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The Second Essential Tension: On tradition and innovation in interdisciplinary research.

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Abstract: In his analysis of "the essential tension between tradition and innovation" Thomas S. Kuhn focused on the apparent paradox that, on the one hand, normal research is a highly convergent activity based upon a settled consensus, but, on the other hand, the ultimate effect of this tradition-bound work has invariably been to change the tradition. Kuhn argued that, on the one hand, without the possibility of divergent thought, fundamental innovation would be precluded. On the other hand, without a strong emphasis on convergent thought, science would become a mess created by continuous theory changes and scientific progress would again be precluded. On Kuhn's view, both convergent and divergent thought are therefore equally necessary for the progress of science. In this paper, I shall argue that a similar fundamental tension exists between the demands we see for novel insights of an interdisciplinary nature and the need for established intellectual doctrines founded in the classical disciplines. First, I shall revisit Kuhn's analysis of the essential tension between tradition and innovation. Next, I shall argue that the tension inherent in interdisciplinary research between, on the one hand, intellectual independence and critical scrutiny and, on the other hand, epistemic dependence and trust is a complement to Kuhn's essential tension within mono-disciplinary science between convergent and divergent thought.

Key words: Thomas S. Kuhn, paradigm, incommensurability, scientific community, epistemic dependence, interdisciplinarity

In the late 1950s, Thomas Kuhn presented an analysis of what he called "the essential tension between tradition and innovation"; an analysis that later became the core of Kuhn's phase model of scientific development in terms of normal science and revolutions. He focused on the apparent paradox that, on the one hand, normal research is a highly convergent activity based upon a settled consensus, but, on the other hand, the ultimate effect of this tradition-bound work has invariably been to change the tradition. Kuhn's analysis of the essential tension between tradition and innovation as a key mechanism in the development of science was not only a descriptive account of how science had developed through history, it also carried normative implications for the practice of science and science education. Thus, contrary to many of his contemporaries, who wanted to reform science education to be directed towards creativity and open-mindedness, Kuhn stressed that what he called convergent thought was equally important to scientific advance and that an important part of science education therefore had to remain the rigorous training in convergent thought.

Kuhn's focus was on normal science as a convergent activity *within* a particular discipline and how this kind of normal science over time inevitably provokes its own replacement. But what about interdisciplinary research that reaches *across* scientific disciplines? In this paper, I shall argue that a similar fundamental tension exists between the demands we see for novel insights of an interdisciplinary nature and the need for established intellectual doctrines founded in the classical disciplines. A historical expression of this tension can be seen through the fact that there has been an ongoing discourse for decades about interdisciplinarity in science. On the one hand, there are the recurrent demands for more interdisciplinary research to solve the many complex problems that face us in today's society, from the consequences of anthropogenic global warming to the health care epidemic that is the growth of obesity in the Western world. On the other hand is an equally stable insistence by many scientists that interdisciplinary research necessarily needs to rest on solid disciplinary grounds. Therefore, I shall first revisit Kuhn's analysis of the original essential tension between tradition and innovation, and I shall argue that Kuhn's analysis of the diachronic relation between different theoretical stages within the same discipline can be used as a model for an analysis of the synchronic relations between disciplines in contemporary science.

KUHN'S ESSENTIAL TENSION

A central point in Kuhn's phase-model of the development of science is the essential tension implicit in scientific research between the tradition preserving activity of normal science and the tradition-shattering and innovative activity of scientific revolutions. On Kuhn's model of scientific development, normal science is a convergent activity in which "the characteristic problems are almost always repetitions, with minor modifications, of problems that have been undertaken and partially resolved before" (Kuhn, 1959, p. 233). This activity attempts to adjust existing theories and observations in order to bring them into closer and closer agreement, to collect data required for the application and extension of existing theory, or to extend existing theory to areas that it is expected to cover but in which it has not been tried before. The pursuit of this activity is not expected to produce radically new discoveries or fundamental changes in the existing theory. On the contrary, solutions to the scientific problems are expected to be in consonance with the existing theory: "The research scientist is not an innovator but a solver of puzzles, and the puzzles upon which he concentrates are just those which he believes can be both stated and solved within the existing scientific tradition" (Kuhn, 1959, p. 234). A key point in Kuhn's phase model is that this form of normal research activity is immensely effective in solving the problems or puzzles that existing theory defines, and that the confident and continuous use of the accepted theory enables science to move faster and penetrate deeper than if major theory changes were needed all the time. Kuhn provides a simple cost-benefit argument for this claim: As long as a theory is followed faithfully it is clear which problems have been solved and which should be solved for science to progress further. But in contrast, to change theory is to reopen problems that already had been solved, and that will often appear as retrogression. In this respect, the tradition preserving activity of normal science or, as Kuhn also calls it, convergent thought, increases the effectiveness and efficiency with which new scientific problems are solved.

But although convergent thought usually increases the effectiveness and efficiency with which scientific puzzles and problems are solved, science could not lead to fundamental innovations if it were the only mode of doing science. The tradition-bound work of normal science needs a tradition-shattering complement. Again and again the ultimate effect of tradition-bound work is the shattering of this same tradition. Although this tension may seem paradoxical, the paradox is only apparent. As Kuhn argued, it is the stable, focused effort to investigate in detail each question that a paradigm presents which ensures that eventually it will be discovered where the paradigm may run into probems:

> As least for the scientific community as a whole, work within a well-defined and deeply ingrained tradition seems more productive of tradition-shattering novelties than work in which no similarly convergent standards are involved. How can this be so? I think it is because no other sort of work is nearly so well suited to isolate for continuing and concentrated attention those loci of trouble or causes of crises upon whose recognition the most fundamental advances in basic science depend (Kuhn, 1959, p. 234).

This is what Kuhn saw as the fundamental tension between tradition and innovation in scientific research. Without the possibility of divergent thought, fundamental innovation would be precluded. Without a strong emphasis on convergent thought, science would become a mess created by continuous theory changes and scientific progress would again be precluded. This is why, on Kuhn's view, both convergent and divergent thought are equally necessary for the progress of science.

An important aspect of Kuhn's analysis of the essential tension between tradition and innovation is the risk spreading mechanism necessary for maintaining the tension.[1] The distribution of conservative and innovative dispositions among the members of the scientific community ensures a spreading of risk in the scientific community with respect to advancing radical new solutions as well as to conservative preservation of well-established approaches. As Kuhn phrased this risk-spreading argument:

> If all members of a community responded to each anomaly as a source of crisis or embraced each new theory advanced by a colleague, science would cease. If, on the other hand, no one reacted to anomalies or brand-new theories in high-risk ways, there would be few or no revolutions (Kuhn, 1970).

[1] Kuhn's version of this mechanism has been analyzed in detail by Hoyningen-Huene (1992). Further developments on cognitive division of labor can be found in the works of, among others, Kitcher (1990), D'Agostino (2008), and de Langhe (2010; de Langhe & Greiff, 2010). Analyses of concrete cases of distribution of latent differences in the scientific community can be found in Andersen (2009) and the publications of the Andersen-Barker-Chen group (2006).

Hence, the mechanism that upholds Kuhn's essential tension contains both a cognitive and a social component. First, with respect to the cognitive component, the continued action along the same line of thinking ensures that every puzzle is investigated in detail which may, eventually, lead to the recognition that something is wrong with this line of thought. Second, with regard to the social component, in order to be able to uncover when divergent thought is called for, a risk spreading mechanism is needed that can mediate between the unproductive situation of incessant changes and the equally unproductive situation of ruling out change all-together. Therefore, individual scientists need to react differently to anomalies so that for each encountered anomaly, only some start considering alternatives, while others continue working along the traditional lines.

This risk spreading mechanism requires that the normal science consensus is not total but that some latent differences exist and can become manifest. As argued by Hoyningen-Huene (1992, p. 235), "dissent in extraordinary science is thus the manifestation of differences that exist in normal science, but only in latent form".[2] A cornerstone to the essential tension between tradition and innovation is therefore how the cognitive resources are distributed within the scientific community.

Paradigms and Communities

Already in *The Structure of Scientific Revolutions* Thomas Kuhn had been interested in the relation between a scientific community and the conceptual structures that the members of this community hold. But in the Postscript to the second edition of *Structure* Kuhn saw a circularity in the way he had introduced scientific communities and the various cognitive elements that he at that point still referred to with the overarching concept of paradigms, namely that "a paradigm is what the members of a scientific community share, *and*, conversely, a scientific community consists of men who share a paradigm" (Kuhn, 1970, p. 176). Later, after Kuhn had taken his cognitive turn, he argued that what the members of a scientific community share is the *general structure* of the scientific lexicon. On the new definition a scientific community is

> a community of intercommunicating specialists, a unit whose members share a lexicon that provides the basis for both the conduct and the evaluation of their research and which simultaneously, by barring full communication with those outside the group, maintains their isolation from practitioners of other specialties (Kuhn, 1991, p. 8).

Hence, on Kuhn's view, members of a scientific community share the overall structure of their lexicon although the individual details may differ from scientist to scientist. If, on the contrary, the overall structure of the lexicons of two scientists differs, they will have different expectations about the world and communication difficulties will arise:

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[2] As argued by Hoyningen-Huene (1992, p. 235) such latent differences can be caused by different criteria for concept use, different interpretations of values, or differential identification with the reigning views. See also Andersen (2009) for a detailed case study of latent conceptual differences and their importance for the reaction to anomalies.

> What members of a language community share is homology of lexical structure. Their criteria need not be the same, for those they can learn from each other as needed. But their taxonomic structures must match, for where structure is different, the world is different, language is private, and communication ceases until one party acquires the language of the other (Kuhn, 1983, p. 683)

Later, this emphasis on communication differences due to differences in taxonomic structures led Kuhn to the idea that during the historical development of science new subspecialties emerge and gradually get isolated from each other due to a growing conceptual disparity between the developed tools, and he claimed that this incommensurabilty was what keeps scientific disciplines apart:

> ... what makes ...specialties distinct, what keeps them apart and leaves the ground between them as apparently empty space ... is incommensurability, a growing conceptual disparity between the tools deployed ... . Once the two specialties have grown apart, that dispartity makes it impossible for the practitioners of one to communicate fully with the practitioners of the other. And those communication problems reduce ... the likelihood that the two will produce fertile offspring (Kuhn, 2000, p. 120)

However, as I have argued elsewhere (Andersen, 2006), this new role ascribed to incommensurability revives the incommensurability problem as it was originally raised by Shapere (1971), namely how to make sense of the idea that incommensurable theories are actually *competing*. The conceptual disparity between two specialties placed at different branches of the evolutionary tree of the sciences is different in important ways from the conceptual disparity between the two specialties at each side of a revolutionary divide. The latter face communication difficulties because they hold beliefs that they can somehow identify as *incompatible*, but that is not the case for scientists from different disciplines. If they have communication difficulties this stems not from disagreement on how best to describe and solve problems that both sides can recognize as falling within their own area of expertise. That would constitutes an overlap that the two communities can disagree on. Rather, the difficulty for different disciplines is a *lack* of overlap between them.

Kuhn's view about conceptual disparity between distinct specialties reflects a classical view of unidisciplinary competence according to which the practitioners of a given discipline have "undergone similar educations and professional initiations", "absorbed the same technical literature and drawn many of the same lessons from it" and "see themselves and are seen by others as the men uniquely responsible for the pursuit of a set of shared goals, including the training of their successors" (Kuhn, 1970, p. 177). However, as argued by Campbell (1969), among others, a discipline consists of a congerie of narrow specialties and these specialties are integrated into a comprehensive discipline as a *collective* product of the discipline's community. This product is achieved exactly because the multiple narrow specialties *overlap,* and because a collective communication, a collective competence and breadth, is achieved through this overlap.

Admittedly, Kuhn also realized that scientific communities exist at different levels, from the global community of all natural scientists over the standard disciplines such as physics and chemistry and subdisciplines such as organic chemistry and high-energy physics to finally the invisible college or closely-knit research network working on a particular problem area such as, for example, the early phage group. It was only this latter kind of group which Kuhn characterized by their members attending the same specific conferences, being in the same informal communication networks, etc., and which he estimated to be of the order of about a hundred members or less (cf. Kuhn, 1970, p. 178).

Although Kuhn sometimes emphasized communication difficulties and isolation between different scientific communities, at other times he conceded that "individual scientists, particularly the ablest, will belong to several such groups either simultaneously or in succession" (Kuhn 1970, p. 178). In these latter cases he admitted that members of one community can acquire the taxonomy employed by members of another community, but at the same time he emphasized that this process would produce bilinguals, not translators. But he never fully spelled out how he saw the spectrum: from the isolated specialty, over the congeries of specialties that together form a discipline, to finally full-fledged interdisciplinarity. For Kuhn, the key characteristic of a specialty remained that within the community "communication is relatively full and professional judgment relatively unanimous" (Kuhn, 1970, p. 177) and that, in contrast, for different scientific communities which are focused on different matters, "professional communication across group lines is sometimes arduous, often results in misunderstandings, and may, if pursued, evoke significant and previously unsuspected disagreement" (Kuhn, 1970, p. 176).

Apparently, Kuhn never considered a third possibility, namely that professional judgment is neither unanimous, nor characterized by disagreement, but instead that professional judgment is *distributed.* That is, that scientists may collaborate across specialties in a way where each are responsible for the pursuit of some subset of goals that together make part of an overall shared goal and that, therefore, each provide the professional judgments within their own area of expertise and need to rely on the judgments of their collaborators within neighboring areas of expertise. Hence, instead of the situation known from scientific revolutions where scientists *disagree* with scientists from *competing* communities, the situation here is that in areas that *complement* their own expertise scientists desist from making their own judgment and instead *depend* on the judgment made by scientists from neighboring communities .

Interdisciplinarity and Epistemic Dependence

In contemporary science, most new scientific knowledge claims are produced by collaborations in which several scientists combine individual pieces of knowledge.[3] The

[3] For overviews of this development, see e.g. (Beaver & Rosen, 1978; Beaver & Rosen, 1979; Beaver & Rosen, 1979; Thagard, 2006; Wray, 2002; Wray, 2006).

nature of this widespread epistemic dependence in science has been described by, among others, Hardwig (1985; 1988; 1991). The basic structure of Hardwig's argument is that in an area of expertise for which a scientist has limited competence, he or she can appeal to another more competent scientist B in order to ground his or hers beliefs in propositions within this area of expertise. In this case, A's belief in propositions based on testimony from B will be superior to belief in the same propositions based on direct evidence because B's reasons are epistemically better than any that A could come up with. However, since A may not understand B's reasons for adopting these propositions and why they are good reasons, A simply has to trust B's testimony. In other words, A is epistemically dependent on B.

Although most contemporary science is based on collaborations, there is an important difference between, on the one hand, research *within* a particular discipline where collaborators are generally capable of understanding each other's reasons for adopting particular propositions and why they are good reasons, and, on the other hand, *interdisciplinary* research where collaborators understand less of each other's reasons and why they are good reasons. This difference may be a difference in degree rather than a fundamental difference in kind, nevertheless, the more interdisciplinary the group, the higher the degree of epistemic dependence.

Further, a research group is often characterized by multilateral trust relations which means that the researchers in the group are mutually epistemically dependent, and that conclusions, which follow from the combination of the premises that they each provide, are drawn by the group, not by an individual. As Hardwig explains, "by accepting each other's testimony, individual researchers are united into a team that may have what no individual member of the team has: sufficient evidence to justify their mutual conclusion" (Hardwig, 1991, p. 697).[4] Hence, contrary to the standard ideal of knowledge as something possessed by the *individual*, in collaborations characterized by widespread, mutual epistemic dependence knowledge becomes the possession of the *group*.

However, a practice of widespread mutual epistemic dependence runs counter to deeply entrenched ideas about intellectual independence and critical scrutiny as key norms of the scientific enterprise (Hagstrom, 1965; Merton, 1973; Mulkay, 1993). These norms can easily be encompassed in Kuhn's account of mono-disciplinary normal science. On a Kuhnian account, the practitioners of a discipline have undergone similar training and have absorbed the same literature and drawn the same lessons from it. As a consequence, they share the pursuit of the same goals, namely to solve characteristic problems that resemble other problems solved by the profession before, and they are in principle all capable of pursuing the puzzles that their field defines. Hence, when exchanging results, each participant is capable of critical scrutiny before accepting any new claim from a colleague and of providing a detailed justification of it once it is accepted. At the same time, it is this repeated critical scrutiny of the same results by

[4] See also Andersen & Wagenknecht (2012) for a detailed analysis of epistemic dependence in interdisciplinary groups.

multiple individuals who are intellectually independent that both makes normal science so efficient in identifying any loci of trouble and ensures that risks are spread among intellectually independent individuals in the community.

But the situation is different in interdisciplinary science. Contrary to the ideal of intellectual independence, in cases of mutual epistemic dependence new knowledge claims cannot be fully justified by any of the collaborators individually but only by the group as a collective.[5] Similarly, contrary to the ideal of critical scrutiny, in cases of mutual epistemic dependence some claims simply need to be trusted. Hence, two contrary options are available for interdisciplinary research. The one option is to adhere to the ideals of intellectual independence and skepticism and to teach each other enough of each involved discipline to make each individual capable of making a rough assessment of the overall justification for the knowledge claims the group has produced and of judging each individual piece of it critically. This option preserves the ideals of intellectual independence and critical scrutiny, but at the cost of the time spent training collaborators in competences already possessed by other group members. The other option is instead to save time by relinquishing on the ideals of intellectual independence and critical scrutiny and accept instead a profound epistemic dependence and the relations on trust on which it builds.

In this way, the tension inherent in interdisciplinary research between, on the one hand, intellectual independence and critical scrutiny and, on the other hand, epistemic dependence and trust is a complement to Kuhn's essential tension within mono-disciplinary science between convergent and divergent thought. Without convergent thought, science would become a mess created by continuous theory change and progress would be precluded. Without divergent thought there would be no fundamental innovation and again progress would be precluded. Similarly, without epistemic dependence and trust, interdisciplinary research would never be initiated and instead mono-disciplinary communities of highly specialized experts would remain isolated, unable to work at problems whose solution spread across disciplinary boundaries. Without the repeated critical scrutiny of the same results performed by intellectually independent scientists, interdisciplinary research would not be able to isolate and focus on potential loci of trouble. Hence, it is the essential tension between epistemic dependence and intellectual independence and scrutiny that provides the underlying epistemological mechanism for what has been called the disciplinary paradox. Namely the situation that, on the one hand, the continuing fragmentation of knowledge into separate disciplines necessitates interdisciplinary approaches, but on the other hand, that interdisciplinary research can only receive epistemic justification from the established disciplines.

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[5] For a detailed argument, see Andersen (2010) as well as Andersen & Wagenknecht (2012).

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