Convergence on the Kuhnian view of theory choice

Abstract

The Kuhnian view of theory choice (post *Structure*) leaves a lot of space for a diversity of theory choice preferences. It remains mysterious, however, how scientists could ever converge on a theory, given this diversity. This paper will argue that there is a solution to the problem of convergence, which can be had even on Kuhn's own terms.

Keywords: theory choice, Kuhn, theoretical virtues, algorithm, Okasha

1 Introduction

In *The Structure of Scientific Revolutions* (SSR, for short), Kuhn took a very radical view on theory choice in science: scientists' arguments in favor of a paradigm are "necessarily circular", because they presume the standards which are at stake (Kuhn 1962/1996, 94). Given that Kuhn believed that paradigms were incommensurable (Kuhn 1962/1996, 148f.), this was particularly problematic: how could rational theory choice ever occur under these conditions?

In the *Postscript* and *Reflections on my critics* (Kuhn 1970), Kuhn began to develop a much more plausible and appealing view of paradigm and theory choice, which he then brought to full fruition in his *Objectivity, Value Judgment, and Theory Choice* (Kuhn 1977). In these texts, Kuhn argued that scientists choose theories and paradigms on the basis of what he called "standard values": simplicity, internal and external consistency, accuracy, scope, and fertility.[1] Perhaps rather surprisingly for the reader of *Structure*, Kuhn implied that these values were criteria applied *throughout* science and its history.

Although Kuhn no longer spoke of any circularity or incommensurability, theory choice for Kuhn still remained a highly indeterminate matter. In his *Objectivity* paper Kuhn argued not only that values are equivocal (simplicity e.g., can be interpreted differently by different scientists), but also that scientists tend to have different value preferences (Kuhn 1977). Kuhn concludes that there is "no neutral algorithm for theory-choice" (200).

In a highly influential paper, Okasha (2011) has suggested that Kuhn's dictum of "no neutral algorithm" can be read in two ways: either as there being many different algorithms for theory choice, none of which is privileged, or as there not being any algorithm whatsoever. Plausibly,

[1] In the *Postscript*, Kuhn listed these values as one out of four elements of his notion of "disciplinary matrix" (Kuhn 1962/1996, 184-85).

Kuhn held the former view, but Okasha argues that even the latter view may be supported. More specifically, Okasha argues that Arrow's impossibility theorem for social choice can be applied to theory choice, resulting in the impossibility of *any* algorithm for theory choice.

Okasha has himself offered a way out of this result (Okasha 2011). There is a plethora of other responses and criticisms (Morreau 2014, 2015; Stegenga 2015; Bradley 2016; Marcoci and Nguyen 2019; Nguyen 2019; Cresto and Tajer 2020; Sagrafena 2022). However, even assuming that Arrow's impossibility theorem can be avoided, Kuhn's "no neutral algorithm" view of theory choice still poses a problem: how do scientists converge on the same theory if different scientists have different preferences? I call this the *problem of convergence*, which, by some accounts, is the biggest problem for Kuhn's account of theory choice (Laudan 1986, 16; Carrier 2002, 59).[2]

In this paper, I propose a solution to the problem of convergence, without violating Kuhn's "no neutral algorithm" for theory choice dictum.

This paper is structured as follows. Section 2 briefly reviews Okasha's challenge and how the critics may have successfully undermined it. Section 3 turns to the problem of convergence and discusses a solution that have been proposed by Kuhn himself and defended by others. Section 3.2 outlines my own solution to the problem of convergence. Section 5 relates the discussion to the recent literature on pursuit. Section 6 gives a conclusion.

2 Is rational theory choice impossible?

Social choice problems are problems in which a community wants to make joint decisions: shall we build a swimming pool or a cinema? Should we extend the opening hours of our library, or use the money to sweep our streets cleaner? Each individual of a society will have their own individual preferences. Those preferences need to be aggregated to determine a joint preference.

Arrow (1950) pointed out that it may be impossible to aggregate individual preferences into a joint preference, so long as four highly plausible basic premises are satisfied: unrestricted domain (**U**), weak Pareto (**P**), non-dictatorship (**N**), and independence of irrelevant alternatives (**I**). In Social choice problems, such as voting, condition **U** refers to the idea that voters can rank the candidates in whatever way they like; condition **P** says that if all voters prefer candidate x over candidate y, the joint preference should rank x over y; condition **N** says that there cannot be a voter who can dictate their preference to all other voters; and condition **I** says that the choice between x and y can only depend on x and y; it cannot be affected by other preferences (say the preference of y over z). For example, if society would overall prefer Biden over Haley, that preference should be unaffected by society's preference of Haley over Trump.[3] Arrow proved that if all of these four conditions are met, and there are at least three social alternatives (e.g., cinema vs. swimming pool vs. library) then an aggregation function is impossible.

[2] Rueger (1996) and D'Agostino (2005) have discussed the opposite problem, namely how to get from a paradigm consensus to divergence.

[3] Okasha concedes that condition I is not uncontroversial.

It is Okasha's insight to apply Arrow's results for social choice to the problem of theory choice by treating Kuhn's five theory choice criteria (accuracy, consistency, simplicity, scope, fertility) as analogous to individuals in social choice and the alternative theories as analogous to social alternatives. On that reading, each theory choice criterion rank-orders theories from best to worst, whereby ties are allowed (it is assumed that the produced ordering is *weak*).[4] Instead of an ordered list, one may also speak of a "profile" that each theory choice criterion produces. Just like in the case of social choice, Arrow's theorem says we cannot produce an overall profile from the individual profiles when the four aforementioned conditions are satisfied. In the problem of theory choice, the conditions are as follows:

- **U:** the criteria may rank theories whichever way;
- **P**: if all of the criteria rank one theory highest, then the overall theory preference must rank that theory highest;
- **I**: if a criterion ranks theory T1 above another theory T2 (e.g., T1 is ranked simpler than T2), then this ranking should be unaffected by how another criterion ranks T1 and T2 (e.g., T1 is ranked to have a higher scope than T2);
- **N**: There is no criterion that dominates the overall ranking, so that all other criteria would become irrelevant.

Several escape routes from Arrow's impossibility theorem have been explored for the case of theory choice.[5] But even the analogy between social choice and theory choice itself can be challenged. As Morreau (2015) has argued, contrary to what Okasha claims, condition **U** does not hold in theory choice. In other words, it is not true that in theory choice, theories can be ranked whichever way. For example, if one theory has more scope than another, then this is just a fact about those two theories. For example, Einstein's theory of general relativity has more scope than Newton's theory. The criterion of scope then cannot be allowed to rank Newton's theory higher than Einstein's. Einstein's theory always will come out on top of the ranking. But that's a violation of condition **U.** Arrow's impossibility theorem does not apply. Okasha agrees with this assessment. In his reply to Morreau he calls it a "well-taken criticism" (Okasha 2015, 288).[6] Rational theory choice is not impossible after all.

3 Convergence in Kuhnian theory choice: old and new

Theory choice may very well be rational. It probably is, but it is an open question whether it can be on the Kuhnian picture of theory choice. In defense of the Kuhnian picture, one may for example

[4] Weak orderings are also reflexive, transitive, and complete.

[5] Okasha himself suggests that Arrow's impossibility theorem can be avoided by introducing cardinal information, rather than just ordinal information (Okasha 2011). For criticisms of this suggestion see Bradley (2016), Rizza (2014), Morreau (2014, 2015), Stegenga (2015), and Sagrafena (2022). Explorations of other solutions can be found in Bradley (2016), Nguyen (2019), and Marcoci and Nguyen (2019).

[6] Although Okasha accepts Morreau's criticism, he expresses doubt that it also applies to weaker domain assumptions, which in some cases have been shown to still generate Arrow's impossibility result. However, as Nguyen (2019) points out, the domain restriction highlighted by Moreau for theory choice *has* been proven to be "Arrow consistent" (in agreement with Morreau's conclusions).

want to invoke a "new rationality" according to which each scientist may act fully rationally when choosing different theories for different reasons (Kuhn 1977; Okasha 2011). I have no objections against such a more "liberal" view of rationality than perhaps what Carnap had in mind (Okasha 2011, 94). Still, this leaves us with an important question: if scientists have different virtue preferences and end up choosing different theories for different reasons, how can they ever converge on the same theory? After all, that is what is required for them to adopt a theory as a paradigm. In this section I will first outline a proposal made by Kuhn himself and embraced by others. I call this proposed solution *convergence qua ultimate success*. I will then propose my own solution, which I call *theoretical virtue convergence*.

3.1 Convergence qua ultimate success

Prima facie, divergent value preferences and interpretations seem to detract from a solution of theory choice. Interestingly, Kuhn argues that diverging value preferences are actually conductive to the development of science, because choosing a new theory "involves major risks", presumably inductive risks: it will still have to be proven whether a new theory will actually be empirically adequate in the future (Kuhn 1970, 262). If different scientists choose different theories, then the risk is spread (Kuhn 1970, 241; 1977, 332).[7] Kuhn does not spell this out any further, but on this perspective theory choice, plausibly, is an *extended process* in which different scientists may explore different theories *for some time* before converging on a single theory once it turns out (with further experiments) that one of those theories is the most (empirically) successful theory. That theory will then serve as (part of) the paradigm. One may refer to this solution to the problem of theory-choice as *convergence qua ultimate success*.

Although Kuhn did not himself spell out the convergence-qua-ultimate-success idea, several other authors have picked up on Kuhn's sparse remarks. For example, Hoyningen-Huene has argued that, since for Kuhn "the principal agent in science" is the scientific community, one needs to approach the problem of convergence from this perspective (Hoyningen-Huene 1992, 495). But on that perspective, convergence is achieved over time: "so many arguments in favour of one candidate have piled up that whatever the individual value system consists in, everybody makes the same choice" (Hoyningen-Huene 1992, 496).[8] Wray, just like Hoyningen-Huene, argues that "at some point, most [scientists] agree that the conceptual resources afforded by one theory are superior to those afforded by the competitors" (Wray 2011, 163).[9]

Convergence qua ultimate success seems plausible at first sight. At second sight, though, questions arise. On one reading, the proposed solution looks a bit mysterious: if there is disagreement about how to weigh the value at time t1, why should we think that the disagreement must (or is likely to) disappear at a later time t2? Maybe it just persists.

[7] This argument is known as Kuhn's "risk spreading" argument. See e.g., Rueger (1996) and D'Agostino (2005).

[8] See also Hoyningen-Huene (1993, 240).

[9] See also Brown (1988) for similar remarks.

If we read "success" in terms of empirical success, and successor theories as theories with greater empirical success, then convergence qua ultimate success wins in plausibility. Then again, Kuhn did not treat empirical accuracy much differently from the other theoretical virtues. So even if T2 is empirically more accurate than T1, for Kuhn, scientists may still legitimately decide not to adopt T1, for example, when they prefer simplicity over (complete) empirical accuracy, and T2 happens to be simpler than T1. This thought is not as outrageous as one may think. As Forster and Sober (1994) have pointed out, at least in model selection, there exist real trade-offs between a model's fit with the data and the model's simplicity, *and* a model's simplicity is positively correlated with fit with future data.[10]

Finally, it may well be that many arguments in favor of one theory "have piled up" over time, as Hoyningen-Huene puts it. But that seems to assume that practitioners have *already* made the switch and worked on this particular theory, shoring up support for the theory. Had they not made the switch, maybe the other theory may have received just as much argumentative support in *its* favor.

In sum, convergence qua ultimate success may provide *a* solution to the problem of convergence, but it may not be the best solution. Let me now propose my own solution to the problem of convergence.

3.2 Theoretical virtue convergence

Suppose there happens to be a theory T* that possesses *all* the virtues and all other available theories possessed (some of) the virtues to a lower degree,[11] then different virtue preferences do not lead to divergent theory choices. For example, say scientist X prefers simplicity, and scientist Y prefers unification, scientist Z prefers external consistency, etc. Then, in just described scenario, scientists X, Y, Z will converge on T* *despite* their divergent preferences. I refer to this solution to the problem of theory choice as *theoretical virtue convergence*.

Theoretical virtue convergence is fully compatible with the Kuhnian picture of theory choice. In his *Objectivity* paper, Kuhn considered situations in which different theories have different virtues. For example, theory T1 has virtue V1, but not V2, and theory T2 has virtue V2, but not V1. In these kinds of theory choice situations, scientists with different theory choice preferences are bound to diverge in their choices. This raised the problem of convergence. Yet Kuhn did not consider situations of the kind suggested above, in which there is one theory in the pool of theories to be chosen from, which possess all the virtues to the highest degree. In these situations, scientists may still have divergent theory choice preferences, as Kuhn thought they did, and converge regardless. It is then also still true that there is no "neutral algorithm" for theory choice, just as Kuhn claimed there was not, because each scientist employs their own algorithm, as it were. But in contrast to the situations considered by Kuhn, in our type of situation, convergence can still occur.

---

[10] Okasha makes use of this work in his application of Arrow's impossibility theorem to theory choice. In particular, he argues that empirical accuracy should not be a "dictator", and therefore Arrow's Dictatorship condition does not hold.

[11] That Kuhn thought of virtues as having degrees he made clear in (Kuhn 2000, 114-15).

There is evidence in *Structure* that Kuhn himself believed that theories must stick out somehow for scientists to adopt them as paradigms. For example, Kuhn says that for a theory to become a paradigm it must be "sufficiently *unprecedented* to attract an enduring group of adherents away from competing modes of scientific activity" (Kuhn 1962/1996, 10; added emphasis). Similarly, Kuhn says elsewhere that theories "gain their status [as paradigms] because *they are more successful than their competitors* in solving a few problems that the group of practitioners has come to recognize as acute" (Kuhn 1962/1996, 23; added emphasis).

Benjamin Franklin's theory of electricity, Kuhn argues, was such a theory (15). Before Franklin, negative and positive charges were treated as different phenomena. In fact, they were treated as different electrical "fluids". Franklin united the theory so that there was only one electrical fluid that would result in either positive or negative charges, depending on the pressure of the fluid. Of course, the theoretical posits of Franklin's theory are utterly mistaken, but still, the theory successfully unified two phenomena that belong together. In contrast to the preceding "two fluid" theories of electricity, which only ever accounted for some of the known phenomena, Franklin's theory accounted for them all.

Maybe one may want to object here that it is one thing to say that a theory was explanatorily more powerful than its competitors and another thing to make a claim about theoretical virtue convergence. However, explanatory power is usually linked with theoretical virtues to the effect of an explanatorily powerful theory being a theory that has explanatory virtues. For example, simplicity is widely regarded as a virtue of explanatory power and a theoretical virtue (Harman 1965; Schindler 2018).

Regardless of this issue, there clearly are cases in which some theories seem to be vastly more virtuous than their competitors, in possibly any conceivable dimension. Consider for example Newton's theory as compared to its immediate competitor in the 17th century, namely comparatively primitive Cartesian contact motion physics. Surely, Newton's theory scored higher on any of the theoretical virtue dimensions one can think of. Likewise, Darwin's theory of evolution was surely superior to the main competitor of its time in the 19th century, namely creationism, in any of the theoretical virtue dimensions.

It goes without saying that not in all theory choice scenarios there is one clearly superior theory. Notoriously, Copernicus's theory appeared to be externally inconsistent with the background belief that the earth was stationary; no terrestrial physics had yet been developed that would allow for Earth to move and for objects not to fly through the air (Kuhn 1957, 150f.). This turned out to be a major impediment to accepting Copernicus's theory, although it clearly offered major advantages for astronomers calculating heavenly motions (ibid., 185f.). And although Copernicus's theory was qualitatively simpler, it was arguably not quantitatively simpler (nor more complex) than Ptolemy's system (ibid.). Tycho Brahe famously tried to have it both ways: even though he effectively accepted Copernicus's system by having all planets except earth orbit the sun, he still placed the earth at the center of the universe, with the sun orbiting the earth (ibid., 200-209). The problem of external consistency would finally get resolved with Newton's towering achievement, which for the first time would unify terrestrial and celestial mechanics. The example

goes to show that when a theory is not clearly more virtuous than its competitors, theory choice can take time and be less ordered than when there is a clearly most virtuous theory.

4 Objections

In this section I will consider some possible objections one may have to what I have argued in this paper.

Objection 1: Even though Kuhn did not think that theory choice was just a matter of indisputable taste (Kuhn 1962/1996, 336), he did argue that theoretical virtues are vague and allow different interpretations by different scientists. All of this is an obstacle to my argument from theoretical virtue convergence.

Reply: As Okasha (2011) has pointed out, the problem of virtue ambiguity actually reduces to the problem of preference. Any virtue V may be ambiguous so that V can be understood either as V1, V2, or Vn. For example, simplicity may be ambiguous between qualitative and quantitative parsimony. So, when scientists assess a theory's simplicity, they may end up choosing different theories, because some are assessing their qualitative parsimony and others their quantitative parsimony. This can of course lead to misunderstandings and communicative problems but barring the kinds of communication failures associated with Kuhn's problematic thesis of incommensurability, there is no reason to think that scientists would not be able to sort out their differences and disambiguate the ambiguous virtue in question.

Objection 2: Theoretical virtue convergence is just the Pareto condition in Okasha's rendering of Kuhnian theory choice. But the Pareto condition is trivially true. Theoretical virtue convergence does not add anything to this truism.

Reply: On Okasha's account, theoretical virtues play the same role that individuals play in social choice. The individuals making theory choices, namely scientists, do not receive any representation on Okasha's account. Pareto for theory choice on Okasha's proposal says that if a theory is simpler, more unifying, more fruitful, etc., then it must be preferred. Theoretical virtue convergence says, moreover, that such theories will be preferred *even when scientists have wildly different theory choice preferences*. There is nothing in Okasha's account that represents scientists' theory choice preferences.

Objection 3: In *Structure*, but also in his Objectivity paper, Kuhn indicated that social and personal considerations may influence a scientist's theory choice. For example, Kuhn suggested that Copernicus' Neoplatonism played a role in his attraction to his own system (Kuhn 1957, 131-33). But if these external factors play a role in theory choice, theoretical virtue convergence may not happen, even if a very virtuous theory is available: scientists may still simply choose another theory for personal reasons.

Reply: The objection assumes that personal considerations like Copernicus's Platonism adds another dimension to theory choice that is not captured by Kuhn's five virtues. Although that is of course a possible view to have (albeit a problematic one), it was not Kuhn's view. For him,

personal considerations affect the weighting of the virtues. For example, Copernicus's Neoplatonism made him weight simplicity highly. In other words, personal considerations motivate the virtue weightings, but they do not add further dimensions.[12]

5 What about pursuit?

There are other proposals of how to make sense of Kuhn's view of theory choice, which appear to sidestep the problem of convergence, which I want to mention for completeness's sake.

Kuukkanen, for example, suggests that coherentist epistemology makes better sense of Kuhn's account than foundationalism (Kuukkanen 2007, 2009). He argues in particular that the problem-solving capacity of a paradigm can be perceived of in coherentist terms, so that a problem unexplained by a paradigm "decrease the number and strength of inferential relations between the components of the set, making the system less coherent" (Kuukkanen 2007, 561). Theoretical virtues, Kuukkanen believes, are instrumental for increasing the overarching goal of problem-solving capacity and each theoretical virtue can be construed in coherentist terms. For example, simplicity and unifying power enhance coherence, because the simpler and more unifying the explanations offered by theories, the fewer theoretical "subsystems" are needed (ibid.). Although Kuukkannen's proposal may be read as proposing a coherentist solution to the problem of theory choice (Šešelja and Straßer 2009), he has made clear that this is not his intended reading. Instead, his account is meant to offer "a more comprehensive characterization of the cognitive process behind theory change than any of the five or six criteria alone can offer" (Kuukkanen 2009, 329). Maybe it does, but the coherentist reading of Kuhn does not seem to help us with the problem of convergence.

Some authors have argued that theory change on Kuhn's account is best understood in terms of pursuit rather than acceptance (Šešelja and Straßer 2013). Pursuit makes much lower epistemic demands than acceptance: when one is pursuing a theory, one is exploring the potential of the theory, without in any way committing to the truth of the theory. Šešelja and Straßer, for example, argue that Kuhn's claims regarding scientists' assessment of the "future promise" of a theory, which normal science then must cash out, lend themselves particularly well to an interpretation of persuit rather than acceptance. When a new paradigm is proposed, it would not make much sense to speak of acceptance, anyway, because, as Šešelja and Straßer put it, "the newcomer is not sufficiently developed to undergo such an evaluation" (13).

Even though Šešelja and Straßer's proposal is plausible as far as it goes, it does not constitute a solution to the problem of convergence. Instead, it changes the topic. But even pursuit must at some point end in acceptance, especially on Kuhn's view, for otherwise there would never be paradigms (which require acceptance).

[12] See Hoyningen-Huene (1992, 1993) and Wray (2011) for rebuttals of the view that Kuhn was an externalist about theory choice.

6 Conclusion

Apparently leaving behind the problematic notion of incommensurability and radical paradigm change, Kuhn outlined a view of theory choice in which there is a standard set of theory choice criteria that apply throughout science. Yet this picture is still liberal enough to allow different scientists to have different theory choice preferences. Accordingly, to put it in Okasha's words, there is no "unique algorithm" for theory choice. This paper argued that even if that is so, scientists may well converge in their theory choice, namely when there is a single theory that is more virtuous than all its competitors. Even though Kuhn never considered such situations when discussing theory choice, there is evidence that he thought of at least some historical examples in this way. Regardless of what Kuhn thought, with very virtuous theories, the paper has shown that it is possible to accept a very basic Kuhnian premise about theory choice, and not despair in the face of the problem of convergence.

References

Arrow, Kenneth J. 1950. "A Difficulty in the Concept of Social Welfare." *Journal of Political Economy* 58 (4):328-46. doi: 10.1086/256963.

Bradley, Seamus. 2016. "Constraints on Rational Theory Choice." *The British Journal for the Philosophy of Science* 68 (3):639-61. doi: 10.1093/bjps/axv063.

Brown, Harold I. 1988. *Rationality*. London: Routledge.

Carrier, Martin. 2002. "Explaining Scientific Progress: Lakatos' Methodological Account of Kuhnian Patterns of Theory Change." In *Appraising Lakatos: Mathematics, Methodology, and the Man*, edited by G. Kampis, L. Kvasz and M. Stöltzner, 53-71. Dordrecht: Kluwer Academic Publishers.

Cresto, Eleonora, and Diego Tajer. 2020. "Confirmational Holism and Theory Choice: Arrow Meets Duhem." *Mind* 129 (513):71–111. doi: 10.1093/mind/fzy062.

D'Agostino, Fred. 2005. "Kuhn's Risk-Spreading Argument and the Organization of Scientific Communities." *Episteme* 1 (3):201-09. doi: 10.3366/epi.2004.1.3.201.

Forster, Malcolm, and Elliott Sober. 1994. "How to Tell When Simpler, More Unified, or Less Ad Hoc Theories Will Provide More Accurate Predictions." *The British Journal for the Philosophy of Science* 45 (1):1-35. doi: 10.1093/bjps/45.1.1.

Harman, Gilbert H. 1965. "The Inference to the Best Explanation." *The Philosophical Review* 74 (1):88-95. doi: 10.2307/2183532.

Hoyningen-Huene, Paul. 1992. "The Interrelations between the Philosophy, History and Sociology of Science in Thomas Kuhn'S Theory of Scientific Development." *The British Journal for the Philosophy of Science* 43 (4):487-501. doi: 10.1093/bjps/43.4.487.

Hoyningen-Huene, Paul. 1993. *Reconstructing Scientific Revolutions: Thomas S. Kuhn's Philosophy of Science*. Chicago: University of Chicago Press.

Kuhn, Thomas S. 1957. *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*. Harvard: Harvard University Press.

Kuhn, Thomas S. 1962/1996. *The Structure of Scientific Revolutions*. 3rd edition ed. Chicago: University of Chicago Press.

Kuhn, Thomas S. 1970. "Reflections on My Critics." In *Criticism and the Growth of Knowledge, Proceedings of the International Colloquium in the Philosophy of Science*, edited by I. Lakatos and A. Musgrave, 231-78. Cambridge: Cambridge University Press.
Kuhn, Thomas S. 1977. "Objectivity, Value Judgment, and Theory Choice." In *The Essential Tension*, 320-33. Chicago: University of Chicago Press.
Kuhn, Thomas S. 2000. *The Road since Structure*. Chicago: Chicago University Press.
Kuukkanen, Jouni-Matti. 2007. "Kuhn, the Correspondence Theory of Truth and Coherentist Epistemology." *Studies in History and Philosophy of Science Part A* 38 (3):555-66. doi: 10.1016/j.shpsa.2007.06.011.
Kuukkanen, Jouni-Matti. 2009. "Closing the Door to Cloud-Cuckoo Land: A Reply to Šešelja and Straßer." *Studies in History and Philosophy of Science Part A* 40 (3):328-31. doi: 10.1016/j.shpsa.2009.06.002.
Laudan, Larry. 1986. *Science and Values: The Aims of Science and Their Role in Scientific Debate*. Berkeley: University of California Press.
Marcoci, Alexandru, and James Nguyen. 2019. "Objectivity, Ambiguity, and Theory Choice." *Erkenntnis* 84 (2):343-57. doi: 10.1007/s10670-017-9961-8.
Morreau, Michael. 2014. "Mr. Fit, Mr. Simplicity and Mr. Scope: From Social Choice to Theory Choice." *Erkenntnis* 79 (6):1253-68. doi: 10.1007/s10670-013-9549-x.
Morreau, Michael. 2015. "Theory Choice and Social Choice: Kuhn Vindicated." *Mind* 124:239 - 62. doi: 10.1093/mind/fzu176.
Nguyen, James. 2019. "The Limitations of the Arrovian Consistency of Domains with a Fixed Preference." *Theory and Decision* 87 (2):183-99. doi: 10.1007/s11238-019-09702-x.
Okasha, Samir. 2011. "Theory Choice and Social Choice: Kuhn Versus Arrow." *Mind* 120 (477):83-115. doi: 10.1093/mind/fzr010.
Okasha, Samir. 2015. "On Arrow's Theorem and Scientific Rationality: Reply to Morreau and Stegenga." *Mind* 124 (493):279-94. doi: 10.1093/mind/fzu177.
Rizza, Davide. 2014. "Arrow's Theorem and Theory Choice." *Synthese* 191 (8):1847-56. doi: 10.1007/s11229-013-0372-3.
Rueger, Alexander. 1996. "Risk and Diversification in Theory Choice." *Synthese* 109 (2):263-80. doi: 10.1007/bf00413769.
Sagrafena, Cristina. 2022. "Theory Choice and Social Choice: Two Proposals to Escape from Arrovian Impossibility for 'Large Scale'theory Choices Based on Kuhn's Criteria." *Erkenntnis*:1-17. doi: 10.1007/s10670-022-00630-x.
Schindler, Samuel. 2018. *Theoretical Virtues in Science: Uncovering Reality through Theory*. Cambridge: Cambridge University Press.
Šešelja, Dunja, and Christian Straßer. 2009. "Kuhn and Coherentist Epistemology." *Studies in History and Philosophy of Science Part A* 40 (3):322-27. doi: 10.1016/j.shpsa.2009.06.003.
Šešelja, Dunja, and Christian Straßer. 2013. "Kuhn and the Question of Pursuit Worthiness." *Topoi* 32:9-19. doi: 10.1007/s11245-012-9144-9.
Stegenga, Jacob. 2015. "Theory Choice and Social Choice: Okasha Versus Sen." *Mind* 124 (493):263-77. doi: 10.1093/mind/fzu180.
Wray, K Brad. 2011. *Kuhn's Evolutionary Social Epistemology*. Cambridge: Cambridge University Press.