analogical reasoning to the "merely psychological" realm of non−rational, inspirational noodling that precedes the hard work of actually justifying knowledge claims. Furthermore, between and among moments of discovery and moments of justification is the undertheorized "context of pursuit," wherein competing active possibilities are ranked for their promise and feasibility for further investigation. In this context, elevating a hypothesis to the status of candidate for active pursuit in the target field does indeed counts as the conferral of significant sort of epistemic merit. For these reasons, metaphorical uses of scientific research merit further epistemological investigation.

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