Scientific Pluralism and Inconsistency Toleration

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ABSTRACT

In this paper I examine the problem of inconsistency toleration in the context of scientific pluralism. I argue that, first of all, the notion of inconsistency toleration has to be qualified with respect to the evaluative attitude that one takes towards a given scientific theory or theories. Second, I show which types of inconsistency toleration are compatible with two major approaches to scientific pluralism, the so-called modest and the radical one. In view of this I suggest some points of demarcation between these two approaches.

1. Introduction: three perspectives on inconsistencies in science

Consistency is traditionally considered to be one of the key epistemic and methodological standards for the assessment of scientific theories. During the twentieth century discussions in philosophy of science, internal consistency has been emphasized as the sine qua non of scientific knowledge. Karl Popper (1959), for example, took internal consistency to be a necessary condition for the acceptance of scientific theories.[1] A similar view has more recently been advanced by Heather Douglas (2009) who takes internal consistency to be an epistemic criterion that needs to be satisfied if a given scientific theory is to be accepted. Both Popper's and Douglas's arguments are rooted in the principle of classical logic Ex Contradictione Quodlibet, sometimes also called Ex Falso

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[1] Popper writes: "In order to show the fundamental importance of this requirement it is not enough to mention the obvious fact that a self-contradictory system must be rejected because it is false.... the importance of the requirement of consistency will be appreciated if one realizes that a self-contradictory system is uninformative. It is so because any conclusion we please can be derived from it." (Popper 1959, p. 72).

Quodlibet or the 'principle of explosion'. This principle is an inference rule valid in classical logic, according to which from a contradiction follows anything:

$$A, \sim A \vdash B.$$

Nevertheless, a number of discussions in the context of post-Kuhnian philosophy of science have brought strict applicability of this requirement into question (e.g. Feyerabend 1975; Lakatos 1978; Nickles, 2002; Batens, 2002). According to these scholars, history of science shows that inconsistencies are not a threat to scientific rationality and that the standard of consistency needs to be weakened. This discussion gave rise to three different perspectives on the issue of inconsistencies in science:

1. *The historical,* descriptive perspective, which concerns the question whether inconsistencies commonly appear in science, and whether scientists sometimes accept and reason from inconsistencies;
2. *The logical*, normative perspective, which concerns the questions whether we can rationally reason from an inconsistent set of premises without ending up in a logical explosion, and if so, how;
3. *The methodological*, normative perspective, which concerns the role of the standard of consistency in evaluations of scientific theories.

The discussion concerning the first, historical perspective has recently been reopened by Vickers (2013), who argues that most cases of allegedly inconsistent scientific theories are, upon closer inspection, not examples of inconsistencies that can be found in commitments of the relevant scientists. The idea that scientific theories, such as Bohr's model of atom or early calculus are inconsistent have, according to Vickers, resulted from the lack of historical rigor. While some have at least partially agreed with Vickers's analysis of historical case studies (e.g. Muller 2014), others have challenged his conclusions concerning the logical perspective (item 2. above). Let's take a closer look at this latter discussion.

The late twentieth century discussions on the question of rational reasoning in face of inconsistencies have resulted in the development of non-classical logical frameworks. In contrast to classical logic, these logics prevent logical explosion in case of inconsistent premise sets. A family of such logics, known under the name of paraconsistent logics, has been developed in different

schools, such as the Brazilian (initiated by the work of Newton da Costa), the Australian (including the school of dialethism, most prominently advocated by Graham Priest), the US school (around relevance logicians such as Alan Ross Anderson and Nuel D. Belnap), the Belgian (embedded in the programme of adaptive logics, pioneered by Diderik Batens), etc. Vickers critical analysis aims to undermine the aptness of paraconsistent logics for the formal modeling of scientific reasoning. Nevertheless, his conclusions on this issue have been criticized as unwarranted (e.g. Brown, 2015; Šešelja and Straßer, 2014).

Finally, the third, methodological perspective has emerged within discussions on epistemic or cognitive values that underlie scientific evaluations and decision making. Kuhn's point that consistency is one of the values of theory choice –together with accuracy, scope, simplicity, and fruitfulness (Kuhn 1977)– suggested that, just like the other values, consistency contributes to the overall epistemic status of the given theory. However, such an approach also opened the possibility that consistency may be disregarded if the given theory excels in other respects. This motivated a weakening of consistency as a methodological standard used in the evaluations of scientific theories, especially with respect to preliminary evaluations of research programs (Lakatos,1978).

A similar question, concerning inter-theoretical, or external consistency[2] has been raised in the recent literature on scientific pluralism. Scientific pluralism, broadly construed, is a normative stance, according to which the parallel existence of multiple theories or research programs within a given scientific domain is considered epistemically and methodologically beneficial (e.g. Feyerabend,1968; Rescher,1993; Chang, 2012; Longino, 2002a; Kellert et al., 2006). Since such a theoretical diversity allows for incompatibility and inconsistency between different rivaling conceptions, pluralists have been reluctant to endorse the requirement for external consistency. For instance, according to Nicholas Rescher (1993): "Life being what it is, the community as a whole is bound to adopt inconsistent views." (p. 95). Similarly, Helen Longino writes (2002b): "I countenance the possibility of different equally defensible background assumptions facilitating inferences to quite different and irreconcilable, even non-mutually-consistent, representations of what is pre-theoretically identified as the same phenomenon." (Longino, (2002b, 575).

[2] While consistency is usually taken in the sense of internal consistency of the given theory, external consistency between a theory and other accepted theories, or between a theory and observations (Priest, 2002) have also been considered relevant standards for the assessment of scientific theories.

Even though pluralists have in this way suggested some kind of inconsistency toleration, they have been too vague about what this precisely means, and to which extent inconsistencies are tolerable.[3] It is no surprise then that some have used the fact that pluralist frameworks allow for mutually inconsistent theories as an argument against their epistemic feasibility (e.g. see Freedman's (2009) criticism of Longino).

The aim of this paper is to show in which sense inconsistencies can be tolerated within accounts of scientific pluralism, and to specify the borders of such inconsistency toleration. First of all, I will distinguish between two types of scientific pluralism, namely the so-called modest and the radical one (Section 2). Next, I will tackle the above question with respect to the former (Section 3), and then with respect to the latter (Section 4). I will conclude the paper with some more general remarks regarding the analysis of inconsistencies in science (Section 5).

2. Two conceptions of scientific pluralism

One way to explicate the central features of scientific pluralism is to start from the opposite standpoint, namely scientific monism. According to Kellert et al. (2006) Scientific monism is the view that consists of the following assumptions:[4]

1. *Axiological assumption*: the ultimate aim of science is to establish a single, complete, and comprehensive account of the natural world (or the part of the world investigated by the science) based on a single set of fundamental principles.
2. *Metaphysical assumption*: the nature of the world is such that it can, at least in principle, be completely described or explained by such an account.
3. *Methodological assumption*: there exist, in principle, methods of inquiry that if correctly pursued will yield such an account.
4. *Methodological criterion*: methods of inquiry are to be accepted on the basis of whether they can yield such an account.

[3] An exception is Rescher, who has discussed this topic in more detail (see below Section 3).

[4] I have added labels for each of the assumptions, which are directly taken from Kellert et al. (2006, p. x) for the sake of easier reference to them in the remainder of this article.

5. *Epistemic criterion*: individual theories and models in science are to be evaluated in large part on the basis of whether they provide (or come close to providing) a comprehensive and complete account based on fundamental principles.[5]

The stance of monism, construed in this way, may be a rare view among philosophers of science.[6] Nevertheless, it is a useful analytical tool for explicating two main types of scientific pluralism, which are widely adopted.

Modest pluralism. Modest pluralism retains the monist assumptions in an adjusted form. As Kellert et al. (2006) point out, accounts of modest pluralism[7] are not easily distinguishable from sophisticated forms of monism since they can usually be reduced to a nonfundamentalist or nonreductionist kind of monism (pp. xii–xiii).[8] Modest pluralism can then be specified as a view that typically adopts the following nonreductionist versions of the above five assumptions:

1a. *Axiological assumption*: the ultimate aim of each scientific domain is to establish a single, complete, and comprehensive account of the part of the natural world, which is compatible with accounts in other scientific domains.

2a. *Metaphysical assumption*: the nature of the world is such that any domain of phenomena can, at least in principle, be completely described or explained by such an account.

3a. *Methodological assumption*: there exist, in principle, methods of inquiry that if correctly pursued will yield such an account.

4a. *Methodological criterion*: methods of inquiry (in a broad sense of the term) that aim at integration and synthesis of different theories are conducive to the achievement of such an account.

[5] Chang (2012) adds to these five points that "monists also typically suppose that there is one best method of inquiry at least in each domain" (p. 260).

[6] Though perhaps it is not so rare among scientists, especially physicists (see Chang (2012), p. 259).

[7] I'll mention philosophers who are considered to be proponents of modest pluralism in Section 3, while the proponents of radical pluralism will be mentioned in Section 4.

[8] Note though that reductionism and pluralism may not be necessarily incompatible, as argued by Steel (2004).

5a. *Epistemic criterion*: individual theories and models in science are to be considered accepted in the strong sense of the term[9] on the basis of whether they provide (or come close to providing) a comprehensive and complete account of the relevant domain of phenomena, and on the basis of their compatibility with other accepted theories.

For modest pluralists plurality is primarily a means to an end, motivated by the uncertain and defeasible nature of scientific reasoning. This is why this viewpoint can also be labeled as methodological pluralism. Moreover, plurality is envisioned as accompanied by the goal of integration and synthesis of different models and theories, which is why this approach has also been dubbed as consensual pluralism (see Van Bouwel, 2015).

Radical pluralism. Radical pluralism can be specified as a view that typically rejects all five monist assumptions, as well as all five modest pluralist assumptions. Rather than positing a unified account of the given phenomena as an ultimate goal of each scientific domain, radical pluralism allows for a plurality of scientific theories and practices within the same domain to be considered epistemically beneficial. Whether each domain can achieve a single complete account of the relevant part of the natural world remains an open empirical question (Kellert et al. (2006), p. x). Hence, radical pluralism allows for the possibility that some phenomena in the world are such "that there can never be a single comprehensive representation of everything worth knowing" about them (p. xi). While plurality of models and theories is envisioned as compatible with their irreconcilability, interaction among the proponents of different theories is considered to play an important methodological role (Van Bouwel 2015).[10]

Let's now turn to the question how to account for inconsistency toleration within each of these two pluralist perspectives.

[9] The notion of strong acceptability will be specified in Section 3, but for now it will suffice to take it as indicating that the given theory has been ratified as settled scientific knowledge.

[10] Van Bouwel (2015) labels this kind of pluralism agonistic pluralism, in parallel with Chantal Mouffe's account of agonistic pluralism which concerns a model of democracy. In addition to consensual and agonistic pluralism Van Bouwel also mentions a third kind, namely antagonistic pluralism, which envisions plurality as a co-existence of theories with the undesirability or impossibility of interaction, relating it to Kuhnian views on science (p. 155). In my discussion on the toleration of inconsistencies I will leave this third type of pluralism out since its analysis would result in similar conclusions as those we will get for radical pluralism.

3. Modest pluralism and inconsistency toleration

The most prominent account of modest pluralism is Philip Kitcher's conception. According to Kitcher, one and the same phenomenon may best be explained by different scientific theories since different classificatory systems reflect different cognitive interests. However, accepted theories should be mutually translatable and a single theoretical account should be able, in principle, to accommodate all explanatory interests.

A view typically shared by proponents of modest pluralism is that consistency is an uncontested standard of scientific knowledge. For instance, according to Kitcher (2002a), "the representations that conform to nature ... are jointly consistent" (p. 570; see also Section 4). Another example is Mitchell (2004) who, when explicating her account of integrative pluralism, writes:

> Minimally, we expect representations to be consistent with each other. If the world is one, and scientific claims accurately describe it, then two contradictory statements cannot both be true. (p. 82)

This poses the question whether modest pluralism allows for any kind of inconsistency toleration (i.e. whether certain kinds of inconsistency toleration are perhaps compatible with it). In order to give a precise answer to this question, we first need to specify evaluative attitudes that scientists may have when assessing inconsistent theories. This is important because inconsistencies may be tolerable with respect to some attitudes, but not with respect to others.

I will thus distinguish three such attitudes –pursuit worthiness, acceptance in a strong sense, and acceptance in a weak sense– all of which play an important role in scientific inquiry. For each of them I will examine to which extent an inconsistency can be tolerated from the perspective of modest pluralism. All the cases of inconsistency toleration that will be mentioned under modest pluralism also hold for a less restrictive view of radical pluralism. Whether the latter includes some additional cases will be the topic for the next section.

3.1 The attitude of pursuit worthiness

The idea that the assessment the pursuit worthiness of a scientific theory needs to be distinguished from its acceptance goes back to the twentieth century discussions in methodology of science. Starting from Pierce's economy of research (cp. McKaughan, 2008), to Laudan's notion of the context of pursuit (Laudan, 1977), many scholars have emphasized the difference between these

two types of evaluations (e.g. McMullin, 1976; Whitt,1992; Franklin,1993; Šešelja et al., 2012; Šešelja and Straßer, 2014a). Most prominently, Nickles (1996; 2006; 2009) has characterized the former as heuristic appraisal, which is a prospective assessment that regards heuristic and pragmatic considerations concerning the fruitfulness of research directions. In contrast, epistemic appraisal is a retrospective assessment that regards truth-conducive features of justification and decision-making, and stands for the traditional idea of theory confirmation.

While modest pluralism assumes that scientific inquiry in each domain should ideally result in a comprehensive and complete account of the relevant phenomena, it nevertheless encourages plurality of pursued methods and theories. The methodological criterion (item 4a) only suggests that those methods and strategies that seem promising of integrating the given theory with other areas of knowledge are desirable. Nevertheless, this doesn't mean that multiple, mutually incompatible or even mutually inconsistent methods or theories cannot be considered worthy of pursuit at the same time.

The reason why two mutually inconsistent theories may simultaneously be considered promising is simple: we do not know which of them (or whether perhaps both) will lead us to an acceptable theory, which is why we should hedge our bets by having multiple lines of inquiry.[11] Hence, a typical feature of modest pluralism is toleration of inconsistencies between two theories in the same domain, both of which are considered worthy of pursuit.

However, this is not the only kind of inconsistency toleration characterizing this type of pluralism. Modest pluralism is also compatible with a toleration of internal theoretical inconsistencies, external inconsistencies between a pursued theory and already accepted theories in other scientific domains, and inconsistencies between a pursued theory and observations.[12] For instance, take Kitcher's view on external inconsistencies between a pursued theory and a non-rivaling established theory:

> ... a well-studied example is the Bohr's model of the atom, where the picture of electrons arrayed in shells and 'jumping' between them was inconsistent with classical electromagnetic theory. In cases like this, the inconsistency is typically seen *as a spur to further research*; scientists want to amend one, or both, of the conflicting representations (theories, models, maps, or whatever) so as to arrive

[11] This argument has recently been elaborated by Hasok Chang (Chang (2012), pp. 270-271).
[12] For a detailed discussion on each of these points see Šešelja and Straßer (2014a).

> at a consistent account of the area of overlap. (Kitcher, 2002a, p. 570, italics added)

In other words, inconsistencies may be temporarily tolerated as a problem that should eventually be resolved.

It is important to notice though that the argument for the toleration of such inconsistencies doesn't hinge on a pluralist stance,[13] but on the specific nature of evaluation that concerns the pursuit worthiness of scientific theories. The basic idea is this: a theory can be considered worthy of pursuit despite the presence of empirical and conceptual problems (including explanatory anomalies, inconsistencies, etc.) if it has a so-called programmatic character that can counterweight these problems. This means that a theory is equipped with methodological and theoretical means to tackle its current problems and to catalyze further inquiry (see e.g. Whitt, 1992; Šešelja and Straßer, 2014a). This is especially important in case of young, underdeveloped theories, which often suffer from numerous problems, but which may after some time successfully resolve them (see e.g. Laudan,1977).

For instance, during the first half of the twentieth century, Alfred Wegener's theory of continental drift had a high explanatory potential, but it had one major problem, namely the lack of a plausible mechanism of the drifting continents. The claim that continents can move through the solid ocean floor seemed inconsistent with the evidence that the inside of the Earth is solid. As Rachel Laudan puts it: "The problem with drift was not simply that there was no known mechanism or cause, but that any conceivable mechanism would conflict with physical theory" (Laudan, 1981, p. 230) Nevertheless, the theory was equipped with sufficient heuristic means, forming its programmatic character.[14] First, Wegener's account was compatible with the theory of isostasy, according to which continents could be seen as floating in hydrostatic equilibrium, where the substrate in which they are embedded behaves over geological time in a fluid manner (Oreskes,1999, p. 65). Moreover, in the late 1920s Arthur Holmes proposed the model of 'seafloor thinning', which postulated that the continents

[13] Indeed, even a reductionist monist perspective is compatible with the toleration of internal inconsistencies or inconsistencies between a theory and observations with respect to the attitude of pursuit worthiness, as long as the given theory is promising of offering a unified account of the given domain of phenomena, based on fundamental principles. In principle, one could argue that a monist reductionist view is also compatible with the toleration of external inconsistencies between theories with respect to their pursuit worthiness, as long as the given theories are promising of becoming reconciled into a unified account

[14] For a detailed discussion on the programmatic character of Wegener's theory in the first half of the twentieth century see (Šešelja and Weber, 2012).

drift apart by being carried along the backs of the convection currents, generated through radioactivity (Frankel, 1979, p. 68). Even though Holmes's hypothesis of convection currents could not be substantiated at the time, it offered a programmatic character to the theory of continental drift by pointing to paths of its further investigation (such as the examination of the presence of convection currents in the interior of the earth).

To sum up, consistency –be it internal, external, or between a theory and observations– is not a necessary requirement a theory needs to satisfy in order to be worthy of pursuit from the perspective of modest pluralism. The magnitude of problems that an inconsistency creates depends on the presence of a programmatic character in the given research program, which may offer ways of proceeding further with the inquiry in spite of inconsistencies and towards their resolution.

3.2 Acceptance in a strong sense

According to modest pluralism, as long as there is no complete and comprehensive theoretical account in the given scientific domain, neither of the rivaling theories can be considered acceptable in the strong sense of theory confirmation. Hugh Lacey's (Lacey, 2005) definition of sound acceptability adequately captures this kind of evaluative attitude:

> A theory is soundly accepted (of a specified domain of phenomena), I maintain, if and only if it is confirmed that it expresses well-grounded understanding of these phenomena, if and only if it manifests the cognitive values highly with respect to an appropriate array of empirical data gained from observing these phenomena ... –sufficiently highly that the knowledge expressed in the theory can properly be considered settled, to need no further evidential support. (p. 980)

As examples of settled knowledge Lacey mentions "e.g., molecular chemistry, viral and bacterial causation of disease, electronic theory as applied in technological devices, classical mechanical accounts of terrestrial motions" (p. 983). For each of these scientific theories, "there is no plausible scenario that we can describe in which a new perspective would lead to putting these results into question by, e.g., suggesting new experimental investigations that might put them into doubt." (p. 984). However, Lacey points out that this does not mean such challenges are categorically ruled out: since we may never be sure about future inquiries, theory acceptance can be granted only defeasibly.

Now, according to modest pluralism, inconsistencies (of any kind) are usually a reason that the given theory (or a domain consisting of multiple theories) cannot be considered settled even in a defeasible sense. This is due to the fact that an inconsistent theory fails to manifest the value of consistency sufficiently highly. For, if the nature of the world is such that it can be described by a complete and comprehensive account (as assumption 2a states), then we should expect from the settled theories not to be (mutually) inconsistent (at least defeasibly).[15]

Clearly though, the above notion of acceptance is very strong, setting standards that are rarely satisfied at the scientific frontier. This raises the question how inconsistency toleration stands with respect to weaker notions of acceptance.

3.3 Weaker notions of acceptance

Rescher's notion of provisional acceptance. Rescher (1988) distinguishes between different types of inconsistencies, and accordingly, between different types of inconsistency toleration, where he defends only one, weakest kind as fruitful for scientific inquiry. More precisely, he defends the toleration of weak inconsistencies, which should be understood as "admit[ting] the prospect that for some thesis p we knowingly accept both it and its negation: A(p) and A(¬p), for some p." (p. 75). In contrast, strong inconsistency toleration –"To admit the prospect that: A(p&¬p), for some p" (Ibid.)– goes beyond the norms of rational scientific inquiry.[16] Weak inconsistency toleration thus means provisionally accepting mutually inconsistent claims without conjoining them within one and the same context:

> ... we may well be able to achieve intracontextual consistency in various situations, even though the claims of one context may fail to be consistent with those of another. Global consistency all across the board may well elude us. The

[15] There is one scenario though where tolerating inconsistent theories with respect to their sound acceptance seems compatible with modest pluralism. If we assume that there are two theories, which are mutually inconsistent, and each of which can be soundly accepted in the sense that each provides a complete and comprehensive account of the same domain of phenomena, and each of which is compatible with other accepted theories (assumption 5a), then it seems that such an inconsistency would be tolerable from the perspective of modest pluralism.

[16] Rescher adds two more types of stronger inconsistency toleration, none of which is according to him warranted: "*Hyperinconsistency*: To admit the prospect that: A(p&¬p), for all p." and "*Logical Chaos*: To admit the prospect that: A(p), for all p (and accordingly A(p) and A(¬p), for all p)." (italics in original, p. 75). A logical reconstruction of these ideas can be found in Rescher and Manor (1970).

> 'resolution criteria' we use to extract a consistent conclusion from an inconsistent set of initial data may well operate in a context-sensitive way, yielding results that are acceptable here but unacceptable there. (p. 89)

The primary reason why weak inconsistency is, according to Rescher, tolerable lies in the fact that scientific reasoning is plausible in character, which means that it is always tentative and fallibilistic. Hence, while consistency should play the role of a regulative ideal, it may at times be sacrificed for the sake of other cognitive values. Or put differently: in order to increase the cost-effectiveness of knowledge acquisition, it may be useful to provisionally accept mutually inconsistent information "hoping to 'straighten things out' as we go along" (p. 80). This view seems perfectly compatible with modest pluralist assumptions.

French and da Costa's notion of acceptance. A similarly weak notion of acceptance has been explicated by Steven French and Newton da Costa (Da Costa and French, 2003). Similarly to Rescher, Da Costa and French explicitly discuss the acceptance of possibly inconsistent theories within a restricted application domain where we have good reasons to believe that they reliably hold.

Da Costa and French motivate their approach by noticing that the notion of belief used by scientists differs from the received philosophical view, according to which beliefs are propositions accepted as true. Scientists rather "use 'belief' with a certain vagueness, a vagueness that reflects their epistemic fallibility" (p. 64). Taking over Sperber's (1982) distinction between factual beliefs and representational beliefs, da Costa and French argue that scientific theoretical knowledge, that is, scientists' beliefs in theoretical models are of the latter kind.[17] In contrast to factual beliefs that concern facts or data, representational beliefs have a "semipropositional" content in the sense that they refer to conceptually incomplete objects or phenomena. While the former should be understood in terms of correspondence theory of truth, the latter should be understood in terms of "pragmatic" notion of truth:

[17] While da Costa and French relate their view to Cohen's distinction between belief and acceptance, they argue that the two attitudes can't be clearly distinguished since observations, used in support of acceptance, still require beliefs (Da Costa and French (2003), p. 63). They root the problem in the notion of belief, traditionally used by philosophers, which does not correspond to the way this term is used in scientific practice. Instead of Cohen's distinction they propose the one between factual and representational beliefs, where only the latter correspond to a conscious and voluntary act (p. 79). See also Footnote 20 in the current paper.

> When holding a representational belief of semipropositional content ... there is awareness of a commitment to a representation, and in such cases talk of correspondence truth is inappropriate, since it is not at all clear to what, if anything, a semipropositional representation 'corresponds'. Here the representational belief that p is interpreted as a belief that p is *pragmatically* or *quasi*-true only. (Da Costa and French, 2003, p. 67, italics in original).

> To accept a theory is to be committed, not to believing it to be true, but to holding it *as if* it were true, for the purposes of further elaboration, development, and investigation. (p. 79, italics in original)

Defined in this way, da Costa and French's notion can accommodate rational acceptance of both refuted and inconsistent theories. As an example of the former they bring up Newtonian mechanics, which is nowadays accepted within a limited domain of phenomena –a domain within which it has not been refuted and from which it draws its empirical support (p. 81). As an example of an inconsistent theory, they mention Bohr's theory of the atom, which had sufficient empirical support to counterbalance its inconsistent foundations, that is its inconsistency with classical electrodynamics.[18]

Similarly to Rescher's acceptance, provisional acceptance of inconsistent theories in da Costa and French's sense of the term does not violate any of the principles of modest pluralism. The representational nature of scientific beliefs that are provisionally accepted (which means that they are considered to be true only in a pragmatic sense) indicates that the given theories are not to be taken as representing a complete and comprehensive account of their respective domain of phenomena.

Lacey's notion of endorsement. In addition to sound acceptance (introduced in the previous subsection) Lacey introduces the notion of endorsement, which concerns the context of application.[19] The legitimacy of implementing a theory depends not only on its efficacy but also on the assessment of benefits and risks of its implementation, where social and ethical values play a crucial role.

[18] See, however, Vickers's (2013, Chapter 3) discussion on Bohr's theory of the atom, where he argues that no inconsistent set of propositions can be ascribed to the doxastic commitments of the relevant scientists.

[19] The context of application refers to the application of scientific knowledge where "innovations that are informed by a theory may be implemented in the lifeworld" (Lacey (2015), p. 92).

> To endorse p = to treat p –after considering the consequences of accepting[20] p, should it be false, and their ethical salience (in comparison with that of the consequences of not accepting p, should it be true)– as being supported by evidence that is sufficiently strong that the legitimacy of courses of action (or regulation/policy making), informed by it, should not be challenged *on the ground* that p has insufficient empirical support. (Lacey (2015) p. 93, italics in original)[21]

Therefore, a theory should be endorsed within the given application context if in view of the available evidence it can be considered a reliable source of information for that particular domain, where we have to take into account the consequences of its application in case it turns out to be wrong, and the consequences of not applying it if it turns out to be true. These consequences concern non-cognitive values, such as ethical and social ones.

Hence, to which extent either type of inconsistency can be tolerated when it comes to theory endorsement depends on the effect the inconsistency has on the reliability of the given theory in the given application domain, that is, on possible consequences of the implementation of the given (inconsistent) theory. For instance, if a scientist or a given scientific community endorses mutually inconsistent theories, each of which applies to a different domain of phenomena, and where each theory is a reliable source of information within its own domain with no grave consequences of error, then such an endorsement does not violate any of the main modest pluralist principles. The example of the inconsistency between quantum mechanics and the theory of relativity is a case in point. From the perspective of modest pluralism, identifying such an inconsistency (see e.g. Norsen, 2009, Seevinck, 2010) doesn't imply that an endorsement of each of these theories, within their respective domains of phenomena is problematic.

Nevertheless, this should not be taken to imply that inconsistencies never disqualify a warranted endorsement of scientific theories. Identifying inconsistencies between a theory and observations, or between a new theory and a number of other soundly accepted theories, may very well show that further endorsement of the former one may have socially harmful consequences.

[20] Lacey here doesn't refer to the notion of sound acceptance but to Cohen's notion, according to which to accept that p "is to have or adopt a policy of deeming, positing, or postulating that p –i.e., of including that proposition... among one's premisses for deciding what to do or think in a particular context, whether or not one feels it to be true" (Cohen (1992), p. 4).

[21] It is important to notice that Lacey's notion is normative rather than descriptive. Hence, a community is justified in endorsing a theory if and only if these conditions are satisfied. All the other notions of acceptance discussed in the paper are clearly normative as well.

For instance, epidemiological findings regarding the risks of the hormone replacement therapy in menopause by the Women's Health Initiative (WHI) suggested that the therapy increased the risk of breast cancer. Such results were inconsistent with the commonly adopted views that guide medical practice:

> The risk-benefit profile found in this trial is not consistent with the requirements for a viable intervention for primary prevention of chronic diseases, and the results indicate that this regimen should not be initiated or continued for primary prevention of CHD [coronary heart disease]. (Writing Group for the Women's Health Initiative Investigators, 2002).

Consequently, WHI suspended its endorsement of the hormone replacement therapy. The inconsistency between the hypothesis that the therapy is a safe treatment for post-menopausal women and observations obtained in this study was not tolerable since the possible consequences of the hypothesis being false were too high. Similarly, endorsement of hypotheses coming from the area of fringe medicine is commonly considered to be unwarranted given the inconsistency between such conceptions and established scientific theories, as well as the possible consequences of applying therapies based on these views.

Altogether, we have seen a number of different ways in which inconsistencies are tolerable from the perspective of modest pluralism. All of them also hold for a less restrictive stance of radical pluralism. But does radical pluralism allow for something in addition? I now turn to this question.

4. Radical pluralism and inconsistency toleration

As mentioned in Section 2, radical pluralism rejects all five monist and modest pluralist assumptions. This approach has most prominently been advanced by Hasok Chang (Chang, 2012), and Helen Longino, Stephen Kellert and Keneth Waters (Kellert et al., 2006).[22] As mentioned at the end of the previous section, radical pluralism perhaps goes a step further in inconsistency toleration than the modest one. I say 'perhaps' because, as I will show below, the situation is not that clear.

[22] Kellert et al. (2006) also mention John Dupré's "promiscuous realism", but point out that while Dupré's account is hard to distinguish from radical relativism, their own approach comes with "the idea that there are constraints that limit the variety of acceptable classificatory or explanatory schemes" (p. xiii).

In order to get to the core of this puzzle, the 2002 discussion between Kitcher and Longino is a useful starting point. In his (2002b) Kitcher maintains that a pluralist view on science is motivated by incompleteness rather than inconsistency, and he uses this point to contrast his stance with Longino's one:

> In advocating Pluralism, Longino goes beyond the modest view ... to the suggestion that the representations we achieve may not be 'congruent', may resist reconciliation, or may be 'nonreconcilable'... Although she seems to be a fan of the Principle of Non-Contradiction (as I think she should be), she wants to allow for the acceptability of representations that are 'hard to reconcile'. (pp. 555-556)

And indeed, Longino explicitly rejects the requirement for consistency. When describing her own view on pluralism she writes:

> I countenance the possibility of different equally defensible background assumptions facilitating inferences to quite different and irreconcilable, even non-mutually-consistent, representations of what is pre-theoretically identified as the same phenomenon. (Longino, 2002b, p. 575)

> The demand for consistency of all true statements is only problematic if one supposes that statements can be detached from their truth conditions and the contexts in which those are determinable. A contextualist denies that such detaching is possible without constructing a further or more encompassing context. (Longino, 2002a, p. 94)

A similar thought is advanced by Kellert et al. (2006) in the Introduction to their volume, where their rejection of the standard of consistency is presented as a distinguishing feature of their stance, in comparison to modest pluralist accounts:

> The pluralist stance differs from more modest versions of pluralism because it acknowledges the possibility that there may be no way to integrate the plurality of approaches or accounts in a science. For example, we do not believe that the tension among different models can always be resolved by partitioning the domain so that the conflicting models apply to different subdomains. In addition, we do not assume that the plurality of accounts should be consistent, that all truths from one accepted account must be translatable into truths of the other accepted account(s). (p. xiv)

The authors explain that such a situation may occur in the case of complex scientific inquiry, consisting of multiple approaches, where the most feasible

solution for each approach is to parse causes of the given phenomena in a specific way. While such alternative ways of parsing the causes may be mutually incompatible, each may be most beneficial for the specific issues under examination. As a result, each theoretical account may highlight some causal aspects of the given phenomena, while obscuring others.

> If this is the case, and if two models distort some of the same aspects, they might distort these aspects in different ways, giving rise to inconsistencies. This is just one kind of situation in which a plurality of inconsistent approaches might be defended. (p. xiv-xv).

This quote raises two questions: first, which evaluative attitude do Kellert, Longino and Waters have in mind when they speak of inconsistency toleration? And second, if two accounts are not mutually translatable, that is, if they are incommensurable in the Kuhnian sense of the term, can they be considered really inconsistent, or is some other notion, such as incommensurability or incompatibility more apt to describe the relationship between them?

I will answer these questions in view of two case studies from Kellert, Longino and Waters's volume.

4.1 Incompatibility or inconsistency? Endorsement or sound acceptance?

Longino's case study. Longino's analysis of different theories of behavior aims to exemplify the above mentioned plurality and the stance of radical pluralism. (Longino, 2006, Longino, 2013). Longino presents a number of different theoretical accounts of behavior, relevant for the study of phenomena such as aggression or sexual orientation, each of which has a different approach to this problem field.

For instance, according to quantitative behavior genetics, behavior largely depends on hereditary genes; according to social/environmental approaches, it depends on contextual and environmental factors; according to neurophysiological and neuroanatomical approaches, behavior depends on the neural substrate of behavior; according to developmental systems theory, it depends on the whole set of inter-dependent factors.

Longino shows that each of these approaches focuses on a different object of inquiry and employs a different method. For example, one of the typical methods used by geneticists is a study of identical twins who reared separately, in significantly dissimilar environments. However, environmentalists object that this approach disregards the similarity of uterine and early postnatal

environments, and that the degree of environmental influence may depend on age at the time of adoption. Moreover, the same object of inquiry, namely behavior, is specified in different ways, as "tendencies in a population, particular episodes in the history of an individual, patterns of behavior, or dispositions to respond to situations in one way rather than another" (p. 110) And while proponents of different approaches agree that the significance of any causal factor can be analyzed only relative to the impact of others, they disagree "about the weight or strength of one type of factor vis-a-vis that of others, about the degree to which certain types of factors can be ignored, and about the relative value of different kinds of knowledge" (p. 111).

Longino's case study thus suggests that these different conceptual frameworks, as proposed in the literature, are mutually incompatible and incommensurable (see, e.g., Longino, 2013, pp. 127–129). However, incompatibility or incommensurability toleration does not necessarily mean inconsistency toleration. For instance, two theories can be incompatible in the sense of Kuhnian semantic incommensurability (Kuhn,1983), Hoyningen-Huene and Sankey (2013), p. ix–xiii), in which case there is "no common language" within which two theories can be expressed, and hence they can neither be characterized as consistent, nor as inconsistent (see also Dickson (2006), p. 44). Or they can be incompatible in virtue of different understandings of the objects of inquiry and different views on what counts as a legitimate method of inquiry.[23]

But this is not to say that we cannot identify apparent inconsistencies between the claims made by different scientists in the given domain. For example, some scientists may deffend the claim that a given type of behavior X is primarily caused by p, while others may defend the claim that X is not primarily caused by p, but by another relevant factor q. However, from a meta-perspective (such as the perspective of a methodological analysis by a pluralist phiosopher) the inconsistencies are removed once the philosopher has identified that the

[23] While Longino doesn't specify which notion of incommensurability she has in mind, more than one type of incommensurability might be applicable to her case study. On the one hand, different ways in which relevant concepts are used indicate semantic or meaning incommensurability; on the other hand, lexicons developed for each approach are a product of different disciplines from which they stem, which indicates incommensurability resulting from specialization (Wray (2011), p. 74–77). Moreover, different assessments as for what is to count as a legitimate method for investigating, or a relevant way to conceptualize human behavior suggests methodological (Hoyningen-Huene and Sankey (2013), p. xiii-xv) or topic-incommensurability (Wray (2011), p. 66–70). A detailed analysis of different types of incommensurability applicable to this case exceeds the scope of this paper.

scientists actually refer to different aspects of the same phenomenon.[24] Hence, incompatibility originates from different conceptual systems that constitute each of the given approaches, where each approach comes with the commitment of the relevant scientists concerning the epistemic superiority of that very approach (and which thus fuels the given scientific disagreement). Since from the perspective of the philosophical analysis such commitments are absent, there are no inconsistencies (except for the 'apparent' ones) that require toleration.

But even if assume that the given case illustrates inconsistencies between the given theories, it is not clear to which evaluative attitude their toleration relates. Commenting on the 2002 discussion between Kitcher and Longino, Lacey (2005) suggests that while Longino doesn't distinguish between attitudes of sound acceptance and endorsement, her view applies to the latter.[25] This conclusion seems to be supported by Longino's recent discussion on the above mentioned case study, where she suggests that "the practical problems and their associated constraints shape the criteria involved in the evaluation of scientific research" (Longino, 2013, p. 149; see also pp. 147–150). If this interpretation is correct (i.e. if her arguments primarily concern the attitude of endorsement rather than sound acceptance), then we are back at the toleration of one's weak acceptance or endorsement of mutually incompatible or inconsistent theories in the given domain, which has been shown as unproblematic already with respect to modest pluralism. I will thus take a look at another case study in order to discuss the possibility of inconsistency toleration with respect to sound acceptance.[26]

Dickson's case study. A more explicit example of inconsistency toleration can be found in Michael Dickson's discussion on pluralism in quantum dynamics (Dickson, 2006). The case study concerns different accounts of dynamics for

[24] Note though that scientists may not side with such a philosophical reconciliation, since they may still maintain that their respective view is right and that the philosopher pluralist just hasn't got it, since he/she doesn't have a sufficient expertise to understand the problem. This issue is elaborated as the problem of the recognition of rational scientific disagreements in (Straßer et al., 2015).

[25] Lacey's discussion concerns Kitcher and Longino's disagreement over the role of non-cognitive values in judgments of the cognitive acceptability of theories.

[26] It is important to notice that even if pluralists, such as Longino, may reject the notion of sound acceptance on the ground that such an attitude is irrelevant for all the practical purposes, this still doesn't disqualify the analytical significance of the distinction between this attitude and the one of endorsement. The notion of sound acceptance, as well as its demarcation from endorsement does not violate any of the radical pluralist assumptions.

quantum theory, which are mutually inconsistent, where Dickson argues that there are good reasons to tolerate this inconsistency.

A theory of dynamics within quantum mechanics aims at accounting for the change of the individual properties of a physical system, rather than the change of probabilities which define the quantum state of that system. Dickson motivates the need for the dynamics of this kind in the following way. Quantum theory makes explicit predictions only about the state of a physical system at a given time point, where the state stands for the probability measure of the observable quantities characterizing the system (such as energy, momentum, etc.). These predictions are thus probabilistic in nature. Moreover, quantum theory determines how probabilities change in time, and in this sense it provides a dynamics. However, Dickson points out that this is a dynamics of statistics since it only tells us how the statistics of a system, that is, probabilities associated with it, change over time (p. 47). What it does not tell us is how the definite values that a system takes for observables change over time.

While this is not problematic from the perspective of empirical adequacy of the theory, it poses a problem for certain questions that cannot be answered unless the theory is supplemented with a different kind of dynamics (namely a dynamics accounting for the definite values of observables). As an example of such a problem Dickson discusses the so-called problem of measurement in quantum mechanics.[27]

Dickson then shows that there are multiple, mutually inconsistent dynamical schemes, which are equally compatible with the dynamics of the quantum state and with empirical predictions of the theory, but which may be suitable for different explanatory contexts. In particular, some contexts require that we take into account the principle of stability, while others require that we take into account the principle of relativity:

> There is such a thing as relativistic quantum theory, and the principle of relativity plays a crucial role in that theory, giving rise to the prediction of such significant facts as the existence of antiparticles (for example, the positron). Therefore, there are good theoretical and empirical reasons to adopt the principle of relativity... But stability has equally impressive credentials, both theoretically and

[27] Put briefly, the problem is that on the one hand, in typical situations the theory assigns nontrivial probabilities (i.e. probabilities that are not 0 or 1) to observables that clearly have a single definite value. On the other hand, it turns out that it is not possible to assume that every observable always has a certain definite value, where the probabilities would just indicate our measure of ignorance, since such an interpretation leads to a logical contradiction. This latter result comes in the form of the Kochen-Specker theorem. (Dickson (2006), p. 52, 61).

> empirically. We do not, in fact, witness books flying willy-nilly off bookshelves. Nor do we, in theoretical contexts, normally countenance violations of the conservation of momentum and energy. When we seek an answer to why-questions in a context where such empirical facts and theoretical considerations must be explicitly acknowledged, we cannot easily give up stability. (p. 59)

And while there are good reasons to adopt each of these principles, there is no unified dynamical account within which both principles can be accommodated. Dickson doesn't deny that some future theory might be able to reconcile stability and relativity, but he also doesn't believe that physics is in need of such a theory: "I believe that physics can live with complementary dynamical principles." (p. 60).[28]

Dickson's remark thus seems to suggest that inconsistencies of this kind may not necessarily be considered a problem that needs to be solved in the domain of physics.[29]As a result, a theory that would contain such inconsistencies (assuming it had no other open problems) could perhaps be considered even soundly acceptable.

This last point explains why Kellert, Longino and Waters take Dickson's case to be illustrative of the difference between modest and radical pluralism. Commenting on his paper they write:

> This is perhaps the clearest example illustrating the following point, which modest pluralism overlooks: there can be a tension within the plurality of accounts even though each account correctly describes, models, or explains an important aspect of the same part of the world toward which it is aimed. (Kellert et al., 2006, p. xx).

This suggests that radical pluralism really goes a step further than the modest one by allowing for inconsistency toleration also with respect to the attitude of sound acceptance. More precisely, radical pluralism allows for the possibility that a given domain, altogether with its incompatibilities and/or

[28] Dickson emphasizes that such a plurality of dynamics in no way results in contradictory empirical predictions: "the complementarity of dynamical principles of which I speak does not extend to the level of empirical predictions, that is, to the level of the dynamics of the quantum state.... The plurality—that is, the existence of complementary dynamical schemes—becomes apparent only when we insist on a dynamics for the properties of individual systems" (p. 60). The primary motivation for introducing different dynamical schemes lies in their role in interpretations and explanations, rather than in empirical predictions.

[29] This is not to say that, according to him, physics is in no need of a successor theory: "I do believe that physics is in need of a successor theory, but for other reasons" (p. 62), i.e. reasons other than the above mentioned inconsistency.

inconsistencies, may satisfy the criteria of sound acceptance, simply in virtue of exhausting the paths of possible challenges. If inconsistencies in the field are not considered to be a problem that requires further solutions, or a problem that allows for new lines of criticism to be pursued, then the given theory may satisfy the criteria of sound acceptance.

4.2 Demarcating modest and radical pluralism

The preceding discussion brings up an interesting question: would modest pluralists find inconsistencies in Dickson's case study intolerable? There is no reason to assume that they would. In his reply to Longino, Kitcher (2002a) writes that, according to his version of pluralism, "the representations that conform to nature ... are jointly consistent" but "at any stage in the history of the sciences, it's likely that the representations *accepted* are *not* all consistent" (pp. 570-571, italics in original). Thus, if we discover inconsistencies in accepted theories, then we can conclude that the given accounts do not fully conform to nature. That is, if we discover inconsistencies in theories that have previously been considered soundly accepted, we might retract such an assessment and instead adopt a weaker attitude of acceptance (depending on how grave implications such inconsistencies may have). But none of that implies that from the perspective of modest pluralism these inconsistencies cannot be tolerated, at least with respect to a weaker attitude of acceptance.

It seems then that the main point at which modest and radical pluralism differ is the assessment of the epistemic status[30] of the given domain in which inconsistencies are tolerated, rather than any concrete act of inconsistency toleration. This raises the question which methodological implications such a demarcation point between the two types of pluralism has.

On the one hand, for all practically relevant application contexts both modest and radical pluralism seem to prescribe similar methodological norms that are to guide scientists facing an inconsistency in their inquiry. Even though modest pluralism may emphasize the significance of resolving inconsistencies, radical pluralism doesn't object to a possible fruitfulness of such a resolution, if it is available. While modest pluralists may assess a theory that has certain inconsistencies as not manifesting the value of consistency sufficiently high to be soundly acceptable, they may still agree that its endorsement is

[30] By an epistemic status I mean the evaluative attitude (such as those discussed in this paper) one can rationally hold towards the given theory.

unproblematic for all the relevant application contexts. And the other way around: while radical pluralists allow for inconsistent theories to be jointly soundly acceptable, they in no way object to the idea that these theories should be criticized and challenged. The only issue that will be relevant for both approaches is whether the given inconsistency allows for new, fruitful lines of inquiry that could possibly undermine the given theory, and the impact this has on the treatment of the theory as a reliable source of information. How strong this impact is determines how tolerable the given inconsistency is.

On the other hand, the two approaches do differ with respect to the impact that the epistemic status of a theory or a scientific domain containing inconsistencies has. While the difference in such an assessment seems not to have consequences on methodological norms that guide one's research activities in a narrow sense of the term, they may nevertheless influence norms that concern broader methodological realm, such as the distribution of resources for scientific research and the social organization of scientific inquiry. For instance, whether theories in a given domain are considered as soundly acceptable or not may affect decisions concerning the significance of an inquiry that aims to explore the paths of its further improvement. An even more important point of divergence concerns the vision of a consensus-driven science typical for modest pluralism, and the lack of consensus as a regulative ideal in the case of radical pluralism (see Van Bouwel, 2015). If inconsistencies between two theories are a source of disagreements, the former view may prioritize those lines of inquiry that aim towards reconciliation of different view points, while the latter view may prioritize lines that keep the diversity alive.

5. Conclusion

In this paper I have examined the question how to qualify inconsistency toleration with respect to two main types of scientific pluralism, the modest and the radical one. As we have seen, there are numerous ways in which both modest and radical pluralism can allow for inconsistency toleration, with respect to different evaluative attitudes.

I conclude the paper with a remark on different ways in which inconsistencies in science can be identified and analyzed. On the one hand, we can take the perspective of scientists who are involved in a certain scientific inquiry. The unit of analysis will in this case be "pointed groups of propositions", as Vickers (2013) suggests, to which a relevant scientist or a group of scientists is/are

committed. Rather than examining whether any two propositions in a given theory, or between two theories, or between a theory and observations are inconsistent, we are only interested in whether such inconsistent propositions can be found in the doxastic or instrumental commitments of the relevant scientists.

On the other hand, we can take a meta-perspective, where the unit of analysis will be propositions constituting the given theory or theories, irrespective of whether individual scientists are committed to an inconsistent set of propositions or not. Vickers has dismissed this approach, suggesting "theory eliminativism" in the context of the analysis of inconsistencies in science. His argument starts from an observation that investigations of inconsistencies are often sidetracked by disputes on what the theory in question is, or what theories in principle are. He thus suggests that we abandon theories as units of appraisal, and instead focus on pointed groups of propositions.

Nevertheless, and notwithstanding the validity of Vickers's point regarding the debates on the notion of theory, for certain philosophical discussions the latter, theory oriented approach may still be preferable. First, in discussions on scientific pluralism, where one of the relevant questions is the plurality of theories constituting a given domain, it may happen that no scientist has a commitment to an inconsistent set of propositions. However, discovering whether the given theories are mutually inconsistent and how this impacts their reliability may be valuable for an assessment of the given domain, and for the question of inconsistency toleration in this context. Second, scientists often employ strategies of inconsistency avoidance. For instance, internal inconsistency may be resolved via a conceptual change, external inconsistency by ad-hoc adjustments of one theory in order to make it consistent with another, and in case of inconsistencies between a theory and observation evidence can be reinterpreted in order to fit the theory.[31] If we only focused on the commitments of the relevant scientists we might easily miss to recognize an inconsistency that

[31] A nice example of this last case is the research on the enzyme urease in the 1950s. The enzyme was first identified in stomachs of mammals, including humans, but its origin was unknown. Two scientists Lieber and Lefvre observed that antibiotics radically reduced the activity of urease, and concluded that the antibiotics eradicated urease-producing bacteria, i.e. that urease is of bacterial origin. However, the scientific community, convinced that bacteria cannot survive in human gastric acid, rejected the hypothesis, arguing that the given antibiotic must have inhibitted the activity of urease in some direct chemical way. Inconsistency (between the view that bacteria cannot survive in human gastric acid, and the observation that there are bacteria that do survive in it) was thus avoided by explaining the evidence in a way that was consistent with the dominant theory (see Šešelja and Straßer, 2014b).

may still be informative of the given domain, but which is not endorsed by any of the relevant scientists.

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